Alive Engineering Education

Transforming and Innovating Engineering Education

BOOK ORGANIZERS
Getúlio Antero de Deus Júnior
Leonardo Guerra de Rezende Guedes
Marcelo Stehling de Castro
Marcos Lemos Afonso
Ricardo Henrique Fonseca Alves
Rodrigo Pinto Lemos

ISBN: 978-85-495-0151-6
Publisher: Gráfica UFG
Online Resource

BOOK EDITORS

Getúlio Antero de Deus Júnior
Ricardo Henrique Fonseca Alves

GRAPHIC DESIGNERS

Getúlio Antero de Deus Júnior
Ricardo Henrique Fonseca Alves

LATEX DESIGNER

Ricardo Henrique Fonseca Alves

EBOOK DESIGNER

Ana Gabriella Freitas Hoffmann

LANGUAGE REVIEWERS

Responsibility of authors

COVER

Getúlio Antero de Deus Júnior

Alive Engineering Education

Transforming and Innovating Engineering Education

October 20, 2017

ICAEEdu 2017

International Conference on Alive Engineering Education
21-23 June 2017, Rio de Janeiro, Brazil

INTERNATIONAL SCIENTIFIC COMMITTEE

Aly El-Osery, New Mexico Institute of Mining and Technology,
The United States of America
Christian Weiner, Darmstadt University of Applied Sciences, German
Christof Sumereder, FH Joanneum University of Applied Sciences, Austria
Emmanuel Daniel, Télécom Bretagne, France
Getúlio Antero de Deus Júnior, Universidade Federal de Goiás, Brazil
Jesús Mária López Lezama, Universidad de Antioquia, Colombia
Leonardo Guerra de Rezende Guedes, Universidade Federal de Goiás, Brazil
Lina Paola Garces Negrete, Universidade Federal de Goiás, Brazil
Lueny Morell, Lueny Morell & Associates and Director of InnovaHiED, Puerto Rico
Luiz Carlos de Campos, Pontifícia Universidade Católica de São Paulo, Brazil
Marcelo Escobar de Oliveira, Instituto Federal de Goiás, Brazil
Marcelo Stehling de Castro, Universidade Federal de Goiás, Brazil
Marco Antônio Assfalk de Oliveira, Universidade Federal de Goiás, Brazil
Marcos Lemos Afonso, Universidade Federal de Goiás, Brazil
Nival Nunes de Almeida, Universidade do Estado do Rio de Janeiro, Brazil
Natasha Van Hattum-Janssen, Saxion University of Applied Sciences, Netherlands
Rodrigo Pinto Lemos, Universidade Federal de Goiás, Brazil
Rui Manuel Sá Pereira Lima, Universidade do Minho, Portugal

Alive Engineering Education

Transforming and Innovating Engineering Education

BOOK ORGANIZERS
Getúlio Antero de Deus Júnior
Leonardo Guerra de Rezende Guedes
Marcelo Stehling de Castro
Marcos Lemos Afonso
Ricardo Henrique Fonseca Alves
Rodrigo Pinto Lemos

Cataloging in Publication data (CIP)

D486c Deus Júnior, Getúlio Antero de, Org.

Alive Engineering Education: Transforming and Innovating Engineering Education,
[Online Resource]/Getúlio Antero Deus Júnior (Org.). [et al.]. – Goiânia:
Gráfica UFG, 2017.

472p.

ISBN: 978-85-495-0151-6

1. Engineering Education. 2. Higher Education.
3. Active Methodologies. I. Title.

UDC 378

We dedicate this work to all those people that, directly or indirectly, have contributed to make this book come true.

List of Figures

List of Tables

Contents

Preface

Since education is the activity of spreading knowledge with the teaching principles, Engineering Education includes all forms of related education focused on resolving a condition through the application of techniques and technologies. It is about solving problems!

Engineers and their professors can use several knowledge-teaching tools: mathematical methods and structured knowledge – the hard ones –, process-facilitating strategies and contextual knowledge – the soft ones. Above all, the inseparability of knowledge and its practical application is in fact a unique characteristic of Engineering Education itself.

This publication collects alive experiments and experiences from several professors, students and professionals that dedicated their precious time in thinking the Engineering Educations practices and tools. Therefore, here it can be found the emerged truth from the passion for knowledge-spreading of Engineering principles.

Leonardo Guerra de Rezende Guedes

CHAPTER 1

Building the Da Vinci's Self Supporting Bridge

Arthur Campanelli Scantamburlo[*], Evandro Lucas Moraes[♦], Gabriela Rocha Esteves[▴],Sheila Stravate Leonel[▾], Tiago Souza Rodrigues Reis[○] and Luiz Carlos de Campos[✡]

[*]Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: arthurcampanelli@outlook.com

[♦]Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: evandrolucasmoraes@gmail.com

[▴]Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: gabriellaesteves@hotmail.com

▾Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: sheilastravate@gmail.com

○Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: settiago@hotmail.com

✲Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: lccampos@pucsp.br

Abstract: The building of the Da Vinci's self supporting bridge reply was a design handled by a team of students of the fourth semester of the Civil Engineering Course at Pontifícia Universidade Católica de São Paulo in combination with the Mechanics of Rigid Bodies course, given in a traditional manner, using the Project Based Learning (PjBL) approach. The project was part of the assessment process in such course. Leonardo Da Vinci was a master of innovation and Engineering. The history notes that he designed four types of bridges. The design of the self supporting bridge was the most simple and ingenious of them. Its design was developded from 1485 to 1487 attending the request of his patron Cesar Borgia, and it was to be of simple assembly by troops without woodworking skills. The design is held together by its own

weight without requiring any ties or connections. When a downward force is applied to the structure the braced members are forced to interlock and tighten together through the structural concepts of shear and bending. This work was carried out in three steps. The first one was a bibliographic research on the issue. In the second step the students set up a prototype of the bridge where test and analysis were made to understand the structures behavior as result of a downward applied force, and presented it to the classmates. In the third and final step the students set up a bridge in real size and shown that it permitted and tolerated the weight of several people passing along the bridge. Each step of the work was recorded in a video, available in youtube, where the students report their opinions on the project and the main concepts, skills and competences acquired along the development of the project.

Keywords: Downward Force, Engineering Design, Project Based Learning, Self Supporting Bridge, Teamwork.

1.1 Background

According to Mills & Treagust (2003)[1], the modern Engineering profession requires skills in human relations as well as technical competence. The Project Based Learning (PBL) is a new approach that several schools of are implementing around the world. Despite these implementations are growing, they present a lot of challenges and the predominant model of Engineering Education remains like to that put into practice in 1950's. The application of learning systems based on activities that are against theoretical perspectives and practical has been important tools in academic studies last years, used in main Brazilian Universities, Santos et al. (2012)[2]. To adequate to these tendencies the professor of the course Mechanics of Rigid Bodies (MCR) at Pontifical Catholic University of Sao Paulo in the Civil Engineering course proposed the development of a project to put in practice theoretical concepts learned in the classroom. The theme of the project was: "Building of Da Vinci's Self Supporting Bridge". The choice of this theme was because the design of this bridge, developed by Da Vinci from 1485 to 1487, (Bernaroni, Taddei, Zanon)[3], was the most simple and ingenious of the four bridge types that Da Vinci designed. Its design was developed to attend the request of his patron Cesar Borgia and it was to be of simple assembly by troops without woodworking skills. The design is held together by its own weight without requiring any ties or connections. When a downward force is applied to the structure the braced members are forced to interlock and tighten together through the structural concepts of shear and bending.

1.2 Purpose

The main objective of this paper was to understand the concepts related to the MCR course carrying out a full study of the Physics aspect and concepts used in the bridges building. In order to carry out this work a bibliographic research on the issue was done and a prototype was built.

1.3 Method

The academic world is changing in its learning concept and new methodologies and approaches are being used to prepare the students for a future where we don't know what must be taught, Campos et al., (2011)[4]. The Project Based Learning (PBL) is an approach that put the student face to a real world developing competences, skills, teamwork and critical thinking. According to Powell & Weenk (2003)[5] PBL gives to students the opportunity to face a real problem whose solution needs theoretical concepts but the application must be discussed in a teamwork where each member must give a contribution to solve it. In this work PBL methodology was used. The development of this work was made in three steps. The first one was a bibliographic research that give to the students the knowledge of the project under scientific and cultural-history visions. In the second step the students set up a prototype of the bridge where test and analysis were made to understand the structures behavior as result of a downward applied force. In the third and final step the students set up a bridge in real size and show that it permitted and tolerated the weight of several people passing along the bridge. The choice of the appropriated wood with its special characteristic such as shape (cylindrical), size (1,20 m) and type (eucalyptus) was made using biomimetism concepts.

1.4 Results

The building of the Da Vinci Self Supporting Bridge is very simple and the materials used are cylindrical wood pieces where are made sockets in the extremists of some pieces. Some pieces haven't sockets and they are used only to fit the structure in that with sockets. The simplicity of the bridge is in the fact that there is no nail, screw or stick to maintain the structure stick up. All the steps of our self-supporting bridge building are shown in[6].

1.5 Conclusions

The building of Da Vinci's Self Supporting Bridge gave to the teamwork a critical and analytical thinking development to apply knowledge to solve a real project. The most important result of this work was the opportunity to work in teamwork facing a real problem where the contribution of each member was fundamental to the project success. In conclusion, the challenges of this project put the students in contact with a type of problem that they will can face as a professional in the civil Engineering area.

Bibliography

1. MILLS, E. J.; Treagust F. D. Engineering Education – is Problem Based or Project Based Learning the answer. *Australasian journal of engineering education*, Barton, v. 3, n. 2, p. 2-16, 2003.

2. DE JESUS SANTOS, A. R. et al. *Práticas e reflexões de metodologias de ensino e pesquisa do Projeto PRODOCÊNCIA da UEL*, Londrina : Universidade Estadual de Londrina, 2012.

3. BERNARDONI, A.; TADDEI, M.; ZANON, E. *I ponti di Leonardo*, Milano: Leonardo3, 2005.

4. CAMPOS, L. C.; DIRANI, E. A. T.; MANRIQUE, A. L. *Educação em Engenharia Novas Abordagens*, São Paulo: EDUC, 2011.

5. POWELL, W.; POWELL, P.; WEENK, W. *Project-led Engineering Education*, Ultrech: Lema Publishers, 2003.

6. TV PUC. *Ponte Arqueada de Leonardo Da Vinci - Engenharia Civil da PUC-SP.* [2017?]. 1 video. Avaiable in: <https://youtu.be/issE7-XHBgo>. Acessed in: 30 may 2017.

CHAPTER 2

An Extension Project Experience for Engineering Students

Rosely Maria Velloso Campos* and Vinícius Laguardia de Castro Oliveira♦

*Departamento de Engenharia Mecânica, Pontifícia Universidade Católica de Minas Gerais,

Belo Horizonte, Brazil

E-mail: rcampos@pucminas.br

♦Departamento de Engenharia Mecânica, Pontifícia Universidade Católica de Minas Gerais,

Belo Horizonte, Brazil

E-mail: vinicius_laguardia@hotmail.com

Abstract: This paper means to analyze the work with Engineering Students in a University extension project that propose teach robotics and automation applications for kids, improving their technological and programing interest. The project involves Mechanical, Mechatronic, Control and Automation Engineering students in a case study, the purpose is to examine if the university's classes prepare them to work with this project and how it impacts in their formation, which can be technical, personal (emotional), and/or professional.The society demonstrates the need for a graduated professional who has a formation more complete, not only technic, but also etic, humanistic and cultural, which can act with their profession in favor of the society. So, the participation of these students in this project contributes for their acting on the society with competence, responsibility and justice, helping for the construction of a prosperous, solidary and just country. This project is aligned with the Institutional Developing Plan (PDI) – PUC Minas (2011, p. 62): "This University vocation is the formation of a student competent, scientific and technically, who know act with strong professionalism and responsibility in their area and, besides, who has behavior based on the ideals of justice and solidarity." The job market for Engineering areas is inviting and the desire of the students of these areas in teaching is gradually becoming lower. The students were in direct contact with

the class room, maybe for the first time as teachers, so, we can analyze if this wish for teaching was created, which is so profitable to the Academic's Institutions in Brazil, because it's a capacitation during the student's graduation. The students prepared and put in practical so many different applications using Arduino, their tasks were: prepare the content and resources to the classes, thinking in make the most of these resources; give classes and evaluate each class. The results show the values added to the students of the Engineering Courses in relation of humanistic training, didactics and social problems.

Keywords: Arduino, Engineering, Extension, Learning Objects, Robotic.

2.1 Background

Over the past years, Brazil's performance in exams as PISA (Programme for International Student Assessment) was not satisfactory. The last PISA, released in 2016, reveals that Brazil's score is below the OECD (Organisation for Economic Co-operation and Development) average, following a sequence of bad results. In Brazil, about 70% of students fail to achieve the most basic level of proficiency in mathematics and less than 1% of students can be considered "top performers" in math and science. While in countries like Singapore the number of top performers is about 33%[1, 2, 3]. This result comes, in part, from the precarious elementary education in Brazil, where the mathematics is seen as an obstacle and without applicability. This demands a new teaching method, that changes this situation and stimulate students.

The communication between science and others social spheres benefits both sides. This kind of project brings science closer to children and teenagers, what makes the new generations more interested in science[4, 5, 6]. Also is important the ethical and human view from the university extension programs that promotes the communication between science and children/teenagers, with the goal to awaken the interest in many areas of science as possible, and with these projects spread a culture that valorizes and do science. Therefore, in this project students applied Math and Physics concept's on projects using the open-source prototyping platform Arduino, during theoretical and practical classes this made students more interested in mathematics[7].

2.2 Problem

2.2.1 Case Study Analysis

This project benefit the undergraduates that had a great development as professionals and as human beings. One of the reasons of this project was to create professional that stick their actions on ethical principles. At the view's point of the extended learning, more than just give the technical knowledge to undergrad students is also important to give them the opportunities to put into practice the technical knowledge in service of the community. This activity is so important to the education of a student as a human being, that MEC (Ministry of Education - Brazil) includes in their evaluation programs/projects of extension as one of the items evaluated at the Assessment of Teaching Conditions. This project is in accordance with the guidelines from the pedagogical projects of the Engineering's courses of PUC Minas (Pontifical Catholic University of Minas Gerais), because it is in service of the society, meeting its necessities and demands from different areas, as Electronics and IT. Thus, enabling the interaction between society and university, articulating theory and practice, in addition to shape professional citizens.

In this regard, the undergraduate students made children think about the social value and possibilities of the project ongoing. It was worked through the Arduino platform ideas to promote social inclusion because the classes were taught in this context. Think and simulate projects that help special needs people to integrate into society, in one the practical classes students were challenged to design a pedestrian semaphore with a sound signal for the blind. Beyond that, the three cornerstones of the University were worked, Education, Research, and Extension. About the undergraduates, we can say society demands a professional that has a complete formation, not only technical but also ethical, humanistic and cultural, that can work in a multidisciplinary team. Thus, the participation of students in this project, undergraduates and teenagers, contributes that they act with responsibility, competence, and justice, and therefore, paving the way to a better country. As described in the Institutional Development Plan - PUC Minas (2011, p. 62): "The vocation of this university is the formation of a qualified student, scientifically and technically, that knows how to perform with professionalism and responsibility in it area and, furthermore, that has it behavior stuck on ideals of justice and solidarity".

Projects like this become the engaged student body more responsible, given that they need to prepare activities, correct tests, keep the timetable and learn a little bit of the reality of the children/students. It is worth mentioning, that this kind of experience is being valued at the labor market. From projects like that, the students involved rethink about their activities (reflection - action), enhancing their knowledge and methodology, added to the joy of construct the interaction between university and society. Nowadays the labor market of Engineering areas is more and more inviting, and students are showing less interest to become teachers. With this activity, the undergrad students will be in direct contact with the classroom and maybe they will act as teachers, so is expected that grow inside them the desire to become educators. Thus this is very useful to universities because this can be considered a training during the undergraduate period.

In conclusion, the activities made in this project seek a collective process of reflection and learning, in a democratic way, between educators, student, and community.

2.3 Implementation, Development and Results

Throughout the trial lessons, it was possible to obtain promising results in relation what we expected, that was if the students would understand well the content that would be taught and if the lessons were suitable to that age group. For this purpose, we had two lessons with the test group. The first one was used to introduce the Arduino platform, and to blink a LED with timing. Thus, they were challenged to simulate a semaphore. To accomplish this it was necessary to teach basic electronics and basic programming in C, emphasizing commands as turn on/turn off the LED and the delay.

The second lesson was equally fortunate; using a car we explored the same concepts of the first lesson, digital output, and timing, also the idea of functions in a superficial way, which was not an obstacle at all. A maze was built and the challenge was to cross it without hitting the walls. This created a competition among the groups, what made them pursue ways to improve their projects, leading then to change repeatedly the program; therefore they became familiar with their programs.

Students got really excited with the fact that they programmed a car and the competitiveness produced the need to refine the program. Cases as those should be explored emphatically during the course, since it showed only good consequences to the group. The group's performance was really good, presenting positive results both in programming as well at the car's adjustment. The function's understanding became even clearer, with this, we could introduce the notion of the library. The analogy that we used to introduce the idea of a library (of programming), was the real library, where the books were the functions, containing the instructions to be followed, and therefore all the functions together were the library.

Throughout each practice chosen the will to keep learning the programming language just grew more.

2.4 Project's main Features

2.4.1 Prediction of Public Participation and Target Audience

Children and teenagers between 07 and 10 years old, that have it a high level of skill and want it to learn, students from private schools of Belo Horizonte and metropolitan area.

The majority of the students come from the second part of the elementary school and high school. Which were beneficiaries of the project "Enriquecimento da aprendizagem para desenvolvimento de habilidades: crianças e adolescentes que gostam de aprender" ("Enrichment of learning for the development of abilities: children and adolescent.")

2.5 Conclusion

At the end of the project we could point out the results within the different parts that composed it. From the Academia perspective they developed the ability to formulate problems and projects, and they did a reflection between theory and practice, but they also had a humanistic formation and improved their ethical and critical attitude, which caused a reflection about the professional practice.

Bibliography

1. ANG, K. C. Teaching mathematical modelling in Singapore schools. *The Mathematics Educator*, Athens, v. 6, n. 1, p. 63-75, 2001.

2. RAMOS, L. F. R. P. *Educação: o modelo de Singapura*, Sem Rede, 14 may 2013. Available in: <http://semrede.blogs.sapo.pt/59365.html>. Acessed in: 24 sept. 2015.

3. SINGAPURA ensina americanos a "fazer contas". Available in: <http://matematica2.no.sapo.pt/MatSingapura/matsingapura.html>. Acessed in: 24

sept. 2015.

4. MATHEMATICS programmes of study: key stage 4 National curriculum in England. England: Department for Education, 2013. Available in: <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/331882/KS4_maths_PoS_FINAL_170714.pdf>. Acessed in: 23 sept. 2015.

5. Reys, B. J. et al. High school mathematics: State-level curriculum standards and graduation requirements. *Center for the Study of Mathematics Curriculum*, Missouri, Apr. 2007 Available in: <http://www.mathcurriculumcenter.org/PDFS/HSreport.pdf>. Acessed in: 25 sept. 2015.

6. HIGH School Mathematics Statewide Assessments by State. 2014. Available in: <http://www.fldoe.org/core/fileparse.php/7764/urlt/0084239-hs-assessments-state.pdf>. Acessed in: 25 sept. 2015.

7. Blog Tecnologia na Educação. *Por que ensinar programação na escola?*. Nova Escola, 23 feb. 2016. Available in: <https://novaescola.org.br/conteudo/113/por-que-ensinar-programacao-na-escola>. Acessed in: 31 aug. 2016.

CHAPTER 3

Electrical Engineering Introduction Course Using an Integrated Approach via Group Work Viability Projects

Renan Luis Prado[*], Paulo Fernando Ribeiro[♦] and Tiago Elias Castelo de Oliveira[▲]

[*]Universidade Federal de Itajubá, Instituto de Sistemas Elétricos e Energia, Itajubá, Brazil

E-mail: renanprado@icloud.com

♦Universidade Federal de Itajubá, Instituto de Sistemas Elétricos e Energia, Itajubá, Brazil

E-mail: aslan1952@gmail.com

▲Universidade Técnica de Lisboa, Instituto Superior Técnico, Lisboa, Portugal

E-mail: castelo.tiago@outlook.com

Abstract: This paper shows a case study about a different methodology of teaching applied in the Electrical Engineering Courses in a public university located in Minas Gerais. This document is justified by the need to reduce the student dropout rate in Engineering Courses. The article discusses the initiative that the Universidade Federal de Itajubá (UNIFEI) has used to motivate, orientate and prevent that freshmen students leave the course before finishing it, showing them the vast possibilities the Engineering can offer. For that, the university uses the course called Introduction to Electrical Engineering, which, by the instruction of the mentor of the class, is based in the formation of groups focused in the viability of Renewable Energy Sources projects. The groups are free to guide their researches and initiatives based on their needs, different of what traditionally occurs, where the master is the agent of the teaching and the pupil is the patient of this process[1]. In 2015, a group called Photovoltaic Application in Needy Communities (PANC) was created, and has reached, at

the end of the period, the implantation of the group's objective: a solar system in a Basic Health Center in Itajubá (MG). The methods used by the group: escalated filters on researches; integration of group with apps (Dropbox®); parallel researches to improve programmed chronogram; optimized meetings and Feedback Worksheets; Behavior Rules; development of mockups and logos, etc. are discussed in this paper.

Keywords: Renewable Energy Sources, Academic Education, Different Teaching Methodology.

3.1 Background

The Engineering course has extremely high dropout rates. According to a study conducted from 2001 to 2011 by the National Confederation of Industry (CNI [PT]), the average rate of dropout students of Engineering courses in both public and private colleges in the period was around 55.59%[2]. CNI examined these indexes through the Higher Education Census of 2011[2].

In order to change this scenario, the course of Electrical Engineering, in Federal University of Itajubá (UNIFEI), is using the chair called Introduction to Electrical Engineering, which focuses in motivating and directing students, presenting them the vast paths Engineering can lead.

The course uses a different methodology of teaching, based on the formation of student groups. These groups are free to choose the most diverse subjects of studies, focusing on renewable energy sources. They can use various platforms for publishing the development of their research, such as blogs and pages on social networks. At the end of the course, students present the results of their work, reporting what were their greatest difficulties and achievements in the period.

This article presents a group of 10 freshmen which formed PANC (Photovoltaic Application in Needy Communities), in 2015. In the end of the course, the group achieved its purpose: the development of a Solar System in a Basic Health Unit in the city of Itajubá (MG).

3.2 Development: Researches, Management and Final Presentation

At first, students are asked to split into groups with up to 10 members. So they receive the mission to discuss which issues related to power generation they are more interested or curious to study.

Later, the students organize the team and the functions of each member are determined. The basic structure of the groups is a manager and a general secretary.

It is important to note that throughout the course, students are the agents of the progress in their groups, with the teacher being only a "facilitator" of this process, guiding and directing better the groups[3].

With the groups and the functions of each member clearly defined, they were asked to create ways to broadcast the research progress and development of their groups. PANC created a blog where all the weekly meetings and research progresses were published. Furthermore, there was the creation of a website to present the team members in addition to the presentation of the central proposal of the team. After the basic structure of the teams and the creation of the publishing platform, the groups had freedom to guide their own research as needed.

PANC developed research holistically, that is, all members participated in the research. The members were responsible for the theoretical foundation of their research, although the group has set a starting point: the article Engineering Manual for Photovoltaic Systems[4].

The researches developed in the group were submitted to a filter before being published in the blog. A group called Research Core would summarize the survey of all members and each member of this core (three or four) should produce a new research. Finally the Research Leader would summarize those documents once more. This final research was posted in the blog.

In order to maintain greater control over the activities of the group, PANC created various mechanisms, such that: Meetings based on pre-selected topics, to optimize the time and perform checks of weekly tasks; Attendance and Feedback spreadsheets; a shared folder on Dropbox; a behavior's conduct of all members. This regulation had compensative character, that is, when one member failed to attend a meeting, the group directed the member to produce a parallel survey to complement the planned research.

Several ideas for the final presentation were contemplated in the group. The team sought to approach all proposals that add value to the project. Among the most notorious ideas, there is the model of the Basic Health Unit. The proposal was to have a faithful physical model of reality to represent the group's study object. For the development of the model, the group had to raise money through raffles.

At the end of the course, the groups should show their results and conclusions as well as the challenges and difficulties they had during the course. PANC used the opportunity for an expository presentation. A slide was created including the issues of the group, for example: the theme chosen by the team; the group's motivation, etc.

3.3 Study Object: Basic Health Unit (BHU)

After a few weeks of the creation of PANC, the group started to study the Basic Health Unit Santa Rosa, in the city of Itajubá (MG), which was closed for an expansion. From then on, the whole focus of the research was given to this locality.

Therefore, the team created the position of Field Research Leader, who is in charge of the responsibilities regarding the negotiations with the agencies involved in the administration of the BHU.

The group went to examine the concepts of the energy needs of BHU after the reforms, based on the energy of the local consumption in 2013. Using the site plans, it was decided where the PV modules would be positioned, making the most accurate model of reality. Table 3.1 shows the results of sizing.

Table 3.1 – Solar System Sizing of BHU.

Expected Potency [kW]	4
Potency per module [W]	250
Number of Panels	16
Built Area [m^2]	286.99
Chosen Area for Implantation [m^2]	31.5
Cost of Modules(250W) [R$]	13572.64

Bibliography

1. LEWIS, C. S. *Rehabilitations and other essays.* Oxford University Press, 1939.

2. MONACO, R. *Mais da metade dos estudantes abandona cursos de engenharia.* Avaiable in: <http://www.portaldaindustria.com.br/cni/impren- sa/2013/07/1-,19276/mais-da-metadedos-estudantes-abandona-cursos-de-eng- enharia.ht-ml>. Acessed in: 18 may 2016.

3. FREIRE, P. *Pedagogia da autonomia: saberes necessários à prática educativa.* São Paulo: Paz e Terra, 2011.

4. PINHO, J. T.; GALDINO, M. A. *Manual de engenharia para sistemas foto-voltaicos.* Rio de Janeiro: Grupo de Trabalho de Energia Solar (GTES), CEPEL - DTE – CRESESB, 2014.

CHAPTER 4

Integrating Activity: A Strategy for Development in Humanity Competences

Amanda de Oliveira Careaga[*]

[*]Departamento Acadêmico de Engenharia Química,
Universidade Tecnológica Federal do Paraná, Ponta Grossa, Brazil

E-mail: amandacareaga@gmail.com

Neron Alipio Cortes Berghauser[▲]

[▲]Departamento de Engenharia de Produção, Universidade Tecnológica Federal do Paraná, Ponta Grossa, Brazil

E-mail: neronalipio@gmail.com

Luiz Alberto Pilatti[▼]

[▼]Departamento de Engenharia de Produção,
Universidade Tecnológica Federal do Paraná, Ponta Grossa, Brazil

E-mail: lapilatti@utfpr.edu.br

Elis Regina Duarte[♦]

[♦]Departamento Acadêmico de Engenharia Química,
Universidade Tecnológica Federal do Paraná, Ponta Grossa, Brazil

E-mail: eduarte@utfpr.edu.br

Abstract: Currently the job market requires a "new professional" who has a holistic formation and not just technical knowledge. In this way, Engineering Education needs to be developed under a new perspective that seeks the awakening to Engineering, making the process of teaching and learning more collaborative and promoting the integration between the disciplines through the initial periods. In this work was developed an Integrating Activity that brings a constant dialogue between theory and practice and the integration of knowledge and development of new skills. Based on the problem-based

learning strategy (PBL) that builds knowledge from real problems that are open, complex and allow the student to construct new strategies to solve these problems. The activity consists of integrating all the disciplines of a semester in the solution of a practical problem, applying the interdisciplinary to motivate the student to understand the connection of all the subjects covered and how they relate in the course. The activity follows the format, starts with a dynamic for interaction of the participants and then the formation of the teams, later a real problem is provided and from it the students have to build a prototype. In order to remind or familiarize students with the concepts and phenomena involved in solving the problem, a question and answer game is carried out and to assist in the development of the prototype, a management tool is used. After the development and testing of the prototype as well as analysis of the results, the teams create a presentation and in the round table form, where are discussed the knowledge and skills built and also shared difficulties in the development of the activity. It was tried to deal with the overcoming of the students in situations not found in the daily academic, but very seen in the companies, so that they could understand how the study of the subjects may be involved with the chemical engineer profession. From this activity it can be seen that, in the learning environment, it is vital to insert tools that prepare the student for experiences in the job market, where there won‘t be only idealizations, but practices that require a good technician, leader, solver of problems and with humanistic skills.

Keywords: Engineering, Education, Problem-based Learning, Integrating, Humanistic Skills.

4.1 Background

The job market requires a new professional with holistic training and not just technical knowledge. It is assumed that a new professional Engineering profile is required[1]. It is also true that the current student questions the form of passive learning and only theoretical, inquiring about a greater application of the theory in practice. But often when they develop the practice, they can't visualize the disciplines, because they are studied in a segmented way.

Engineering teaching is an issue to be constantly reconsidered[2]. It is necessary to develop a new perspective, which makes the process of teaching and learning more participatory and promote the integration between the disciplines already at the initial periods.

The use of active teaching methodologies seeks to bring students closer to the reality faced by companies through the development of critical thinking and the use of physical and cognitive skills. An example of this feature is the Problem Based Learning (PBL) methodology[3]. The methodology of the PBL is to propose a complex problem situation, where the student is an active agent on the resolution search of this issue, where the research process constitutes the true phenomenon of learning[4].

4.2 Purpose/Hypothesis

The activity aims to develop multidisciplinary practices to sensitize students about the subjects contained in their academic curriculum, searching to propose to students the development of prototypes that bring together all the subjects taken over a period of their course, seeking to develop skills and abilities such as oral communication, teamwork, critical and quick thinking, leadership and time management.

4.3 Design/Method

The activities have the same format, starting with a dynamic for integration and team formation, in which the students are randomly distributed. Next is provided a real problem, for example, in the first edition the challenge was to develop a cyclone for a mining industry. To recall or familiarize students with the concepts and phenomena involved in solving the problem, a game of questions and answers is performed. Each team receives a score based on accuracy in the questions. This score will define the type of "kit" that each team will receive for building the prototype. The higher the number of hits the better or greater the amount of material the team receives. For continuity of the activity a tool is used that indicates the next steps, helps in planning and develops a new skill. Some of the tools already used were canvas to structure the business model and failure mode and effect analyses FMEA. After the prototype elaborating and testing as well as analysis of the results, the teams create a presentation and in the roundtable form are discussed the knowledge and skills built and also shared difficulties in the development of the activity.

4.4 Results

It was noticed that leaving the groups heterogeneous the collective objective is the same, preventing the casual conversations and stimulating the objective communication between the participants.

At the end of each of the actions, evaluative questionnaires were applied in order to carry out a continuous improvement of the work performed. From the questionnaires, it was observed that, by unanimity, the activity was well evaluated in the view of the students, who affirmed that they developed self-knowledge in finding solutions for the proposed problem. It was found that all the students who participated felt motivated to continue in the course and awakened to the importance of all the disciplines addressed, since they were able to understand the integration of these, facilitating the understanding and increasing the motivation. Other realities addressed by the students were the development of the ability to develop multiple activities simultaneously and teamwork to meet the demands in the stipulated time.

4.5 Conclusions

In all the editions of the participants managed to solve the problem proposed, however the greatest learning comes from the development of humanistic skills and self-knowledge, as pointed out by the participants themselves. The development of work methodologies such as PBL encourages the student to be the agent of their own knowledge, so the greatest difficulty is still a resistance on a part of students to participate in these activities, since many do not want to leave the comfort zone to which they are adapted.

Bibliography

1. SILVA, L. P.; CECÍLIO, S. A mudança no modelo de ensino e de formação na engenharia. *Educação em Revista*, Belo Horizonte, v. 45, p. 61-80, 2007.

2. CAMPOS, A. T., FARIAS, C. V. Reflexões sobre o ensino de Engenharia no Brasil. *Mimesis*, Bauru, v. 20, n. 2, p. 39-57, 1999.

3. BAHM, A. G. The Effects of Discovery Learning on Students' Success and Inquiry Learning Skills. *Egitim Arastirmalari-Eurasian Journal of Educational*

Research, Turquia, n. 35, p. 1-20, 2009.

4. QUEIROZ, A. PBL, Problemas que trazem soluções. *Revista Psicologia, Diversidade e Saúde*, Salvador, v. 1, n. 1, p. 1-13, 2012.

CHAPTER 5

Extension Projects and Partnerships with Companies: Contributing to The Engineer's Professional and Humanistic Training

Cacilda de Jesus Ribeiro[*], Leonardo Lucas de Assis[♦], Ananda Alves de Sousa e Silva[▴], Vitor Nascimento Resende[▾] and Adonay Rodrigues[○]

[*]Escola de Engenharia Elétrica, Mecânica e de Computação, Universidade Federal de Goiás, Goiânia, Brazil

E-mail: cacildaribeiro@gmail.com

[♦]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: leonardolucas3@hotmail.com

[▲]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: anandinha001@hotmail.com

[▼]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: vnresende@hotmail.com

[○]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: adonay1234@gmail.com

André pereira Marques[✲] and Adriano Machado Martins[◘]

[✲]Departamento de Engenharia e Controle da Manutenção, Celg Distribuição
S.A, Goiânia, Brazil

E-mail: andre.pm@celg.com.br

[◘]Departamento de Engenharia e Controle da Manutenção, Celg Distribuição

S.A, Goiânia, Brazil

E-mail: adriano.mm@celg.com.br

Abstract: Studies have shown that continuous advances in technology and the increasing professional responsibilities of engineers require quality and skills in the practice of their activities that go beyond specific course content. The professional must have an all-inclusive vision of the potentialities and difficulties in the country. Education goes beyond the mere transmission of concepts, promoting intellectual and social development in order to stimulate creativity, critical thinking and the ability to learn continuously and autonomously by keeping abreast of changes in society. Scientific and technological development, which induces the creation and enhancement of new knowledge and techniques and their applications, requires all-inclusive human resources training programs at every level, thus explaining the reason for the development of this work. This article discusses the results of extension activities that contribute to the technical, ethical, and humanistic training of future electrical engineers, with a focus on teaching problem-solving skills, thereby enabling a transformative relationship between university and society. This analysis covers two case studies, as follows. Case 1 – an occupational safety and health management study conducted in partnership with the electromechanical workshop of the electric utility company, highlighting the importance

of the university's interactions with the company and the student, and thus aligning theory with practice. Case 2 – involves a study group on Williams syndrome (a rare developmental disorder) and human genetics, which aims to provide assistance through the development of computational tools to monitor patients according to their individual diagnosis. The methodology adopted here was based on the following procedures: a) analysis of action priorities and work environment locations to identify existing risks; b) collection of field data; c) development of control measures and preventive systems in the field of workplace health & safety Engineering; d) creation of spreadsheets for monitoring the health status of patients with physical and intellectual disabilities, aiming at a complete diagnosis; e) implementation and orientation of strategic management actions; and f) result analysis and improvement proposals. This study provided satisfactory results, enabling reflections and studies in the fields of workplace health and safety, diagnostics and society, practical problem solving, and the development of improvement proposals. It can thus be stated that this work achieved its goal of analyzing the significant contribution of extension projects and interaction with companies, the development of teamwork skills, and the professional profile of the engineer, which are required in today's job market. This profile must encompass a comprehensive set of skills and knowledge in several areas of Engineering and related fields, aimed at practicing in all the fields that involve quality of life and development of the country.

Keywords: Diagnosis, Engineering Training, Extension Projects, Health, Workplace Safety.

5.1 Introduction

Studies have shown that continuous advances in technology and the increasing professional responsibilities of engineers require quality and skills in the practice of their activities that go beyond specific course content. The professional must have an all-inclusive vision of the potentialities and difficulties in the country. Education goes beyond the mere transmission of concepts, promoting intellectual and social development in order to stimulate creativity, critical thinking and the ability to learn continuously and autonomously by keeping abreast of changes in society[1]. Scientific and technological development, which induces the creation and enhancement of new knowledge and techniques and their applications, requires all-inclusive human resources training programs at every level, thus explaining the reason for the development of this work.

According to Martins et al.[2], experimentation connects the learner to the objects of his knowledge, to theory and to practice, i.e., it enables him to apply his interpretation to the natural phenomena and processes he observes, based not only on established scientific knowledge but also on knowledge and hypotheses he comes up with in response to challenging situations. This article therefore discusses these studies in real work environments.

5.2 Purpose/Hypothesis

The importance of university-company and university-community partnerships that contribute to the engineer's training, complementing his theoretical education with practices, was analyzed based on two case studies. In the first, students were given the opportunity to participate in activities such as the creation of standard operating procedures, risk maps and proposals for improvements, involving corrective maintenance services in medium and large high voltage equipment, with emphasis on minimum work-related safety and health requirements[3]. The second study consisted of developing a computational tool to aid in the follow-up diagnosis of patients with rare diseases, which is necessary for advances in research on human genetics. This study provided knowledge and analogies of applications in monitoring, as well as experience with volunteer work initiatives, which are valued by many companies.

5.3 Method

This analysis covers two case studies, as follows. Case 1 – an occupational safety and health management study conducted in partnership with the electromechanical workshop of the electric utility company – CELG Distribuição S.A, highlighting the importance of the university's interactions with the company and the student, and thus aligning theory with practice. Case 2 – involves a study group on Williams syndrome (a rare developmental disorder) and human genetics, which aims to provide assistance through the development of computational tools to monitor patients according to their individual diagnosis.

The methodology adopted here was based on the following procedures: a) analysis of action priorities and work environment locations to identify existing risks; b) collection of field data; c) development of control measures and preventive systems in the field of workplace health & safety Engineering; d) creation of spreadsheets for monitoring the health status of patients with physical and intellectual disabilities, aiming at a complete diagnosis; e) implementation and orientation of strategic management actions; and f) result analysis and improvement proposals.

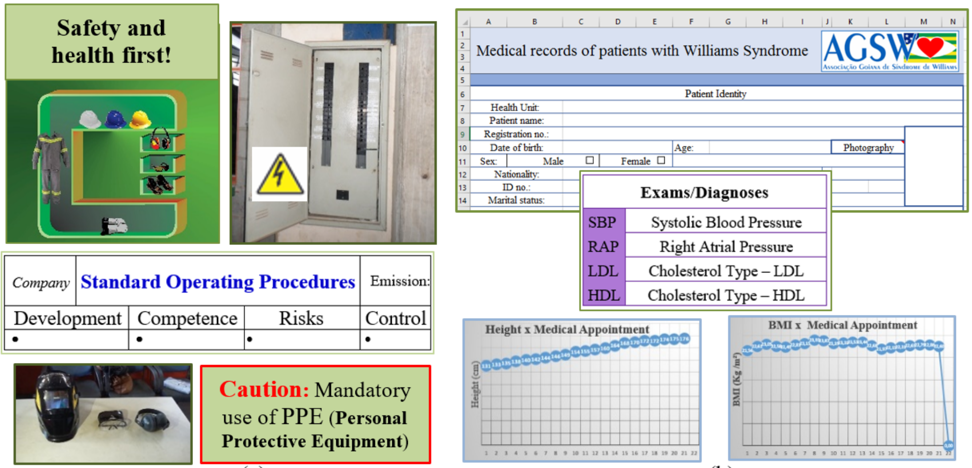
5.4 Results

Figure 5.1 illustrates some of the activities developed in this study, involving: a) occupational health and safety, at the partner's electromechanical workshop; and b) monitoring the clinical status of patients with the rare disease – Williams syndrome (statistical control and diagnosis).

The results demonstrate unequivocally that extension projects provide opportunities for complementary activities, in accordance with the National Curriculum Guidelines of the Undergraduate Engineering Course[4], by bringing the future Engineering professional into contact with society, with professionals and researchers, with the work environment, and with operational efficiency, generating benefits and exchange of experiences pertaining to technical, human and ethical issues.

5.5 Conclusions

This study provided satisfactory results, enabling reflections and studies in the fields of workplace health and safety, diagnostics and society, practical problem solving, and the development of improvement proposals. It can thus be stated that this work achieved its goal of analyzing the significant contribution of extension projects and interaction with companies, the development of teamwork skills, and the professional profile of the engineer, which are required



(a) (b)

Figure 5.1 – Activities involving: a) safety and health in the workplace; and b) monitoring of the patient's clinical status (statistical control and diagnosis).

in today's job market. This profile must encompass a comprehensive set of skills and knowledge in several areas of Engineering and related fields, aimed at practicing in all the fields that involve quality of life and development of the country.

Bibliography

1. SILVEIRA, R.M.C.F.; BAZZO, W. A. Educação Tecnológica: Qual o seu papel? In: XXXV CONGRESSO BRASILEIRO DE EDUCAÇÃO EM ENGENHARIA

– COBENGE, 2007, Curitiba. *Anais...*, Curitiba: ABENGE/UNICENP, 2007. p. 1-15.

2. MARTINS, J. A.; MOSSMANN, V. L. F. Novos desafios para o engenheiro do futuro (Projeto PETROFUT): Oficina de energia e meio ambiente. In: XL CONGRESSO BRASILEIRO DE EDUCAÇÃO EM ENGENHARIA, 2012, Belém. *Anais...*, Belém: ABENGE, 2012. p. 1-15.

3. BRASIL. Ministério do Trabalho. *Legislação: Normas Regulamentadoras*, Brasília, DF, 2017. Available in: <http://trabalho.gov.br/index.php/seguranca-e- saude-no-trabalho/normatizacao/normas-regulamentadoras>. Accessed in: 31 May 2017.

4. BRASIL. Parecer CNE/CES n.º 1.362, de 12 de dezembro de 2001. *Ministério da Educação: Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia*, Brasília, DF, 12 dec. 2001. Available in: <http://portal.mec.gov.br/cne/arquivos/pdf/CES1362.pdf>. Accessed in: 31 May 2017.

CHAPTER 6

Integrating Practice and Theory in Basic Physics Undergraduate Courses: A New Physics Teaching Lab Proposal

Alexandre Guimarães Rodrigues[*] and Jhon Rewllyson Torres dos Reis[♦]

[*]Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: alexgr_28@yahoo.com.br

[♦]Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: jhon_etho@hotmail.com

Newton Martins Barbosa Neto[▲]

[▲]Instituto de Ciências Exatas e Naturais, Universidade Federal do Pará, Belém, Brazil

E-mail: newtonfisico@gmail.com

Abstract: The undergraduate basic physics courses performed in the traditional way, based in theoretical expository methods, is attracting an ever smaller contingent of students, which complain about the abstraction and lack of application of scientific knowledge. In addition, the positive impact that experimentation exerts on physics classes, when performed with a proper and well-planned didactic purpose, is largely known. Here we present a proposal that intends to insert experimental activities as support to the basic courses of physics, which is in resonance with the so-called active learning methodologies based on challenges, projects, open questions and experimental investigative practices that give students deeper levels of commitment and learning. The proposal also finds support in modern pedagogical projects of undergraduate courses in which the theoretical and practical knowledge are integrated in a concatenated and synergistic way. The first step is to employ usual physics classes to construct the knowledge based on problem solving, creating in the students the curiosity and the research spirit. After, some problems are selected, adapted to experimental projects and addressed to the research groups

formed by students. As a prototype case we employed our hypothesis in an electromagnetism basic course, along one semester, where a voluntary student worked on an adapted problem about physics of capacitors and dielectrics. Based on the classical problem of a parallel plate capacitor with the inner volume equally filled with two different dielectrics, the student, under the supervision of professors, was able to expanded the canonical solution of the problem creating a solution that takes into account different filling dielectric profiles. Then, a new technique to measure the dielectric constant of liquids was proposed and implemented, employing a liquid and the air as the two dielectrics in in variable proportions. The chosen liquid was the hexane that has its dielectric properties well established in literature. The values measured in the present work for the dielectric constant of the hexane are very close the value reported in literature (less than 5% error). Furthermore, it is worth to mention that employing the new experimental approach a critical problem in dielectric constant measurements assigned to parasitic capacitance is solved. Concerning about the impacts on the student formation it is clear that, along the course, he developed sharp scientific skills learning how to approach experimental problems from theoretical constructions. Besides the investigative approach this lab proposal incorporates demonstrative activities intending to show through simple practices qualitative and/or quantitative aspects of the physical phenomena presented in the classroom. The current stage of

this proposal, which is in implementation at present days, involves theoretical refinement, adaptation of physical area and participation in calls for funding lab equipment. Finally, the results obtained up to now, support the idea that the present method constitutes both a new physics lab teaching approach as well as can be employed as an innovative proposal for the construction of a new curriculum structure of basic disciplines in the Engineering Courses. The authors are indebted with CNPq, CAPES, FAPESPA and Universidade Federal do Pará.

Keywords: Active Learning Methodologies, Investigative and Demonstration Practices, Lab Proposal, Physics Teaching for Enginnering, Theory and Practice Integration.

6.1 Background

The undergraduate basic physics courses performed in the traditional way, almost totally based in theoretical expository methods, is attracting an even smaller contingent of students, which complain about the abstraction and lack of application of scientific knowledge. Nevertheless, it is well known from literature the positive impact that experimentation exerts on physics classes when performed with a proper and well-planned didactic purpose[1]. This proposal intends to insert experimental activities as part of basic physics courses, which is in resonance with the so-called active learning methodologies based on challenges, projects, open questions and experimental investigative practices that provide deeper levels of engagement and learning for the students.

6.2 Purpose/Hypothesis

This work synthetizes the idea transformed in a project that was awarded in a public funding call from UFPA´s Rectory. Basically, the proposal is conceived on two independent but complementary pillars: 1) Develop pedagogical resources with experimental practices for teaching Physics for Engineering and basic sciences courses. 2) Furnish opportunity, for undergraduate level students, to acquire good formation in experimental scientific research.

In some sense, the interesting and unusual aspects of the proposal are: Integration of the theory and practices by means of two different experimentation modes: demonstrative (bench of well-known pedagogical experiments) and investigative experiences (innovative and developing projects); Adaptation of physical area to merge theory and practice in the same time or in a indistinctly and easy way; Wide range of innovation with an extensive gamma of product and processes; and Mid-term goals in order to collect plenty of contributions to reformulate basic courses on Physics for Engineering.

It is worth keep in mind that the student do not need to have a real scientific problem to do science or to think scientifically. On the other hand, in the role of professor, he must to promote teaching by situations/activities that challenge and/or propitiate to think scientifically. Furthermore, it is extremely necessary that the professor must be straight about developing skills and apprentice´s competences. It means that the professor has to define the didactic (formative) objectives as precise as it possible. We consider that this set of sentences is the tacit background of this proposal.

6.3 Design/Method

The method presented here can be organized as follow. Step 1: at least one class a week is employed to discuss and analyse problems from textbooks. During the analysis of the problems, both the understanding as well as the generalization of them are sought. Step 2: A problem with potential to be transformed in experimental project is selected. Step 3: Under the supervision of the professor, project execution begins with the build of the experiment by the student. Here we have the most critical part of the method, since problems able to make the project unfeasible can take place. Step 4: The experimental data are collected, analysed and compared with the discussed theory. Based on the success of the project and on the commitment of the student to the work a score is assigned to him, substituting a conventional evaluation. Finally, successful projects can be transformed on new lab practices.

6.4 Results

Our investigative experimental method has at least two different approaches. One of them, with real interface among Engineering and physics, has potential to produce new experiments that can be implemented as new practices in a structured didactic laboratory. The other one possibly can be thought as investigative, at least from the student perspective, and is structured from problems that are not so challenging or difficult, from a theoretical point of view. The experiments for both of the methods can be extracted from physics textbooks or even be elaborated by the professor. Here, it is important to emphasize that basic physics textbooks have hundreds of proposed questions that can be implemented as stimulating and economical viable experimental problems.

In order to verify the viability of the first type method mentioned above a prototype case study was implemented with a voluntary student from a basic electromagnetic course. In this one semester study, under the supervision of a professor, the voluntary student worked on an adapted problem about physics of capacitors and dielectrics. Starting from the classical problem of a parallel plate capacitor half-filled with two different dielectrics he was able to create an expanded model considering different profiles of filling for the capacitor. Additionally, he was also able to build and perform the correspondent experiment employing a liquid (hexane) and the air as the two dielectrics, obtaining a dielectric constant value for the liquid very close to the value reported in literature (less than 5% error)[2]. The results obtained with our case study show that, the student involved with the issue of determining the dielectric constant by means of capacitor of parallel plates was able to understand and generalize the theoretical original problem. Besides that, he faced the experimental challenge and experienced scientific method in fact, by doing a real experiment that produced accurate experimental results when compared with theoretical model developed. The main point in this activity is that the student was able to develop worth competences for research in experimental area. The observed developed competences in the case study investigated are: generalization of a stablished situation; elaboration of a theoretical model; idealization and construction of the related experiment; data analysis; comparisons between theoretical model developed and experimental results and finally proof of the developed model trough extraction of an expected value for a physical parameter.

The current stage of this proposal, which is in implementation at present days, also involves refinement by means of studying different kinds of methodological approaches to establish theoretical foundations of the proposal[1, 3-5].

The team is also researching formats to synthesize kinds of reports and registers (media) for projects and for didactic assessments with the purpose to get all the material available for guiding others professors and students in experimental research.

6.5 Conclusions

We believe that a proposal which use the principle of merging theory and practice by means of two modes of experimental activities (demonstrative and investigative ones) in a physical area with mutual access (classroom and lab with the potential to interchanging theory and practice in a easily and natural way) is a stage for innovation in an extended significance, including innovations of content, methodology on teaching/learning activities and in evaluation forms. Here we successfully employed this idea on a case study where we evaluate the impact of the methodology on the learning process of a voluntary student.

The results observed showed that the student developed a series of skills and competences related to how to use the experimentation to obtain knowledge. It is propitious for thinking in terms of mid-term goals with the intention of producing plenty of contributions to reformulate basic courses on Physics for Engineering in a stimulating manner and offering support to hands on activities related with investigative questions in the interface between Physics and Engineering.

Bibliography

1. ALVES FILHO, Jose de Pinho. *Atividade experimental: do método à prática construtivista.* Florianópolis, 2000. Tese de Doutorado, Universidade Federal de Santa Catarina, 2000.

2. HU, Z. et al. An insight into non-emissive excited states in conjugated polymers. *Nature communications*, Shanghai, v. 6, p. 8246-8255, 2015.

3. GRANDINI, N. A.; GRANDINI, C. R. Os objetivos do laboratório didático na visão dos alunos do curso de Licenciatura em Física da UNESP-Bauru. *Revista Brasileira de Ensino de Física*, São Paulo, v. 26, n. 3, p. 251-256, 2004.

4. KIRSCHNER, P. A.; MEESTER, M. A. M. The laboratory in higher science education: Problems, premises and objectives. *Higher Education*, Netherlands, v. 17, n. 1, p 81-98, 1988.

5. GALIAZZI, M. C. et al. Objetivos das atividades experimentais no ensino médio: A pesquisa coletiva como modo de formação de professores de ciências. *Ciência & Educação*, Bauru, v. 7, n.2, p. 249-263, 2001.

CHAPTER 7

Interaction Between Extension and Education: The Game of Integration in The IFMT

Jean Marc Nacife[*]

[*]Gestão Ambiental, Instituto Federal de Educação Goiano, Rio Verde, Brazil

E-mail: jean.nacife@ifgoiano.edu.br

Marcos Lemos Afonso[♦]

[♦]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: afonso_ml@uol.com.br

Abstract: The design presented exerted a strong role of integrating labor market and students. This was an opportunity stage and recognition of the actions of the students in the Association of Artisans from Sinop/MT. Project with bias in extension has been moved to the teaching aiming at providing an opportunity for students to participate in the various steps for preparing the business plan of the house of the Artisan of Sinop/MT: enterprising and innovating with art and science. The project included the implementation and coordination of a team that Extensionist oportunizou the interaction of classes of technical courses in human resources and technical support in subsequent trade in project development, providing the interaction of theoretical and practical knowledge in the Instituto Federal de Educação de Mato Grosso (IFMT), Advanced Campus of Sinop. The methodology used in the project presents characteristics of the concept of active methodology, where Mitre et al, (2007) tells you how characteristics the presence of actions directed to the student can deepen and expand the meanings produced by their participation and also requires the teacher to permanent reflection, availability for the monitoring, which involves the emergence of unforeseen situations and unknown[1].

Keywords: Entrepreneurship, Extension with Teaching, Active Methodology.

7.1 Background

The extension as an educational, cultural and scientific articulated the teaching may be the formal instrument, unquestionable and effective, linking theory with practice. Important to think that the construction of knowledge in schools can be streamed from the society, in order to seek to address demands for knowledge, ideas, skills, attitudes, capabilities and skills, essential to formation of the professional future[2]. For Demo (2001) the Institution of Education has the basic need for existence the vocation to be inserted in the social problematic, because it is part of the construction of the future of any society[3].

Entrepreneurship is the exploitation of active methodologies in the direct relationship between teaching and extension. For Filion (1999) entrepreneurship can be seen as a discipline that studies the enterprise activity [4], already Dornelas (2012, p.28) brings, "entrepreneurship is the involvement of peopleand processes that, together, lead the transformation of ideas into opportunities[5]. And the perfect implementation of these opportunities, leads to the creation of successful businesses". Schumpeter (1988), brings the idea that entrepreneurship involves a direct relationship issues such as innovation, the return on capital and investments in joint ventures[6].

This work describes the perceptions of the dynamic teaching and extension undertaken in the project developed in the Federal Institute of Education of Mato Grosso (IFMT), Advanced Campus Sinop/MT, with “Business Plan of the House of the Craftsman of Sinop/MT: enterprising and innovating with art and science”[7].

7.2 Objective

Describe what the perception about the activities of university extension integrated with teaching using entrepreneurship as a vector of learning in the context of active methodologies, from the point of view, in which the disciplines of teaching can be related to the projects of extension and student groups to act in such a way as to elucidate the problems and solutions found in the organization studied.

7.3 Methodology

The project had the students of technician courses in trade and technician in Human Resources on Campus Sinop The IFMT, in research drawing developed from September 2016 to January 2017[8]. The method applied can be understood as exploratory descriptive aspects of a quantitative approach, with theoretical support. As data collection instrument was used a roadmap of observation in order to unveil[2] “The teaching activities associated with the extension have increased their knowledge and motivating were to study the subjects?”.

7.4 Results

As expected, there was no response that if enquadrasse in category “irrelevant”. Also there was no response of type “insufficient”, as well as a quantitative analysis of the results showed that the perception of students respondents was divided into 62% full and 38% partially as shown in the figure 7.1. Obvious that the result demand new quantitative research to assess gains in learning.

The results showed that the approach entrepreneurs through the extension can be used as a tool of complementarity between the university pillars, enabling the student to experience real situations. Pires and Quintella (2015) bring that the stimulus to entrepreneurship is also seen as an important strategy for approaching the business sector[8].

7.5 Conclusions

This study contributes to the strengthening of belief in entrepreneurship education and in his power of contribution in the social context. It is inferred that in developing projects of extension, teaching can participate as a strategy of active methodologies providing the approximation of theory and practice.

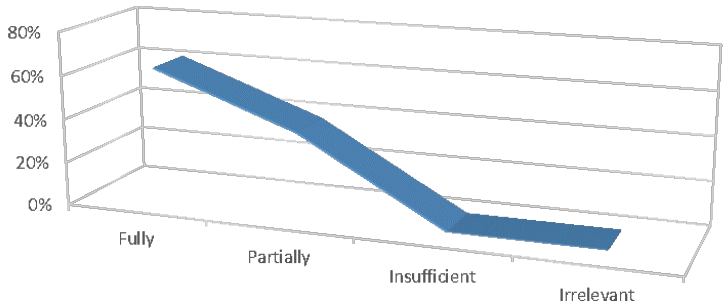


Figure 7.1 – Game teaching and extension.

The results showed that conceptual separation is not a limiting factor, but a tool of complementarity between the university pillars, being a factor of success the integration that allows students to experience real situations.

Bibliography

1. MITRE, S. M. et al. Metodologias ativas de ensino-aprendizagem na formação profissional em saúde: debates atuais. *Ciência & saúde coletiva*, Rio de Janeiro, v. 13, p. 2133-2144, 2008.

2. NEUMANN MARTINS, S. et al. Extended university education propagating entrepreneurship in basic education: report on the project "Entrepreneur for a

day”. *Em Extensao*, Uberlândia, v. 14, n. 2, p. 122-142, 2015.

3. DEMO, Peter. Place of extension. In. FARIA, Doris Santos (Org.). *Conceptual construction of university extension in Latin America.* Brasilia: UnB, 2001.

4. FILION, L. J. Empreendedorismo: empreendedores e proprietários-gerentes de pequenos negócios. *Revista de Administração*, São Paulo, v. 34, p. 45-57, june 1999.

5. DORNELAS, J. C. A. *Empreendedorismo - Transformando Idéias em Negócios.* Rio de Janeiro: Elsevier, 2012.

6. SCHUMPETER, J. A. *The Theory of Economic Development: an investigation of profits, capital, credit, interest rates and the economic cycle.* São Paulo: Nova Cultural, 1988.

7. FINAL Report of the project: Innovative entrepreneurship discourse - Notice 061/2016”. Sinop: Campus Advanced Sinop from the Federal Institute of Education of Mato Grosso, 2017.

8. PIRES, E.A.; QUINTELLA, C. Política de Propriedade Intelectual e Transferência de Tecnologia nas universidades: Uma perspectiva do NIT da Universidade Federal do Recôncavo da Bahia. *Holos*, Natal, v. 6, p. 178-195, oct. 2015.

CHAPTER 8

PBL and Collaborative Learning Applied in The Course of Engineering of Control and Automation: Case Study at CEFET-MG

Erika Tiemi Anabuki[*], Luis Claudio Gambôa Lopes[♦] and Raphael Franzoni Barbosa[▲]

[*]Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: tiemianabuki@gmail.com

♦Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: lcgamboa@gmail.com

▲Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: phaelfranzoni@gmail.com

Abstract: The labor market started to demand from the Engineering professional, in addition to technical skills, transversal competences such as communication skills, teamwork, creativity and innovation to solve problems. To enable learning according to this market demand some of the valid teaching methodologies are Problem-Based Learning (PBL) and Collaborative Learning. In these methodologies, the teaching and learning process should not only involve the teacher-student link, but also all those who are part of the learning group, as well as the processes that can stimulate it. The PBL methodology is based on the student as the center of learning and the teacher as a guide in this process, in which problem situations are used to initiate, direct and motivate the learning of contents and the development of students' skills and competences in the classroom context. In this context, the present work aims to present an analysis and description of the application of PBL and Collaborative Learning methods in the course of Engineering of Control and Automation

at CEFET-MG. In this work, we also evaluate how efficient and motivating the methods are to achieve the objectives that they are proposed, based on the testimonies of students and teachers who participated in the process of application of the above-mentioned methods. The application of PBL and Collaborative Learning involved the disciplines of Digital Systems, Microcontrollers and Control I, so that the teachers who teach these subjects offered for the students problems and projects during the semester. Teachers, especially of the three disciplines mentioned above, were available for guidance and facilitation of the students' learning process. At the end of the semester, each student group presented the solution of the problems that were assigned, and the teachers of the subjects were the evaluators of the learning process. The evaluation was based on the Processual Type, where the evidences of skills and competences developed by the students in the teaching and learning process with application of the problems are observed and analyzed. Regarding the final average of the subjects' grades, there was an increase of approximately 10% in the overall average of students in the three disciplines that applied the method, compared to the previous semesters. In addition to the increase in the average grades of students, there was a greater homogeneity of grades, indicating a greater isonomy in the process of learning and developing students' competences. At the end of the semester, questionnaires were used where the students were able to present their opinions and impressions regarding the

innovative methodologies used, as well as the teachers' performance. Also, the teachers answered a questionnaire where they exposed their impressions, difficulties and experiences regarding these methodologies. Based on the analyzes carried out in this work, through the reports and experiences of teachers in some disciplines of the course of Engineering of Control and Automation at CEFET-MG that applied the methods, it is possible to observe that the PBL and Collaborative Learning methods can be applied in an integral way in the Engineering Course.

Keywords: Collaborative Learning, Education, Engineering, PBL.

8.1 Background

To reconcile the growing volume of knowledge and information with the need to work skills and competences required by the 21st century, such as independent, active and continuous learning ability, teamwork, respect and ethics, some of the valid teaching methodologies are Problem-Based Learning (PBL) and Collaborative Learning[1,2]. In these methodologies, the teaching and learning process should not only involve the teacher-student link, but also all those who are part of the learning group, as well as the processes that can stimulate it. The PBL methodology is based on the student as the center of learning and the teacher as a guide in this process, in which problem situations are used to initiate, direct and motivate the learning of contents and the development of students' skills and competences in the classroom context.

8.2 Purpose

The present work aims to present an analysis and report of the application of the PBL and Collaborative Learning methods in the course of Control Engineering and Automation of the CEFETMG. They also evaluate how effective and motivating methods are to achieve the goals they are proposing, based on testimonials from students and teachers who participated in the process of applying the above-mentioned methods.

8.3 Design/Method

The application of PBL and Collaborative Learning involved the disciplines of Digital Systems, Microcontrollers and Control I, so that the teachers who teach these subjects offered for the students problems and projects during the semester. Teachers, especially of the three disciplines mentioned above, were available for guidance and facilitation of the students' learning process.

The students were divided into groups of up to four students, where they presented different problems/projects during the semester, most of them requiring the development of skills and competences of the three disciplines simultaneously, but for those problems/projects that specifically demanded knowledge worked in a given discipline, the teacher responsible for the same led the development of the problem/project with more caution in comparison with the others. The division of the student groups was based on a questionnaire that analyzed the previous knowledge of each student about the tools and technologies to be used, familiarity with some themes and contents of the subjects and professional experience. In this sense, groups of students with different knowledge and experiences were created, so that they could carry out the group work in the most realistic way possible, and thus exercise the understanding and empathy of different realities.

The application of the methodologies initially consisted of the presentation of the problems (in class time), followed by a discussion by the groups, where the students analyzed the problems, listed concepts that could help in solving the problem and planned their work strategy. In the following classes the groups presented the results of the bibliographical researches, the concepts to be used and the proposed solutions.

After that, the solutions were presented orally, documented in portfolio, or in the form of computer simulation and/or prototype. From the middle of the academic semester, students were presented with large problems that demanded, besides the specific knowledge of the subject, the integration with the other disciplines of the technological axis. These problems were demands of local and community companies. Teachers, especially of the three disciplines mentioned above, were available for guidance and facilitation of the students' learning process. At the end of the semester, each group presented the solution of the problems that were assigned, and the teachers of the disciplines were the evaluators of the learning process.

The evaluation was based on the Processual type where the evidence of skills and competences developed by the students in the teaching and learning process with application of the problems is observed and analyzed[3]. In this evaluation process, not only the final result was evaluated, but the skills and abilities acquired throughout the learning process of the students. Teachers also had to provide feedback during the semester regarding the students' learning process so that they could reflect and motivate themselves.

Also, at the end of the semester questionnaires were used where the students were able to present their opinions and impressions regarding the innovative methodologies used, as well as the teachers' performance. Also, the teachers answered a questionnaire where they exposed their impressions, difficulties and experiences regarding these methodologies.

8.4 Results and Conclusions

During the course of the semester, the teachers observed a much more relevant engagement of the students than when the traditional method of teaching was applied. In addition to the class schedules of each discipline for group development of the problems, the students consulted the teachers during the tutoring hours (extra-class) to solve doubts regarding theoretical problems and concepts. This was not the case when the traditional method of teaching was used, in which students only looked for teachers in days prior to the assessments. Although teachers report a greater effort to work with the PBL and Collaborative Learning methodology, due to their constant updating in relation to problems and projects, as well as providing a greater load of tutoring schedules, the level of satisfaction with the students' engagement was greater than in relation to the use of the traditional teaching method.

According to the students, they reported in the final questionnaire that the approximation of reality and the contact with the practice, through real problems/projects, bring more motivation and interest to the learning process, and reduce the monotony of theoretical classes, besides to develop skills that will help them not only in academic life, but also in professional life. However, most of these students reported that the effort during the semester was greater than the traditional method, since they had to develop solutions and ideas of the problems/projects throughout the school period and were therefore constantly evaluated, and not just at the end of the process. Students also reported a greater incentive for teamwork and improved interpersonal skills. As the methods require constant discussion groups and themes, it is necessary to maintain a healthy interpersonal relationship with all members of the group, learning to share tasks and organize work. With the discussions and dialogues that took place during the cycle of solving a problem, besides the presentation of ideas and opinions, students' oral communication skills are stimulated, and this is another outstanding skill that the PBL and Collaborative Learning method demands.

Regarding the final average of the subjects' grades, there was an increase of approximately 10% in the overall average of students in the three disciplines that applied the method, compared to the previous semesters. In addition to the increase in the average grades of students, there was a greater homogeneity of grades, indicating a greater isonomy in the process of learning and developing students' competences. Based on the analyzes carried out in this work, through the reports and experiences of teachers in some disciplines of the course of Engineering of Control and Automation at CEFET-MG that applied the methods, it is possible to observe that the PBL and Collaborative Learning methods can be applied in an integral way in the Engineering course. It is important to emphasize, however, that for the proper functioning of the PBL and

Collaborative Learning methods these are directly related to the preparation and commitment of the whole school community, such as teachers, students and management, so that innovation is always present aiming at the increase of student motivation and consequently learning. In this context, it is aimed at reducing school dropout, since with the application of innovative teaching methods the student feels more encouraged and motivated to continue his studies.

Bibliography

1. BEHRENS, M. A.; JOSE, E. M. A. Aprendizagem por projetos e os contratos didáticos. *Revista Diálogo Educacional*, Curitiba, v. 2, n. 3, p. 77-96, 2001.

2. TORRES, P. L.; IRALA, E. A. F. *Aprendizagem colaborativa: teoria e prática.* Curitiba: Coleção Agrinho, 2014.

3. HOFFMAN, J. *Avaliação Mediadora; Uma Pratica da Construção da Pré-escola a Universidade.* Porto Alegre: Mediação, 2000.

CHAPTER 9

Outcomes and Teaching Methodologies in Engineering, Food Sciences and Environmental Sciences Courses After Capacitation in Vocational Education Training

Erika Tiemi Anabuki[*]

[*]Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: tiemianabuki@gmail.com

Alexandre F. D'Andrea[♦]

[♦]Instituto Federal da Paraíba, João Pessoa, Brazil

E-mail: alexdandrea@gmail.com

Leonardo Emanuel de Oliveira Costa[▲]

[▲]Instituto Federal do Rio de Janeiro, Rio de Janeiro, Brazil

E-mail: leonardo.costa@ifrj.edu.br

Miguel da Guia Albuquerque[▼]

[▼]Instituto Federal do Rio Grande do Sul, Rio Grande do Sul, Brazil

E-mail: migueldaguia@gmail.com

Vicente de Paulo F. M. Sobrinho[○]

[○]Instituto Federal do Espírito Santo, Vitória, Brazil. E-mail: vicente@ifes.edu.br

Abstract: The present article aims to describe the main outcomes and methodologies used by the LiFe Team (Learning is Fun Educational Team) composed of five teachers from different Federal Institutes in Brazil after qualification under the Vocational Education Training (VET - Teacher for the Future III) Program at the Häme University of Applied Sciences (HAMK), in Hämeenlinna, Finland. The development work of the LiFe Team consisted of motivating actions

involving student-centered and project-based learning (PBL), and the use of active learning tools as well. After a 3 month training period (from April/2016 to June/2016) at the Häme University of Applied Sciences (HAMK), in Finland, empowering in Vocational Education Training (VET), the teachers members of LiFe came back to Brazil to put in practice the plan for a better learning environment and competences acquisition process. Workshops and activities were implemented in several Federal Institute campi, located in five states in Brazil: Espírito Santo, Minas Gerais, Paraíba, Rio de Janeiro and Rio Grande do Sul. Among the actions developed, there are the restructuring of vocational education courses, workshop development involving gamification and PBL, the training of teachers through the immersion in the Finnish educational system and the PBL and gamification application in Environmental Sciences, Food Sciences, and Engineering Courses. In only 6 months after coming back to Brazil, the teachers who received training under the VET program developed and performed workshops, collaborative works, multiplying activities and other innovating techniques, some of them experimented for the first time in classroom, especially in Engineering, Food Sciences and Environmental Sciences courses. The VET program contributed to teacher innovation in the classroom by applying student centered learning and active teaching methodologies, such as the PBL methodology, origami and digital tools. Regarding the execution of the learning in the teachers' institutes, there was research and

solution of problems in the classroom, with the development of numerous products and innovative solutions by the students, in addition to increasing their motivation and consequently decreases of school dropout. The multiplying actions developed have contributed to improve the quality of vocational education in Brazil, but also have represented the hope for small but significant changes in the vocational teaching approach, for better.

Keywords: Engineering, Environmental Sciences, Food Sciences, Vocational Educational Training.

9.1 Background

The starting point of the development work was the willing of coaching the students in the classroom using tools of active learning and Project-Based Learning- PBL[1,2], and the common area of teaching and research, which is Engineering, Food Sciences and Environmental Sciences. The idea of the development work is to propose a set of activities, which are based on the multidisciplinary and interdisciplinary approach and focused on PBL[3]. As in the development work group there is an expert in gamification, the other members immediately agreed to put this concept in the center of the process, together with methods of student centered learning in practical activities outside the classroom[4]. The common goals of our development work were to use active learning tools to encourage students to discover new opportunities of learning and to develop competencies for long-life learning. In this sense, the teacher's role is to know how to explore the educational potential offered by the technological resources.

9.2 Purpose

The present article aims to describe the main outcomes and methodologies used by the LiFe Team (Learning is Fun Educational Team) composed of five teachers from different Federal Institutes in Brazil after qualification under the Vocational Education Training (VET - Teacher for the Future III) Program at the Häme University of Applied Sciences (HAMK), in Hämeenlinna, Finland.

9.3 Design/Method

The name "Learning is Fun Education Team" (LiFe) was chosen to represent our aims and hopes in the implementation of our joint project after the period the teachers have experienced at Finland. This LiFe also represents the willing of transforming for better the educational system in Brazil, a huge country full of natural resources wealth and motivated people, although in need of self-esteem improvement and better outcomes in the Educational field as a whole. Below we will briefly describe the main actions carried out by teachers in the group.

In the IFPB, teacher Alexandre D'Andrea has improved student-centered approach using some digital tools in classrooms, especially Facebook private professional groups created for each one of his disciplines. In these learning environments, tasks were given to the students and assignment deadlines were also made available. This was also an opportunity to receive feedback from students and to begin new topic discussions based on student's doubts and questions. Also, Alexandre has proposed to Electrical Engineering students the challenge to build together a plan for a pedagogical orienteering run, to be developed at the National Forest of Restinga of Cabedelo, in the metropolitan Region of João Pessoa, and managed by Chico Mendes Institute for Biodiversity Conservation. Finally, for the target of multiplying actions Alexandre has been invited by the Secretary of Education of the state of Paraíba to coordinate a group of public state teachers, and to help building a capacitation program together with HAMK (Gira Mundo Finland).

In CEFET-MG, the development work of teacher Erika Tiemi consisted in several workshops where the experiences and learnings of the Teachers for the Future Program were shared with colleagues and students. Learning acquired in Finland is being used in the classroom, so Erika has been able to involve her colleagues. This is noticeably measured as the other teachers are changing their method of approach in the classroom. In the classroom, some practices have been changed in order to apply real phenomena so that the student can be brought closer to the real world (no longer learning based only on content). The idea is to be awakening in the students a potential for the development of their skills. In this sense, the use of digital tools, such as Engineering-specific software, to motivate and facilitate learning has been increasingly constants. To stimulate interest in learning and using renewable energies, for example, a real system for capturing solar energy has been used in class. The result of this process has demonstrated that the performance of the students has improved significantly, showing that the PBL and the application of real phenomena are quite effective in the learning process.

In IFRJ, the actions of Leonardo Emanuel consisted in several actions distributed in some activities. During the microbiology classes, some adaptations were made based on the concepts of PBL and gamification. One of the first activities was that the students made a semicircle in the room. On the floor was the students' disposition a set of cards with beautiful drawings. In the activity, students had to choose a card, and after everyone had chosen their cards, they had to introduce themselves. These students have been studying together for two years around the class, in this sense some of them did not know each other. After a presentation, the students responded to a Google form, which was intended to collect information about the student's background and some of their prior knowledge. Also, a small workshop (Educational games - new ideas on how to create empowerment for learning) was held. During the 2016 Olympic Games of Rio de Janeiro, Leonardo participated in the Finland House with other VET teachers, sharing the experience in VET program with the audience of the House of Finland. He is also responsible for the training course “PBL and gamification” for teachers in the state of Rio de Janeiro.

In IFRS, the development work of teacher Miguel Albuquerque consisted in several actions distributed in the Vocational Course of Geoprocessing and in the course of technology in Building Construction. Initially, the students were interviewed. This process was important so that each student could be known, their expectations and interest in the discipline, course and world of work. After this stage, the students were divided into working groups. Each group was formed based on each student’s skills/abilities. Each month, a set of activities was carried out aiming to bring the student closer to the labor market, giving greater autonomy in the learning process and providing the elaboration of a thought focused on entrepreneurship and the development of new technologies. This set of activities aimed to provide students with an immersion in classroom practices and a contact with technological tools not very common in their daily activities (tools like Zoobe, Tellagami, Thinglink, Pearltrees, among others). In the IFES the development work of teacher Vicente Marques consisted in several actions distributed in lectures, workshops and activities in the classroom. Vicente shared with the staff of the Reference Center in Training and Distance Education (Cefor) of IFES and Seminars in Research on Education in Science and Mathematics his life experiences in the VET III program. This subject is part of the EDUCIMAT course (Postgraduate Certificate in Education in Science and Mathematics) of IFES. In the classroom he aimed to motivate the student to perform a collaborative work always with continuous improvement.

9.4 Results and Conclusions

The VET program contributed to teacher innovation in the classroom by applying student centered learning and active teaching methodologies, such as the PBL methodology, gamification and digital tools. Regarding the execution of the learning in the teachers' institutes, there was research and solution of problems in the classroom, with the development of numerous products and innovative solutions by the students, in addition to increasing their motivation and consequently decreases of school dropout. The multiplying actions developed have contributed to improve the quality of vocational education in Brazil, but also have represented the hope for small but significant changes in the vocational teaching approach for better.

Bibliography

1. JOHANSSON, M. et al. How to desing for meaningful learning – Finding the balance between learning and game components. In: Proceedings of the 8th European Conference on Games Based Learning (ECGLB 2014); Academic Conferences Limited, v. 1, p. 216-222, 2014.

2. LUCARDIE, D. The Impact of Fun and Enjoyment on Adult's Learning. *Procedia - Social and Behavioral Sciences*, v. 142, p. 439-446, 2014.

3. BIEMANS, H. Competence-based VET in the Netherlands background and pitfalls. *Journal of Vocational Education and Training*, v. 56, n. 4, p. 523–538, 2004.

4. BERGSMANN, E. et al. Evaluation of competence-based teaching in higher education: from theory to practice. *Evaluation and program Planning*, v. 52, p. 1-9, 2015.

CHAPTER 10

Electrical Engineering Graduates and Extension Projects: A White Cane Collaborative Development Case Study

Amilton da Costa Lamas[*] and Anderson Gomes Domingues[♦]

[*]Faculdade de Engenharia Elétrica,

Pontifícia Universidade Católica de Campinas, Campinas, Brazil

E-mail: amilton@puc-campinas.edu.br

[♦]Faculdade de Engenharia Elétrica,

Pontifícia Universidade Católica de Campinas, Campinas, Brazil

E-mail: dersongd@gmail.com

Abstract: Engineering graduates are entering a world where the scale of professional challenges is enormous. To be competitive and take the role of leadership in the future, the students need to understand their ethical and professional responsibilities towards the well-being of the communities and the nation itself. The engineers of 2020 are supposed to, among other competences, be capable of being persuasive in multiple social contexts, to be fluent in working with different kinds of intellectual and social capitals, and to have a high level of cognitive flexibility. All these demands are scarcely addressed by the majority of undergraduate Engineering schools. This scenario motivated us to develop a non-classical academic experience where not only the technical aspects are deeply addressed, but new opportunities to improve creativity of the Engineering graduate emerges. The purpose of this paper is to report on a pedagogical strategy adopted by the Faculdade de Engenharia Elétrica at PUC-Campinas, where activities on extension projects are simultaneously conducted along with the regularly schedule classes as a way to better prepare the students. The study case is related to the knowledge and information sharing between students and laypeople (social technicians) dealing with the visually impaired. The method applied in this experience relies on the contribution of

both sides to build a common innovative knowledge while applying a novel Information Appropriation Method (IAM). The participatory method, applied during conversation rounds, is based on a virtuous cyclic process which includes steps like information capture, validation, guidance and feedback. In the present case, the technicians were led to reinterpret, adapt and reinvent technology while contributing to the design and build of a low cost adaptive electronic sensing aid attachable to a white cane. The Engineering students, on the other hand, have the opportunity to develop their communication, analysis and interpretation skills in a way not available in the classroom. They also experience solving conflict situations and find creative uses and applications for they knowledge not otherwise foreseen. This method was applied with success in two local partner institutions, the Sociedade Campinas de Atendimento ao Deficiente Visual (PRÓ-VISÃO) and the Centro Cultural Louis Braille de Campinas (CCLBC), when proof of concepts of electronic white canes where collaboratively designed, developed and tested. Through this experience the Engineering graduates emerged with a greater sense of responsibility with the society and a better understanding of what means to be an engineer. Participation in the Extension Project also brought up several opportunities of professional recognition by the technicians and the visual impaired themselves, which stimulated the students do achieve better performance in the course. The collaborative process allows the discovery of creativity skills and the recognition that laypeople can contribute to find a better technical solution for a given problem. From the case described it is possible to conclude that participating in extension projects while attending regular classes of Electrical Engineering may better prepare the students to face the challenges of the professional world and improve their performance during course attendance.

Keywords: Collaborative Education, Electrical Engineering, Extension Projects, Visually Impaired.

10.1 Background

Engineering graduates are entering a world where the scale of professional challenges is enormous and our classical educational system does not address this issue by focusing in preparing students to outperform in exams and assessments[1]. To be competitive and take the role of leadership in the future, the students must have a strong technical background and simultaneously understand their ethical and professional responsibilities towards the well-being of the communities and the nation itself. Many authors[2-4] agree that the engineers of 2020 are supposed to be persuasive in multiple social contexts, to be fluent in working with different kinds of intellectual and social capitals, and to have a high level of cognitive flexibility. All these demands are scarcely addressed by the majority of undergraduate Engineering schools. The academic world needs to foster higher education students able to develop collaborative solutions and capable of appropriating knowledge from different sources. Major industries stated the need for engineers with deep knowledge and expertise in their discipline, combined with a broad extent of cross disciplinary knowledge having an understanding of human as well as social aspects of Engineering, communication, and being able to pursue coplanning, and cocreation in collaborative problem solving. Collaborative problem solving is "the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve (or work in) a problem by sharing the understanding and effort required to coma to a solution and pooling their knowledge, skills and efforts to reach that solution"[5]. Collaborative problem solving engage individuals in cognitive processing to understand and solve problem situations where a process of solution is not immediately obvious. It is essentially a social collaborative process where is important to establish a joint understanding of the problem and then devise a way to the solution, through processes of interthinking and argumentation.

10.2 Purpose/Hypothesis

The above scenario motivated the development of a non-classical academic experience where not only the technical aspects are deeply addressed, but new opportunities to improve creativity of the electrical Engineering graduate emerges. The purpose of this paper is to report on a pedagogical strategy adopted by the Department of Electrical Engineering at PUC-Campinas, where activities on extension projects are simultaneously conducted along with the regularly schedule classes as a way to better prepare the students for the market. The study case is related to the knowledge and information exchange between electrical Engineering students and laypeople (social technicians) dealing with the visually impaired. The goal is to cocriate an inexpensive and versatile technological white cane capable to detect obstacles above floor level, therefore promoting safe independent mobility.

10.3 Design/Method

The collaborative method applied in this case study makes use of informal conversation rounds, carried out during the execution of a virtuous dialogical cycle. The cycling process, named Information Appropriation Method (IAM), includes steps like information capture, validation, guidance and feedback. In the present case, the technicians were led to reinterpret, adapt and reinvent technology while contributing to the design and build a proof of concept of a low cost adaptive electronic sensing aid attachable to a white cane. The electrical Engineering students, on the other hand, have the opportunity to develop their communication, analysis and interpretation skills in a way not available in the classroom. They also experience solving conflict situations and find creative uses and applications for they knowledge not otherwise foreseen. A detailed description of this model can be found in[6].

10.4 Results

This case study resulted on the cocreation, involving electrical Engineering students and social technicians, of a technological white cane. Figures 10.1, below, shows a detail of the electronic controller and social technician experimenting the proof of concept during an informal gathering, respectively. During the execution of the method electrical Engineering students were able to develop communication skills and promote their ability to work with anyone, anywhere. The participating students also transformed information into knowledge through a dialogical experience with people having a contrasting technological background to its own.

Participation on the project allowed the students to gain hands-on field experience in a challenge driven environment where they face problems for

(a) (b)

Figure 10.1 – (a) detail of the electronic controller, (b) social technician using the technological white cane.

which there are no established answers.

10.5 Conclusions

The study case reported in this paper demonstrated that the participation of electrical Engineering students on extension projects can develop skills and competencies expected by market for the 21st century. The authors would like to thank the Sociedade Campinas de Atendimento ao Deficiente Visual (PRÓ-VISÃO) and the Centro Cultural Louis Braille de Campinas (CCLBC), for their partnership.

Bibliography

1. Luckin, R. et al. SolvedMaking the case for collaborative problem-solving, *NESTA - National Endowment for Science, Technology and the Arts*, London, mar. 2017. Available in: <http://www.nesta.org.uk/publications/solved-making-case-collaborative-problem-solving>. Accessed in: 31 May 2017.

2. Lueny Morell, Engineering Education in the 21st Century: Roles, Opportunities and Challenges. In: 4TH NEA ICETE, 2010, Taichung. *Proceedings...* Taichung, 2010.

3. Mohd-Yusof, K. et al. Future Directions in Engineering Education: Educating Engineers of the 21st Century. *ASEAN Journal of Engineering Education*, Malaysia, v. 2, p. 8-13, 2015.

4. WORLD Economic Forum. 2016. Global Challenge Insight Report: The future of jobs, employment, skills and workforce strategy for the fourth industrial revolution. Geneva: World Economic Forum. Available in: <http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf>. Accessed in: 31 May 2017.

5. DRAFT Collaborative Problem Solving Framework. Paris: OECD. Avaiable in: <http://www.oecd.org/pisa/pisaproducts/DraftPISA2015.Collaborative- ProblemSolvingFramework.pdf>. Accessed in: 31 May 2017.

6. Lamas, A. Método Cíclico de Apropriação de Conhecimento – Uma aplicação na Comunidade de Deficientes Visuais. In: II CONGRESSO INTERNACIONAL

DE CRIATIVIDADE E INOVAÇÃO. *Proceedings...* Campinas, june 2017.

CHAPTER 11

The Importance of Internationalization on Engineering Programs from Minas Gerais Universities: UEMG's Case

Filipe Mattos Gonçalves[*], Aline da Luz Pascoal[♦], Júnia Soares Alexandrino[▲] and Telma Ellen Drumond Ferreira[▼]

[*]Departamento de Recursos Naturais, Ciências e Tecnologia Ambientais, Faculdade de Engenharia, Universidade Estadual de Minas Gerais, João Monlevade, Brazil

E-mail: filipemattosg@hotmail.com

♦Departamento de Recursos Naturais, Ciências e Tecnologia Ambientais,
Faculdade de Engenharia,
Universidade Estadual de Minas Gerais, João Monlevade, Brazil

E-mail: alineluzpascoal@gmail.com

▲Departamento de Recursos Naturais, Ciências e Tecnologia Ambientais,
Faculdade de Engenharia,
Universidade Estadual de Minas Gerais, João Monlevade, Brazil

E-mail: juniaalexandrino@yahoo.com.br

▼Departamento de Recursos Naturais, Ciências e Tecnologia Ambientais,
Faculdade de Engenharia,
Universidade Estadual de Minas Gerais, João Monlevade, Brazil

E-mail: telmaellen@hotmail.com

Abstract: Gradually instigated by cultural, economic and social transformations generated due to globalization, especially with regard to Engineering, both universities and students are looking for new forms of teaching and learning. Concomitantly, as institutions and the labor market increasingly aspire skilled professionals, this search seems to be directed outside the country

where there is greater availability of technology and new qualifications, as well as the possibility of proficiency in another language. In this way, the implementation of academic mobility programs such as Science without Borders (CsF), have great importance for the internationalization of Engineering Courses in Brazil's universities. Through this exchange, undergraduates have the opportunity to train and study abroad in order to maintain contact with competitive education systems in relation to technology and innovation, bringing back such knowledge to universities and to the nation as a whole. In this sense, this work aims to measure and emphasize the importance of this program for Minas Gerais universities, with focus on the performance evaluation of the Universidade do Estado de Minas Gerais (UEMG) Engineering campus, based in João Monlevade city. With the help of the CsF Portal and support of the UEMG International Relations Advisory, it was possible to collect general data about the program and find the number of students which were contemplated with scholarships in the four Engineering Courses of UEMG from 2011 to 2016. In addition, a questionnaire was applied to students who have already participated in this exchange for a qualitative effect. The results showed that Engineering was the most requested area and that Minas Gerais universities presented great potential in the number of scholarships contemplated by the program. In a closer evaluation of the UEMG, it was observed that there is a disparity between the Engineering Courses regarding the number of scholarship students, highlighting the Mining Engineering Course in detriment of the others. However, it should be noted that this program was very important since it has allowed students to acquire more knowledge in specific subjects of their courses, improve another language, experience new cultures as well as learn new methodologies of teaching and assessment, such techniques that they can bring into their Engineering programs in Brazil.

Keywords: Science without Borders, Education, Engineering, Internationalization, UEMG.

11.1 Introduction

Globalization brings with it a new perception of the world, supported by social, cultural, technological and even educational advances. Brazil has experienced the strength of this progress in the last decade and how it has contributed to the creation of an important and challenging scenario, putting the nation in evidence in the world[1]. These changes directly affect the Higher Education Institutions (IES), the main suppliers of skilled professionals for the country.

In view of this, it was observed the need for the internationalization of higher education in Brazil, mainly in science, Engineering and its technologies. According to Aveiro (2014), the process of internationalization of higher education, which encompasses undergraduate and postgraduate studies, is extremely important to guarantee the excellence of universities and generate development of the country[2]. Thus, signing agreements with foreign universities is fundamental to the interaction and integration among students, teachers and researchers around the world.

In this sense, the Science without Borders (CsF) program, created through Decree 7,642/2011, was created to promote students mobility by offering academic and scientific exchange in renowned international universities, placing Brazilian students in the face of innovation, competitiveness and entrepreneurship from developed countries[3]. Considering the current changes due to this globalization in higher education, this research aims to show the important role that student mobility programs have in the internationalization process of Engineering programs from Minas Gerais universities, analyzing more closely the UEMG Engineering campus, located in João Monlevade.

11.2 Methodology

The analysis of this article was made in a descriptive and exploratory way. First, this research deals with the fundamental process of internationalization on higher education in Brazil. Subsequently, with the purpose of evaluating the performance of the Engineering campus of João Monlevade, data were collected with the support of the International Relations Advisory on the number of students enrolled in the sandwich graduation mode by the CsF program in the four Engineering courses present at UEMG (Civil, Environmental, Metallurgical and Mining) from 2011 until the beginning of 2016.

Then, an open questionnaire was applied to UEMG students who have already participated in the CsF for qualitative evaluation of the program. Each student was asked about the main strengths of the program and how they affected their post-program career.

11.3 Result Analysis

Figure 11.1 below shows the distribution of scholarships per course for UEMG campus João Monlevade. From the chart it can be observed that the number of scholarships awarded between the four Engineering courses is not equivalent, especially the Mining Engineering course with almost 48% of the total. Such disparity indicates a differentiation in the courses policies, especially with regard to the professor's encouragement in apply the program, greater preparation of students to meet the excellence requirements and learning English.

Although the total number of students participating in the CsF program is considered low, it is important to emphasize the fundamental role of this

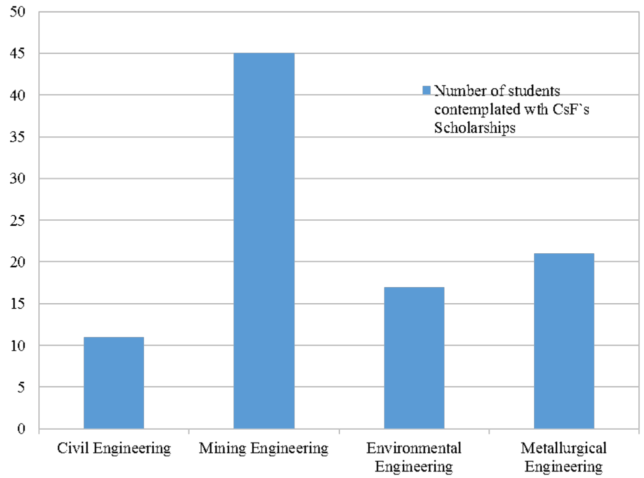


Figure 11.1 – Number of students participating in the CsF program according to each Engineering course.

exchange for UEMG. Such mobility has brought benefits to the study programs in which these students are inserted, allowing a favorable environment for experiences exchange and maturation of Engineering programs of João Monlevade campus. A concrete fact that shows this is the increase in the number of international bibliographies used in academic papers, more articles accepted in international journals and the creation of extension projects aimed at the English education.

The questionnaire applied to the CsF ex-participants helped to identify the program's key qualitative points for the student and professional career of the future engineers. Among the most cited points are the acquisitions of proficiency in another language, new knowledge in specific subjects of the course, possibility of internship and or research, experiencing new cultures and places, increased networking and employment opportunity in Brazil. Such contributions are essential for the training and professional qualification of Engineering undergraduates.

11.4 Conclusions

Mobility programs are very important for the personal and professional growth of students, given the possibility of contact with new cultures and innovative technological centers.

The potential of these programs goes beyond strengthening ties with international universities, they enable the transformation and improvement of Engineering programs in Brazil due to all the experience that these alumni can bring into their courses, especially with regard to Scientific research, new specific knowledge and assessment methodologies.

Bibliography

1. SILVA, Richéle T. P. Política de incentivo a formação de pesquisadores: reflexões sobre o programa Ciência sem Fronteiras. In: IX ANPED-SUL - A PÓS-

GRADUAÇÃO E SUAS INTERLOCUÇÕES COM A EDUCAÇÃO BÁSICA, 2012, Caxias do Sul. *Proceedings...* Caxias do Sul: Universidade de Caxias do Sul, 2012.

2. AVEIRO, T. M. M. O Programa Ciência sem Fronteiras como Ferramenta de Acesso à Mobilidade Internacional. *Revista de Educação, Ciência e Tecnologia*, Canoas, v. 3, n. 2, p. 1-21, 2014.

3. BRASIL. Decreto nº 7.642, de 13 de dezembro de 2011. Institui o Programa Ciência sem Fronteiras. Brasília. *Diário Oficial da União*, Brasília, 14 dec. 2011.

CHAPTER 12

LIBRE-LIBRAS: A Tool with a "Free-Hands" Approach to Assist LIBRAS Translation and Learning

Evandro Terra Gonçalves[*], Renata Monteiro de Oliveira[♦], Rubens Jesse Catharino Deknes Gonçalves[▲],
Sidney Roberto de Sousa[▼] and Michel Estadulho[○]

[*]Instituto Federal de Educação,
Ciência e Tecnologia de Mato Grosso do Sul, Aquidauana, Brazil

E-mail: evandro18.goncalves@gmail.com

♦Instituto Federal de Educação,
Ciência e Tecnologia de Mato Grosso do Sul, Aquidauana, Brazil
E-mail: r.oliveira.ro398@gmail.com

▲Instituto Federal de Educação,
Ciência e Tecnologia de Mato Grosso do Sul, Aquidauana, Brazil
E-mail: rubensjesse26@gmail.com

▼Instituto Federal de Educação,
Ciência e Tecnologia de Mato Grosso do Sul, Aquidauana, Brazil
E-mail: sidney.sousa@ifms.edu.br

○Instituto Federal de Educação,
Ciência e Tecnologia de Mato Grosso do Sul, Aquidauana, Brazil
E-mail: michel.estadulho@ifms.edu.br

Abstract: The Brazilian Signals Language (LIBRAS) is officially recognized as first language (L1) to the Brazilian deaf community. Since its officialization, its teaching is granted by law at public and private institutions. Just like is done in any other discipline, LIBRAS teaching needs specific courseware, as well as tools to assist teachers and students at classroom. We believe that the use of tools for aiding the correct LIBRAS signaling, considering correct hands config-

uration in each signal, is intended to potentialize the good LIBRAS learning at classes. Thus, this work presents LIBRE-LIBRAS, a web application software to aid simultaneous translation and verification of LIBRAS phrases, using Leap Motion sensor to capture signals from gestures provided by the student with his free hands. The software has a module for capturing and storing signals provided by a professional interpreter of LIBRAS. This module was developed using the MEAN stack, a set of technologies (MongoDB, Express, AngularJS, and Node.js) based on JavaScript language that, together, help to leverage web development process. A signals database was created using MongoDB, where such signals are acquired from the interpreter with help of Leap Motion sensor and a web page developed with AngularJS. To send the acquired signals to the signals database, were developed RESTful web services, using Express and Node.js. It was also developed a module to query signals from the student into the signals database. This module uses the Euclidean distances between each hand palm and the fingertips, in addition to the Euclidean distances between the fingertips, to provide a signal descriptor that can be compared to signals stored into the database. We have already developed modules for storing and querying LIBRAS signals. Now, we are working in modules to provide signaling lessons and translation assistance of words and phrases in LIBRAS. To provide a better experience for the student while using LIBRE-LIBRAS, it was developed a 3D hands model that mirrors the student's hands movements, so the student can see his signals or imitate the movements proposed by LIBRE-LIBRAS lessons. LIBRE-LIBRAS development is still in course. Tests on the signals queries confidence are being performed to refine our querying module. Furthermore, we intend to perform tests with LIBRE-LIBRAS at the LIBRAS classes from our institution, in order to get a good LIBRAS teaching tool that helps and encourages students in this discipline.

Keywords: LIBRAS, Computer Aided Translation, Leap Motion Sensor, Languages Teaching, Courseware Tools.

12.1 Background

For a very long time, parents and teachers of Brazilian deaf kids were concerned about making them speak. Only in the end of 1950s, LIBRAS was faced as an adequate way of expression by deaf people[1].

LIBRAS is a space visual language, expressed through gestures and body expressions. Indeed, it is a language so complex as any other[2]. Thus, teaching LIBRAS becomes as complex as teaching Portuguese to initial grades, or even teaching English to Brazilian to infant or teenagers.

So, at the same way that teachers of these two last languages need specific courseware and tools to assist them at their classes, LIBRAS teachers and interpreters also need such resources. However, maybe more complex than teaching LIBRAS to a deaf individual is to train a future LIBRAS teacher that, in its turn, will have to teach this language to other people – including deaf people.

12.2 Purpose/Hypothesis

We believe that the use of tools for aiding correct LIBRAS signalling, considering correct hands configuration at each signal, is intended to potentialize the good LIBRAS learning at classes. Thus, this work presents LIBRE-LIBRAS, a web application software to aid simultaneous translation and verification of LIBRAS terms, using Leap Motion sensor to capture signals from gestures provided by the student with his free hands.

12.3 Design/Method

LIBRE-LIBRAS can be divided in two modules. The first module is responsible for capturing terms signalized by LIBRAS professional interpreters to populate the signals database. For this, the module uses Leap Motion sensor to capture the terms gestures from the interpreter's hands.

A web page was built using AngularJS to provide an interface for capturing the signals from the interpreter and transform such signals in a data model composed by two vectors. The first vector contains the distances from each one of the 5 fingertips to the center of the hand's palm and the distances between each fingertip, not considering thumb. This totalizes 8 distances for one hand signals and 16 distances for two hands signals. Finally, the second vector contains the values of pitch, roll, and yaw angles from the hand, thus totalizing 3 angles for one hand signals and 6 angles for two hand signals.

After the term signal is captured, its data model is sent to the database server, which is served by a RESTful API implemented with Express.js, running over Node.js. Finally, the signal data is stored at a MongoDB database. We decided to use MEAN stack (MongoDB, Express.js, AngularJS, and Node.js) due to its easiness of learning, expressiveness of code, and the fact that all the four technologies use a single programming language – JavaScript.

The second and last module is responsible to compare a gesture from the LIBRAS student to signals stored at the signals database. We borrowed Naidu and Ghotkar approach[3], originally used at Indian Sign Language (ISL), that used Euclidean distance and cosine similarity functions to compare the user's gestures to signals. The signal's data model used in this work is similar to the one used by Naidu and Ghotkar, but in this last work the author did not consider the hands angles.

12.4 Results

We have performed tests over a database with 40 static LIBRAS terms signals, where a static term is a term which signal does not have a hand translation movement during its signalization. In our signaling tests with professional LIBRAS interpreters, 79.88% of the terms stored are correctly recognized. Figure 12.1 shows LIBRE-LIBRAS translation page, which presents a three-dimensional model of the user's hands, in addition to the term corresponding to the user's signalling, when correct.

Figure 12.1 – LIBRE-LIBRAS translation page.

12.5 Conclusions

Now, we intend to refine the signals comparison method to increase its accuracy. Furthermore, we intend to develop an approach to store and compare dynamic terms signals and, so, publish a more robust version of LIBRE-LIBRAS for online use on the web for free. Finally, we aim to create a branch of LIBRE-LIBRAS project, which will substitute use of Leap Motion sensor to capture the user's gestures by the use of webcam associated to computer vision techniques.

Bibliography

1. SOUSA, M.; PORROROZI. R. Ensino de LIBRAS para os profissionais da saúde: uma necessidade premente. *Revista Práxis*, Volta Redonda, n. 2, p. 43-46, 2009.

2. SACKS, O. *Vendo vozes: uma viagem ao mundo dos surdos.* São Paulo: Companhia das Letras, 1998.

3. NAIDU, C.; GHOTKAR, A. Hand Gesture Recognition Using Leap Motion Controlle, *International Journal of Science and Research*, Chhattisgarh , v. 5, n. 10, p. 436-441, oct. 2016.

CHAPTER 13

Interdisciplinarity in Engineering Education: The View of Course Coordinators in Vocational Training

Neron Alípio Cortes Berghauser[*]

[*]Universidade Tecnológica Federal do Paraná, Medianeira, Brazil

E-mail: neron@utfpr.edu.br

Luis Mauricio Resende[▲], Luiz Alberto Pilatti[▼] and Elis Regina Duarte[♦]

[♦]Universidade Tecnológica Federal do Paraná, Ponta Grossa, Brazil

E-mail: lmresende@utfpr.edu.br

▲Universidade Tecnológica Federal do Paraná, Ponta Grossa, Brazil

E-mail: lpilatti@utfpr.edu.br

▼Universidade Tecnológica Federal do Paraná, Ponta Grossa, Brazil

E-mail: draerduarte@gmail.com

Abstract: In the current postmodern scenario, education has experienced difficulties whose proposals for solutions arise in a variety of ways. Among these paths, interdisciplinarity has become a subject present in most schools around the world. In the case of Engineering Education, the problems are not different, and interdisciplinarity has been studied as a possible innovative strategy to increase the results of the teaching and learning process. This article has as main objective to raise the domain perceived by coordinators of courses of a public higher education institution about interdisciplinarity and its role in the formation of the professional. The studied school offers 106 undergraduate courses, including technology and bachelor degrees; 50 of those courses are Engineering that are located in its 13 campus. The proposal to carry out this research is to know the vision that the coordinators of courses of the technological area of the studied institution has on interdisciplinarity and the role that it can represent in the improvement of the professional formation. This research can be classified as applied and exploratory type, with quantitative data treat-

ment. It will be composed of a questionnaire that will be applied electronically to all 76 coordinators of Engineering and technology courses. The main topics defended will be: Interdisciplinarity concepts; How to operationalize it in technological teaching; The importance perceived by the coordinators in the Engineering professional qualification; Investigate if interdisciplinary is being practiced in the courses; And finally, how they think these practices could be implemented at the courses coordinated by them. Data analysis will be done by tabulating the answers to closed questions and interpreting the content in open questions. The expected results of this study are the possibility of inserting the subject "interdisciplinarity" by the coordinators of the courses, as a strategy to improve the teaching and learning process, and as a suggestion to implement these pedagogical practices as a mean to reach a better knowledge appropriation of the student. It is also expected to provide support for the improvement of students' professional skills and their better development for the job market.

Keywords: Technological Teaching, Engineering Teaching, Interdisciplinarity, Innovative Practices in Education, Teaching-Learning Process.

13.1 Background

The Delors Report (1996) describes the fundamental role that education has in promoting the changes needed in a third millennium society. This document defines the four pillars of modern education: learning to know, learning to do, learning to be and learning to live together - an innovative proposal and a challenge of great dimension, which can only be met through long term cultural change[1].

Edgar Morin suggests that the school needs to turn and face future challenges. The writer describes that the changes necessary for humanity to become more just and humane must go through education, which implies demanding serious changes from educators. The author argues that, for the appropriation of knowledge, it is necessary to develop different viewpoints in a multidimensional design effort in order to reduce the blindness of error and illusion[2].

Nan-Zhao defends the need to reorient curricula with learning materials that meet the student's reality, motivating him to seek knowledge and to promote interaction with the teacher, the key figure in this process. Santos and Hammerschmidt claim that interdisciplinarity is a path leading to the reconnection of knowledge, a fundamental condition for learning to take place more fully and profitably[3, 4].

In this sense, understanding interdisciplinarity as a strategy to complement the learning process in the classroom becomes a coherent alternative, since it is a pedagogical proposal that allows one to walk through Morin's ideas while pointing out the path to a complete formation of being human in the future[2].

Ivani Fazenda describes interdisciplinarity as consisting of a new attitude towards the question of knowledge, to understand the phenomena in a complete, open and dynamic form. Japiaussú stresses that it is a complete method that not only includes concepts, but methods, procedures and the organization of research itself[5-8].

This article presents the results of a research carried out with coordinators of Engineering courses at a public university in the State of Paraná on the subject of interdisciplinarity: concepts, importance and interest in practicing. The purpose of the research was to raise awareness within higher-education managers to present an initial setting in the possibility of proposing the establishment of interdisciplinary practices in courses they coordinate.

13.2 Purpose/Hypothesis

The question addressed in this research was: What is the perception of the course coordinators of Engineering and Technology at the Federal Technological University of Paraná (UTFPR) on the subject of interdisciplinarity: concept, importance and presence in the courses they coordinate.

It was hypothesized that there are common aspects in the perceptions of UTFPR Engineering course coordinators on the subject of interdisciplinarity, and that these aspects must be understood in order to discuss proposals for inclusion of interdisciplinary practices in the institution's courses.

13.3 Design/Method

According to Lakatos and Marconi, this research is of the applied type, since it proposes to generate knowledge that can be used to solve any type of problem. It is a quantitative research because the presented results are measurable, having used a computational application to manage the questionnaire, survey and tabulation of the obtained data. The research is also descriptive, defined by Lakatos and Marconi as it seeks to present the characteristics of the phenomenon researched. Gil claims that this type of research describes the phenomenon as it is presented, without, however, interfering in that reality[9, 10].

The data were collected through a questionnaire sent by email to all 86 UTFPR Engineering and technology course coordinators, containing 10 closed questions and one opened, with free text. The answers were presented by means of an agreement scale, ranging from "Strongly Disagree" to "Strongly Agree" with the statement made in the question.

The questionnaire was divided into groups of questions that sought to gather: the knowledge that the coordinators had about interdisciplinarity; the training required for its implementation; the importance of professional training; and the involvement of teachers in discussions on the subject.

13.4 Results

As for the understanding respondents had of interdisciplinarity application, it was identified that the coordinators had a good command in their understanding. However, there is still a group of respondents who have little or no knowledge of the subject, as evidenced by the disagreements to the statements presented in the questions. When questioned in their understanding that there is a need for specific preparation to practice interdisciplinarity in the classroom, respondents agreed with the statement, although almost 40% disagree partially with this opinion.

The fact that most of the coordinators disagreed when asked about the teachers adopting interdisciplinary practices to their respective courses, demonstrates that the subject is little or not discussed and disseminated throughout the institution. The same perception was demonstrated when the respondents answered about the notion that teachers have of the subject matter and also the presence of the subject in meetings of groups that define the structure of each course. This reality shows that there is a great need to plan the insertion of interdisciplinarity as a topic of discussion in the groups that decide the direction of each course.

When asked about the contribution that interdisciplinarity represents to the learning and training of a professional engineer, the majority of respondents partially agreed with the statements, however, it was noted that there were coordinators (about 25%) who totally agreed.

The single free text response question asked the coordinator to describe examples of interdisciplinary practices in their respective courses. It was found that 16% of participants described their experiences of a few teachers using integrative activities combining knowledge from different disciplines within the same or other school periods.

13.5 Conclusions

The research pointed out that the theme is incipient in the institution studied, with precise expression by some teachers. A theme that needs to be better developed in a planned and continuous way.

To meet the new student profile, representative of the technologically advanced generations and the new demands for better trained professionals with multidimensional vision, there is a need for Engineering courses to include more effective proposals. Interdisciplinarity can be a strategy for this to be achieved.

Bibliography

1. DELORS, J. Learning: The Treasure Within. In: REPORT TO UNESCO ON EDUCATION FOR THE 21ST CENTURY-LEARNING: THE TREASURE WITHIN, Paris, 1996. *Report...* Paris: UNESCO, 1996.

2. MORIN, E. *Os sete saberes necessários à educação do futuro.* Brasília, São Paulo: UNESCO/Cortez Editora, 2000.

3. NAN-ZHAO, N. *Four 'Pillars of Learning' for the Reorientation and Reorganization of Curriculum: Reflections and Discussions.* Le Grand-Saconnex: International Bureau of Education-UNESCO, 2005.

4. Costa Santos, S. S.; de Almeida Hammerschmidt, K. S. A complexidade e a religação de saberes interdisciplinares: contribuição do pensamento de Edgar Morin. *Revista Brasileira de Enfermagem*, Brasília, v. 65, n. 4, p. 561-5, 2012.

5. Fazenda, I. C. A. *O que é interdisciplinaridade?* . São Paulo: Cortez, 2008.

6. Fazenda, I. C. A. *Dicionário em construção: interdisciplinaridade.* São Paulo: Cortez, 2001.

7. Fazenda, I. C. A. *Didática e interdisciplinaridade.* Campina: Papirus Editora, 2008.

8. Japiassú, H. *Dicionário básico de filosofia.* Rio de Janeiro: Zahar, 1990.

9. Lakatos, E. M.; Marconi, M. A. *Fundamentos da metodologia científica.* São Paulo: Atlas; 2010.

10. Gil, A. C. *Como elaborar projetos de pesquisa.* São Paulo: Atlas, 2002.

CHAPTER 14

Finite Element Method Use as Educational Appliance of Learning in Electrical Engineering

Vinicius Murilo Lima Rodrigues[*] and Douglas Borges Domingos Figueiredo[♦]

[*]Engenharia Elétrica, Rede de Ensino Doctum, Caratinga, Brazil

E-mail: viniciusmuri@hotmail.com

[♦]Engenharia Elétrica, Rede de Ensino Doctum, Caratinga, Brazil

E-mail: douglasborgesdomingos@gmail.com

Abstract: This paper presents a positive report on the use of the Finite Element

Method (FEM) in Electrical Engineering, particularly in electrical materials discipline, involving the students of the DOCTUM institution in the city of Caratinga, Minas Gerais. FEM is about a mathematical analysis that consists in the fragmentation of a continuous device on smaller elements without altering the characterists of the original device. The elements are described by differential equations, and resolved by mathematical models to obtain the desired results Its feasibility happened only after computer advent, which turned possible the resolution of complex algebraic equations Through the great efficiency and applicability of FEM it was possible to use it in several areas, including biological and exact sciences. In the current economic scenario there is an increasingly demanding labor market searching for the most qualified professionals, showing the need to implementing in Electrical Engineering Course the training of the students about the calculation of static magnetic fields (Magnetostatic), improving the perception of the occurred effects in different types of electrical machines. It's known the difficulties of the students to learning of the content related to the study of the concepts of Electromagnetism used on learning of Electrical Machines. These difficulties are related to the abstract concepts, therefore, there is the need to offer new technological resources so the student can have a plainness about these effects. At first, Maxwell and Poisson equations are presented for the particular case of magnetostatic, after this, the solutions for these equations by the Finite Elements Method. Will be used

the already consolidated FEM programs in this area to simulate the different phenomena that exists in electrical machines, which enables the academic to visualize these phenomena, and a numeric analysis of the effects. The reached results on this study were positive, generating a great impact in the learning of the students, which could be optimized by the simulation implementation.

Keywords: Finite Elements, Electromagnetics, Numerical Methods, Maxwell‘s Equations, Electric Machines.

14.1 Introduction

The model currently employed in most western countries is in a process of exhaustion, we can relate this to the intense changes existing in the job market in an alliance with the continuous emergence of new specialties. The diversification of knowledge, flexibility of teaching models, and the implementation of non-conventional vocational training programs are necessary tools to face the challenges faced in current higher education. In this scenario, the approach of the use of new technologies in education becomes necessary, developing a set of activities with didactic-pedagogical interest[1].

In the discipline of Electrical Machines the student has, at various moments, his understanding of the content compromised as a result of the concepts applied in the discipline to be relatively abstract, due to the physics involved in its study. In order to eliminate this deficiency in teaching, it is essential to develop new resources, stimulating the student's understanding of certain phenomena in the discipline.

In order to better understand the phenomena related to the equations, in this article it is proposed the use of a computational tool to help the teaching of the discipline of Electrical Machines and other associated disciplines, such tools are the following software's: ANSYS Maxwell® e FEMM, that makes use of Finite Elements Method. The experiment was accomplished in Electrical Engineering course of a higher education institute in the city of Caratinga, Minas Gerais.

14.2 The Finite Elements Methods

The Finite Elements Method (FEM) is a tool that allows to resolve differential equations in numerical and approximate form, replacing a differential problem with a similar approximate algebra, which one we know the solution. For this, it is necessary to transform this continuous domain into a discrete domain, where the solution is known at discrete points in the domain of calculation, this subdivision of the geometry into smaller elements, is defined as finite elements[2].

The magnetic field formulation is based on the Maxwell equations beginning with the basic field equations:

$$\nabla x E = -\frac{\partial B}{\partial t}, \tag{14.1}$$

$$\nabla \cdot B = 0 \tag{14.2}$$

and

$$\nabla \cdot H = 0, \tag{14.3}$$

where E is the electric field strength, B is the magnetic flux density, H is the magnetic field strength and J is the electric current density. Equations (14.1), (14.2) and (14.3) are respectively generalization of Faraday's Law, Gauss's Law, and Ampère's Law[3].

14.3 Methodology

With the objective of promoting educational practices of learning and stimulation to students of Electrical Engineering, it was proposed the use of simulation software to provide a better understanding of the contents exposed during the discipline.

In the second semester of 2016, in the discipline of Electric Machines, students were presented to the introductory concepts of the Finite Element

Method. At that time, the FEMM e ANSYS Maxwell® softwares was explained in detail.

At the headquarters of the Doctum Teaching Network in Caratinga, an educational institution in which this research project was carried out, the discipline of Electrical Machines is delivered from five main topics, which are subdivided for theoretical explanation of the content and, later, each of the major topics is amenable to a simulation by the Finite Element Method. The simulations are not carried out individually, but in groups of, on average, five people, where the members of the groups are responsible for performing the simulation, and it is up to the teacher to guide and complement the learning, starting from the initial effort of each group.

14.4 Results

To illustrate the problem solving of electrical machines by FEM, a problem related to the magnetostatic analysis of a three-phase induction motor.

The mesh generation was performed using the ANSYS Maxwell® program. After the problem was solved, the result shown in figure 14.1 was obtained, in which the intensity of the electric field can be seen along the machine.

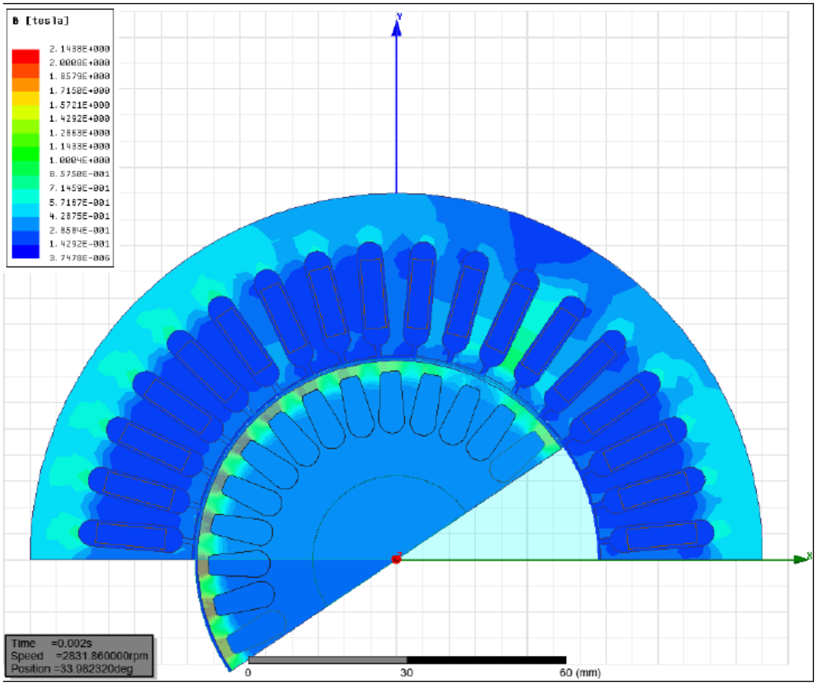


Figure 14.1 – Intensity of the electric field in an asynchronous motor.

14.5 Conclusions

The finite element method is a powerful tool for analyzing problems in electromagnetism. In this article the use of simulation software using FEM and its important function as a tool for studying and allows deepening inside the problems associated to magnetostatic, in Electrical Machines discipline.

Bibliography

1. DE MACEDO, A. R. et al. Educação superior no século XXI e a reforma universitária brasileira.*Ensaio: Avaliação e Políticas Públicas em Educação* , Rio de Janeiro, v. 13, n. 47, p. 127-148, jan. 2005.

2. REDDY, J. N. *An introduction to the Finite Element Method.* Nova York: McGraw-Hill, 1993.

3. HAYT JR, W. H.; BUCK, J. A. Eletromagnetismo. Nova York: McGraw-Hill, 2008.

CHAPTER 15

Improvement of The Digital Systems Laboratory for Computer Engineering

Kollins Gabriel Lima[*] and Maximiliam Luppe[♦]

[*]Departamento de Engenharia Elétrica e de Computação,
Universidade de São Paulo, São Carlos, Brazil

E-mail: kollins.lima@usp.br

[♦]Departamento de Engenharia Elétrica e de Computação,
Universidade de São Paulo, São Carlos, Brazil

E-mail: maxluppe@sc.usp.br

Abstract: The Computer Engineering students, at the Universidade de São Paulo, in São Carlos, have some complaints about the lack of practical classes during the graduation. Also, these classes, they say, are many times limited to reproduce simple results already seen in theory classes, bringing nothing new and making them even more frustrated for not being able to explore new possibilities, functionalities, and that way expand their knowledge. The PBL (Problem-based Learning) can give this challenge to the students and it was chosen to be applied in Digital Systems Laboratory, a 4-semester discipline, trying to fix this problem. The purpose was to use digital logic concepts, already seen in theory, to build basic modules of a processor: combinatory logic, studied through the implementation of an arithmetic logic unit (ALU); sequential logic, through the implementation of the registers and the register bank; and finite state machines, connecting both concepts, making possible to build a control unit. By doing that, the students were instigated to use all the knowledge they already had, once they received only the specification of input and output and were free to implement each module the way they wanted to. Making use of simulators and FPGA boards, they were able to build three main components of a processor and integrate everything in a test platform that was developed to allow them to test their modules in a full processor schematic and

make it work properly. A feedback from the students (through a questionnaire) showed that, although they had some difficulties taking the course, it was motivating and it helped them understand different concepts that are seen during the graduation, like computer organization and architecture, and how they are connected. Based on this experiment, a new material is being elaborated for the next semester, trying to make the specifications clearer and improving some features in the debug platform.

Keywords: Computer Architecture, Digital Systems, Problem-Based Learning.

15.1 Background

Many students of Computer Engineering course, in São Carlos School of Engineering, say that during the graduation, the practical classes offered don't meet their needs, mainly because it's stuck to a laboratory script, giving them a step-by-step solution with no need to think about what they are doing. This study tries to solve this issue through the implementation of in a 4-semester discipline: the Digital Systems Laboratory.

The laboratory practices were focused on the use of Digital Systems concepts to build a processor. Instead of using discrete components to build a basic processor[1-3], it was used an FPGA board to implement a simplified version of a MIPS processor, through circuit diagram schematics. This model of processor was chosen because it is also studied in Computer Organization at the same semester. That way, the student could learn the theory of MIPS and implement its modules in laboratory. To measure the results, the method was applied only in one of the three classes of laboratory, and it was used the grades of the students in the discipline of Computer Organization.

15.2 Purpose/Hypothesis

The purpose of this study is to apply Problem-based Learning (PBL) in Digital Systems Laboratory to motivate and help the students them understand different concepts of Digital Systems and Computer Organization, and how they are related each other. PBL is an active learning process that, through the use of real world problems, motivates learning and helps the students to connect the information, to give a meaning to it, so that way the learning is deeper[4]. It is expected that the students that were submitted to this new method improve its final grade in Computer Organization class.

15.3 Design/Method

The course was divided into four practices. All the practices were divided into 3 steps: logic problem, logic circuit implementation, and report presentation. For each logic problem, it was expected the students to use Digital Systems concepts to solve it. Then, the solution proposed was implement and tested into an FPGA development kit, and a final report was presented. Figure 15.1 shows the architecture of the MIPS processor and the implemented modules[5].

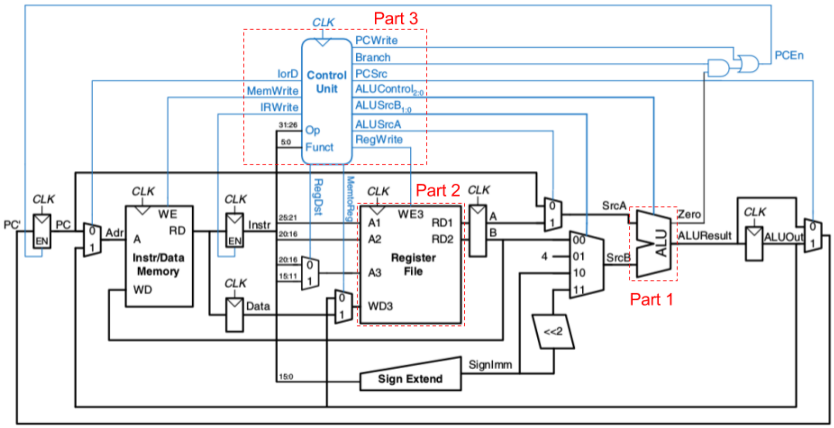


Figure 15.1 – MIPS processor (adapted from[5]).

Following the four practices are described:

- Practice 1 – Combinatorial Logic: An Arithmetic Logic Unit (ALU) was proposed and studied through the use switching functions. In this module, students were able to practice multiplexer, two complement adder and subtractor, and logic operations.

- Practice 2 – Sequential Logic: The study of sequential logic was done based in the implementation of the Register Bank. It also demanded the implementation of a counter for the Program Counter (PC), with parallel load for jumps.

- Practice 3 – Finite State Machine: The Control Unit was built as a Finite State Machine (FSM). The use of a FSM allowed joining both combinatorial and sequential logic. There were 12 states, allowing the decoding of some basic instructions, like Load/Store, Conditional Branch, Jumps, Add immediate and R-type instructions.

- Practice 4 – Final assembly and test: At last, it was created a test platform containing all the MIPS organization (as showed in figure 15.1) and some slots for Register Bank, Control Unit and the ALU, so that each student could integrate their own implementation of these components and test the whole processor using real MIPS.

A questionnaire to evaluate the opinion of the students was also carried out.

15.4 Results

Feedback from the students showed that, although some difficulties, mostly related to the use of the new softwares, it was motivating and it helped them to understand different concepts and how they are connected. The grade of the students in the discipline of Computer Organization was compared. It was possible to notice that there is a slight difference between those who had the PBL experience and the others:

- Final Grade: grades 6.2% higher than the others;
- 71% of the students that applied PBL reached the passing grade; and
- 60% of the others students reached the passing grade.

15.5 Conclusions

The PBL was well accepted and motivate the students to understand different concepts of Digital Systems and Computer Organization. New materials are being elaborated to the next semester.

Bibliography

1. FEINBERG, D. A Simple and Affordable TTL Processor for the Classroom. *Computer Science Education*, London, v. 17, n. 2, p. 107-116, jun. 2007.

2. PILGRIM, R.A. Design and construction of the Very Simple Computer (VSC): a laboratory project for an undergraduate computer architecture course. In: SIGCSE '93 PROCEEDINGS OF THE TWENTY-FOURTH SIGCSE TECHNICAL SYMPOSIUM ON COMPUTER SCIENCE EDUCATION, 1993, Indiana. *Proceedings...* Indiana: ACM SIGCSE Bulletin, 1993, p. 151-154.

3. RODRIGUEZ, B. J. A Minimal TTL Processor for Architecture Exploration. In: Proceedings of the 1994 ACM symposium on applied computing Proceedings of the 1994 ACM symposium on applied computing, 1994, Arizona. *Proceedings...* Arizona: ACM, 1994, p. 338–340.

4. ESCRIVÃO FILHO, E.; RIBEIRO, L. R. DE C. Innovating in the teaching of business administration: an experiment with problem-based learning (PBL). *Cadernos EBAPE.BR*, Rio de Janeiro, v. 6, p. 1-9, aug. 2008.

5. HARRIS, D. M.; HARRIS, S. L. *Digital Design and Computer Architecture*. Burlington: Morgan Kaufmann, 2007.

CHAPTER 16

A Contribution on How to Set The Number of Evaluation Exams in an Electrical Engineering Undergraduate Course Based on Score of Students: An Experience with Linear Systems Analysis at UFG

Sergio Pires Pimentel*

*Escola de Engenharia Elétrica, Mecânica e de Computação,

Universidade Federal de Goiás, Goiânia, Brazil

E-mail: pimentel.ufg@gmail.com

Abstract: The act of planning an undergraduate course could be briefly described as an ability to adjust topics into themes of lessons, declare objectives and procedures to achieve them according to previous knowledge of students, encourage the desired skills on students, prepare related documents and a schedule. Educators must also think about what would be the most suitable evaluation scheme for an effective learning of their students. Many classical and recent mechanisms of evaluation have been proposed in Engineering Courses based on their successful experiences from different areas or institutions. In fact, all those evaluations schemes are fully reasonable and most of them are similar in order to justify their methods by performance improvements, cognitive theories and practical limitations of execution. Based on that, this work describes an experience applied at UFG with students from an Electrical Engineering undergraduate course called Linear Systems Analysis (ASL). During two consecutive semesters (2016-1 and 2016-2), different evaluation schemes were used to score the learning level of students according to academic policy from the university. The first evaluation scheme was based on classical three wide exams covering the main topics of course. The learning level of each student as a quantitative learning index (QLI) was equivalent to

the simple average of scores obtained from exams. Although 26% and 5% of students achieved good and excellent results (QLI>80% or 90%) respectively, it was noticed that 38% of all the students achieved less than minimal acceptable (QLI<60%) for being classified as approved. Even most of individual scores in each of three exams were compatible with Gaussian distribution (which separately validates the applied exams as good reference of learning expectations in a group of people), all the students got an average QLI closed to minimal (58%) with a standard deviation of 16% at the end of semester. Although 11% of students left course, those verified standard deviation and number of rejected students induced the proposal of a second evaluation scheme. Based on continuous evaluation, the second scheme was proposed with seven short exams and covering the same topics of ASL course that were previously verified by the first scheme. Nevertheless, during the second evaluation scheme the QLI from each student was calculated as the weighted average of scores obtained from all exams. As some of covered topics during ASL course have ‘more impact’ on ahead courses, the weighted average had been chosen. By the second scheme and from all students, 30% was classified as rejected, 11% and 9% achieved good and excellent results (respectively), and 9% left course during semester. Besides the total average QLI was 62% with a standard deviation of 18%. From these values, it can be concluded that they achieved similar results for the same range of verified topics. However, students submitted to continuous evaluation method got so much tired preparing themselves to exams that had declared a slight preference for the classical method with three distributed wide exams. Other issues were asked for the students from both semesters and the results are also presented.

Keywords: Education, Electrical Engineering, Undergraduate Evaluation Systems, Teaching-Learning Process, Engineering Scores.

16.1 Background

According to Mondal and Mete (2013), education is the training of the mind and assimilation of ideas leading to dynamism of character and creativity of personality[1]. Considering this dynamism occurs during an undergraduate course, it is normal to detect some deviations related to individual performances in a group composed by so different people (students). Even among the teachers, each of them has his unique manner of perception, teaching and evaluating the students.

It is also true that it is impossible to evaluate correctly the performance of a student considering only its scores obtained by few exams dispersed applied during a semester course. However, a correctly evaluation involves a daily perception of how much students have really learned after each class. From that point of view, an exam is just one of the possible instruments considering during measurement the learning index of anyone and not an evaluation method by itself. Then, a continuous evaluation scheme should be a better option and it was explored in this work.

Many classical and recent mechanisms of evaluation have been proposed in Engineering courses based on their successful experiences from different areas or institutions. In fact, all those evaluations schemes are fully reasonable and most of them are similar in order to justify their methods by performance improvements, cognitive theories and practical limitations of execution[2]. This work is related to an experience captured by author during an undergraduate course (Linear Systems Analysis) considering two different evaluation schemes: three or seven exams all over the semester.

16.2 Purpose/Hypothesis

The main purpose of this work is to contribute with a new method to evaluate an undergraduate school based on the experience of the main author and those methods. Two different evaluating schemes had been tested and their results are presented and discussed during the next sections. This work describes an experience applied at UFG with students from an Electrical Engineering undergraduate course called Linear Systems Analysis (ASL).

16.3 Design/Method

Based on the above purpose, this work describes an experience applied at UFG with students from an Electrical Engineering undergraduate course called Linear Systems Analysis (ASL). During two consecutive semesters (2016-1 and 2016-2), different evaluation schemes were used to score the learning level of students according to academic policy from the university. The first evaluation scheme was based on classical three wide exams covering the main topics of course. Based on continuous evaluation, the second scheme was proposed with seven short exams and covering the same topics of ASL course that were previously verified by the first scheme.

The behavior and scores achieved by all students during the first evaluation scheme (that with only three exams) are presented in Figure 16.1 and in Figure 16.2. In the same way, Figure 16.3 presents the performance of the group of students during the second evaluation scheme (with seven exams).

16.4 Results and Conclusions

From results presented in Figure 16.1, Figure 16.2 and Figure 16.3, it can be concluded that both evaluate schemes have achieved similar results for the same range of verified topics (same undergraduate course and same teacher). In addition, Table 16.1 shows a description of those performances and combined scores during two consecutive semesters. However, that similarity decreases after comparing both performances in terms of quantitative statistical functions related to dispersions and deviations. Therefore, from Table 16.2 it is possible to notice that first evaluation method (with three exams) could be classified as a slightly better option (in this case).

Bibliography

1. MONDAL, A.; METE, J. Continuous and comprehensive evaluation – an appraisal. *Issues and Ideas in Education*, Punjab, v. 1, n. 2, p. 121-138, sept. 2013.

2. KNIGHT, D. W.; CARLSON, L. E.; SULLIVAN, J. F. Improving Engineering student retention through hands-on, team based, first-year design projects. In: 31st International Conference on Research in Engineering Education, Honolulu, june 2007.

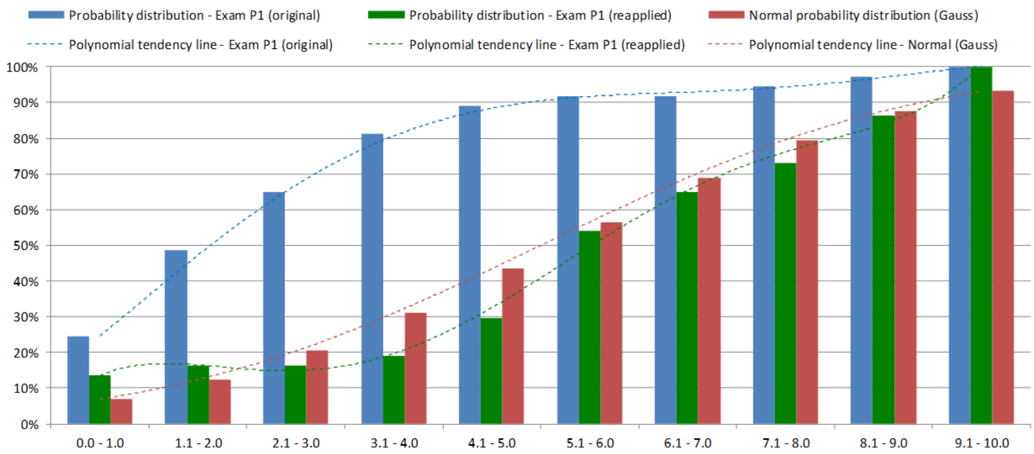


Figure 16.1 – Score distributions related to the first of the three applied exams during 2016-1 semester.

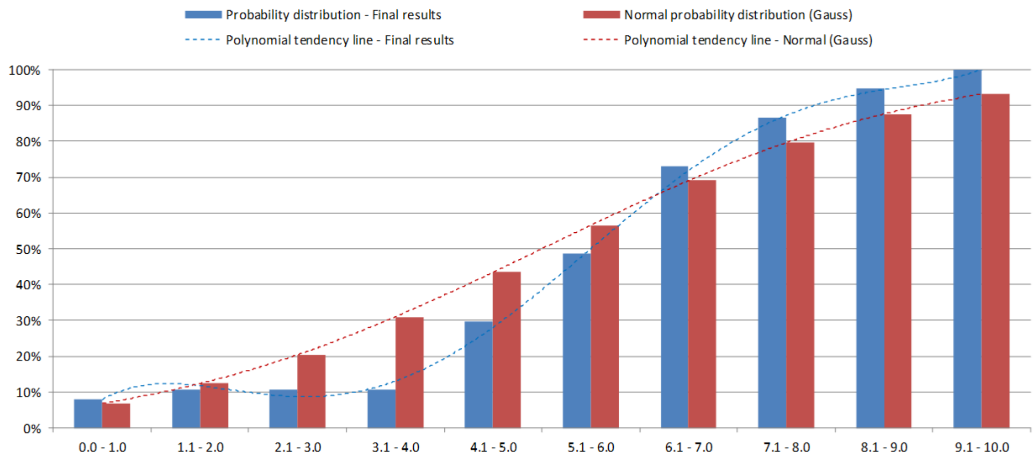


Figure 16.2 – Distributions of final results at the end of course with first evaluate scheme (three exams).

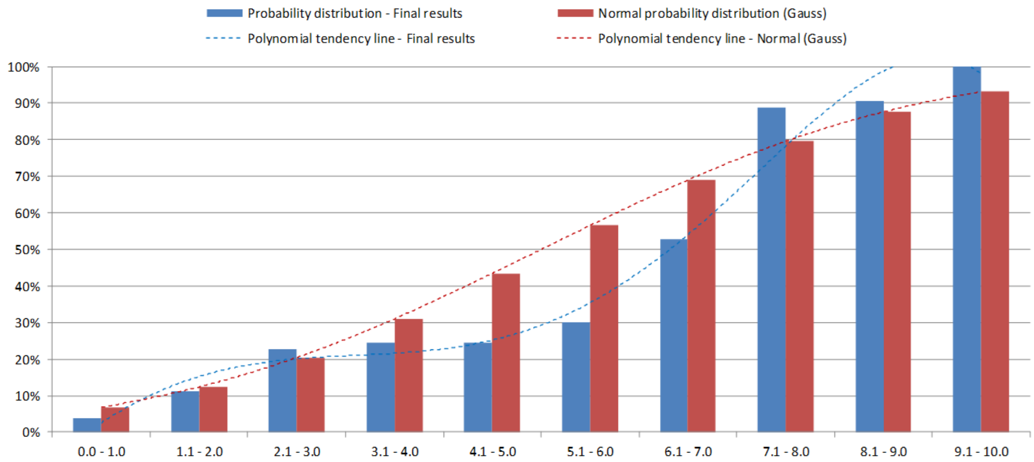


Figure 16.3 – Distributions of final results at the end of course with second evaluate scheme (seven exams).

Table 16.1 – Comparison of score distributions observed at the end of both evaluation schemes.

Score interval	Gauss Distrib.	First scheme	Second scheme	Deviation (1st)	Deviation (2nd)
0.0 - 1.0	6.9%	8.1%	3.8%	-1.2%	3.1%
1.1 - 2.0	12.4%	10.8%	11.3%	1.6%	1.1%
2.1 - 3.0	20.4%	10.8%	22.6%	9.6%	-2.2%
3.1 - 4.0	31.0%	10.8%	24.5%	20.2%	6.5%
4.1 - 5.0	43.4%	29.7%	24.5%	13.7%	18.9%
5.1 - 6.0	56.6%	48.6%	30.2%	8.0%	26.4%
6.1 - 7.0	69.0%	73.0%	52.8%	-4.0%	16.2%
7.1 - 8.0	79.6%	86.5%	88.7%	-6.9%	-9.1%
8.1 - 9.0	87.6%	94.6%	90.6%	-7.0%	-3.0%
9.1 - 10.0	93.1%	100.0%	100.0%	-6.9%	-6.9%

Table 16.2 – Achieved parameters by both evaluation schemes and compared to normal distribution (Gauss).

Parameter	First scheme	Second scheme
Absolute error	79.10%	93.40%
Mean absolute error	7.91%	9.34%
Mean relative error	0.167	0.208
Average error	9.51%	5.10%
Mean square error (MSE)	0.92%	1.51%
Root mean square error (RMSE)	9.57%	12.30%
Final average score	5.76	5.98
Final Approved students	19 (51.4%)	37 (69.8%)
Total of students	37	53

CHAPTER 17

Ontology to Mining Judicial Sentence's Big Data

Antônio Pires de Castro Júnior[*], Wesley Pacheco Calixto[♦] and Viviane Margarida Gomes[▲]

[*]Escola de Engenharia Elétrica, Mecânica e de Computação, Universidade Federal de Goiás, Goiânia, Brazil

E-mail: apcastrojr@gmail.com

[♦]Escola de Engenharia Elétrica, Mecânica e de Computação, Universidade Federal de Goiás, Goiânia, Brazil

E-mail: wpcalixto@gmail.com

[▲]Escola de Engenharia Elétrica, Mecânica e de Computação, Universidade Federal de Goiás, Goiânia, Brazil

E-mail: vivianemargarida@gmail.com

Laís F. A. Silva[▼] and Pedro H. M. Campos[○]

[▼]Instituto Federal de Goiás, Goiânia, Brazil

E-mail: lais.fernanda2009@hotmail.com

[○]Instituto Federal de Goiás, Goiânia, Brazil

E-mail: pedromaionee@gmail.com

Ernesto F. Veiga[✡]

[✡]Ciências da Computação, Universidade Federal de Goiás, Goiânia, Brazil

E-mail: ernestofonsecaveiga@gmail.com

Abstract: The number of Judiciary cases has increased exponentially and overcrowded services, hampering a rapid attendance to society's rights. Research on already rendered decisions on related matters is an essential step on process flow, that of sentences and decisions elaboration, carried out basically in court's sites. Most available filtering and searching tools are substantially textual, making it time-consuming, laborious and unproductive. Judicial advisers, responsible for internet research, consume significant time in studying the

process and through textual search, find similar decisions to the current one. Therefore, facing growing in judiciary demands, it is imperative to build fast, automatic and intelligent database mechanisms to search, filter and choose information, requiring less human actions in the search process. This paper's goal is to present a semantic methodology, intelligent and automatic for data mining in judicial process sentences database, with processes related to the one in trial, using ontology, that is, measure and verify software implemented robot receiving content about processes (nature, action area, poles, subject, class and main part of initial petition content) and conduct database search of past decisions full content, finding the most appropriate decision for the case in question, in view of many judged cases. It's presented an intelligent and automatic method to search for sentences in lawsuits related to the one in trial. For this, four different types of data mining are used: data mining without ontology; data mining using legal ontology with experts rules; data mining using legal ontology without experts rules; data mining using legal ontology with and without experts rules (hybrid). The term experts rules is used because it utilizes human knowledge, from a legal field experts, which works for ten years on legal process decisions/sentences draft preparations. The term without expert rules is used because it makes use of mathematical and computational models to structure words similarity matrix, aiming to find words relation occurring more frequently in order to look for the desired one, within similar

decisions/sentences to the current process universe. The term hybrid is used when employing ontology with and without expert rules. A software named Autosent, built to perform search and classification of large amount of legal sentences, allows to apply mechanisms to measure the propose algorithm's data mining capability. The research use accuracy and recovery to value the propose algorithm. Simulations and tests have demonstrate that application of ontology is feasible for legal decisions data mining, both in accuracy and information retrieval. Another important aspect is to be able to establish a standardization of searches in monocratic decisions full content's universe, avoiding related subjects to have divergent decisions. The method will provide speed in the Judiciary, seeking to quickly solve the yearning of society, as it will be able to simulate the legal advisers work on decisions/sentences preparation. The studies and simulations were done with real data of 2016, Goiania city Judicial Power, in Goias, Brazil. We believe the same proposed semantic method can be applied to judge answers in subjective questions in big databases for Education.

Keywords: Artificial Intelligence, Court Decisions, Data Mining, Knowledge Management and Ontology.

17.1 Background

The numbers of Judiciary cases in Goias are about 2 million active processes. The average time to sentence is about 2 years and the average time for pending cases is 3 years[1]. Every year, the number of pending cases increases and overcrowded the Judiciary, hampering compliance with the rights of society[2].

17.2 Purpose/Hypothesis

The lawsuit can be finalized with the sentence of the judge. However, to sentence the case, it is common to search for similar cases and check the decisions made. Research on already rendered decisions on related matters is an important step on process flow.

Most available filtering and searching tools are substantially textual, making it time-consuming, laborious and unproductive[4]. The operators of law consume significant time in studying the process and through textual search, find similar decisions to the current one.

Is it possible to present an intelligent and automatic methodology for data mining in judicial process sentences database, with processes related to the one in trial, using semantic search with ontology?

17.3 Design/Method

To try to prove an intelligent and automatic method to search for sentences in lawsuits related to the one in study, four different types of data mining are used: data mining without ontology; data mining using legal ontology with expert's rules; data mining using legal ontology without expert's rules; data mining using legal ontology with and without expert's rules (hybrid). Software called Autosent was built to simulate e compare this types of data mining.

Two metrics are applied to measure these types of data mining: accuracy and information retrieval.

Data mass used in simulation and proposed environment tests for all data mining type are: 1.757.132 metadata process in inventories and 100.000 full content sentences/decisions produced in the past.

The data mining without ontology is accomplished simply by performing the textual search using the words consignment and revision. The data mining using legal ontology with expert's rules is used because it utilizes human knowledge, from legal field experts, which works for ten years on legal process decisions/sentences draft preparations. The model used to create ontology without expert rules intend to build automatically known, applying mathematical and computational models, this is a kind of artificial intelligence. This is the main purpose of this project. The term hybrid is used when employing ontology with and without expert rules.

To reach method using ontology without expert´s rules the following steps and techniques was used: 1 - within the universe of correct sentences/decisions entire contents, related in the process under study, the incidence of all words with more than five letters will be counted. From this set, ten words with most incidences are separated; 2 - a term-to-term matrix is created with ten words of highest incidence. In this matrix, the incidence number of the terms in all the 100.000 sentences/decisions in the database will be counted; 3 - after identifying the number of occurrences of the 10 words in each document, the expression (17.1), established by[5], is applied. The result of the combination of the 10 words, two by two, given by[5, 6] is stamped in the similarity matrix; 4 - the combinations of terms/words that remain with the percentage of similarity greater than 50% in the matrix will be used in Ontology without the rules of the expert. The similarity matrix is given by:

$$\frac{\sum_{i=1}^{n} w_{i,k} w_{i,h}}{\sum_{i=1}^{n} (w_{i,k})^2 + \sum_{i=1}^{n} (w_{i,h})^2 - \sum_{i=1}^{n} w_{i,k} w_{i,h}}, \tag{17.1}$$

where i is the document number in total of n documents, w is the term/word in the document, w_k is the k term/word and w_h is the h term/word.

17.4 Results

Figure 17.1 presents the results of the accuracy and information retrieval (acuteness) metrics in the simulations for four approaches of data mining. Utilizing ontology is possible to see significant gains, contrary to not using it, and human ontology showed better results than automatic ontology. It is important to say that data mining methodology used to structure automatic ontology, although achieving better accuracy than not using ontology was not able to overcome ontology with expert rules.

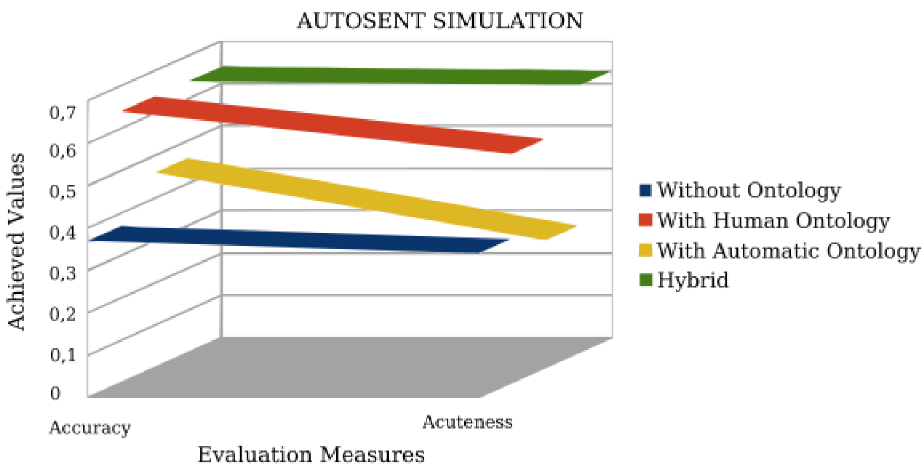


Figure 17.1 – Values achieved by simulation´s evaluation measures.

17.5 Conclusions

Simulations and tests have demonstrated that Ontology application is feasible for Legal Decisions data mining, both in accuracy and information retrieval. Another important aspect is to be able to establish a standardization of searches in monocratic decisions full content's universe, avoiding related subjects to have divergent decisions. Considering the existence of process protocol/record errors in the database used, 64% in accuracy and 63% in recovery, obtained with hybrid solution, are promising numbers.

Work is still under development and since all tests were carried out for revision and consignment nature process, there is intention to work on other related natures, which can bring better results, as well as use other data mining methodologies trying to improve metrics indicators, aiming on overcome Ontology with expert rules.

Bibliography

1. ANTUNES ROCHA, C. L. Justiça em Números. *Revista Digital do CNJ*, Brasília, v. 1, p. 1-404, 2016.

2. SEWALD JUNIOR, E.; SILVA, P. F.; SILVA, E. R. G. Gestão de Conhecimento para Administração Judiciária: Levantamento de demandas de conhecimento e estabelecimento de ontologias. *Revista Democracia Digital e Governo Eletrônico*,

Florianópolis, n. 5, p. 71-83, 2011.

3. CASTRO JÚNIOR, A. P.; FRANCO, B. F.; CALIXTO, W. P. Gestão da informação em grandes volumes de dados no Poder Judiciário. In: ALMEIDA, F. S. et al. (Org) *V Coletânea Luso-Brasileira - Gestão da Informação, Cooperação em Redes e Competitividade*, Porto: Faculdade de Direito da Universidade do Porto, 2014, cap. 2, p. 61-78. . 4. DA SILVA, E.R.G., et al. Representation of Legal Knowledge through Ontologies: Exercise in Electronic Government. *International Conference on Information Systems and Technology Management*, 2009.

5. SALTON, G.; MCGILL, M. *Introdution to Modern Information Retrieval.* New York: McGraw-Hill, 1983.

6. BARION, E. C. N.; LAGO, D. Text Mining. *Revista de Ciências Exatas e Tecnologia*, Londrina, v. 3, n. 3, 2008.

CHAPTER 18

An Approach for Mapping and Simulation of Didactic Games in the Internet

Sandrerley Ramos Pires[*] and Tobias Gonçalves Pires[♦]

[*]Escola de Engenharia Elétrica, Mecânica e de Computação, Universidade Federal de Goiás, Goiânia, Brazil

E-mail: sandrerley@hotmail.com

[♦]Escola de Engenharia Elétrica, Mecânica e de Computação, Universidade Federal de Goiás, Goiânia, Brazil

E-mail: tobiasgp@hotmail.com

Dulcinéia Gonçalves F. Pires[▲]

[▲]Instituto Federal de Goiás, Campus Anápolis, Anápolis, Brazil

E-mail: dulcineiapires@hotmail.com

Abstract: When educators are planning their classes, one of most challenge tasks is to awaken students' interest for the lesson content. The use of educational games may support teachers to reach this goal. However, the use of educational games requires high investments. This paper proposes that a formal model and a knowledge basis can map all necessary details of an educational game, permitting to simulation it in a computational environment. Also, this work shows a software able to understands this formal model and, using an inference engine, understand the knowledge basis. With these resources the software simulates the educational game, offering to students the game in the Internet. The students can play using any computer which Internet access. The first step for the game creation starts with the manufacture of the formal model and the knowledge basis. This work uses a state transition diagram (STD), which can map all possible paths in a specific game. This model mapped the dynamic of several educational games tested. Besides the STD, we used a knowledge basis, like an expert system, with the rules to game

control. After map the game, the teacher must submit the model to the built program. The program reads the model and simulates the mapped game in a computational environment. It has an inference engine that controls the flow by the various states of the game. Students begin playing at the initial stage of the game. The start stage is equivalent to the initial state of the STD. Users can pass to the next stage only if their moves fulfill the game rules stored in knowledge base. Students play the game until they reach the final stage of the game. The final state of the state transition diagram is equivalent to the final stage of the game. To show a feasibility of the proposed approach, some educational games were developed and used in practical classes. Although the game creation is a hard task, the game can be used and improved indefinitely by the teacher. In addition, teachers can exchange their games between them, creating a gaming basis in their institution. The work conclude that the objectives were reached, because the proposed model can map all educational game idealized by the participating teachers, and the software is able to simulate all the games mapped in the proposed formal model.

Keywords: Educational Games, Expert Systems, Game Simulation, Process Modeling.

18.1 Introduction

The use of business games is frequent in business and academic world. This kind of game permit to students to live real situations from the business, where the student (player) analyses a context, planning actions, and make decisions to reach an objective, which is win the game.

In Brazilian market, there are many didactic games available as the Bernard[1], OGG[2] and the Simulare[3]. Although these mentioned business games are good options to academic use, some considerations are important to be enumerated: (i) several analysed games are inflexible to insert new features; (ii) some games are not available to play in Internet; and (iii) games of the market normally have high prices. Besides this, some games require additional training to teacher, increasing more their prices.

Thus, this work based in those restrictions to propose a computational system to create and simulate didactic games mapped in a formal model. The teachers would create their own games, increasing the available resources to their courses. The paper aims to propose a formal model to map a game and to implement a computational software to turn available on the Internet the mapped game.

18.2 Fundaments

The American universities use the business games as since 1950 decade. In Brazil, the companies began to use the business games in 1962[4] and the dissemination occurred only in 1980 decades.

The software Engineering area uses the State Transition Diagram (STD) since 1960 decade[5]. The STD represents the dynamic behavior of a system, mapping all states in a system and actions which cause the changing of states.

The Expert Systems is a kind of computer program which aims to simulate the reasoning of a specialist professional in a specific knowledge area[6]. An Expert System have the knowledge base and the inference engine. The rules in the knowledge base have the follow format IF <condition> THEN <action>. The inference engine can simulate the reasoning manipulating the stored rules.

18.3 Proposed Approach

This section presents the results of analysis performed in several didactic games. The objective is to define what features of a game are necessary to obtain its complete mapping. A mapped game in a formal model must contain all necessary information to its simulation. This information and its notation are:

(i) Entity is a fundamental object of the game. Its notation is: $E_1, E_2, ..., E_n$.

(ii) The Attributes is the element which characterizes an Entity. An Entity should have a finite and small number of Attributes. Its denotation is: E_n: E_n:A_1, E_n:A_2, ..., E_n:A_n.

(iii) The values of entity attributes define an entity state. The set of all entities states defines the game state. The formal model maps just the game states. Its notation is S_i, S_1, S_2, S_3, ..., S_n, S_{f1}, S_{f2}, ..., S_{fn}. Where: S_i is the initial game state; S_k: are a middle game state; and S_{fm}: are a final game state.

(iv) The Game Rules work as functions applied to entities attributes. These functions return a value true indicating a permission to transition of state. The notation of a rule is: $O \leftarrow R_k(E_m : A_n, E_m+1 : A_n+1, ..., E_m+k : A_n+k)$. Where: R_k is the $k-th$ rule of the game; O indicates if movement obeys or not to the rule; and $E_m : A_n$ are entity attributes manipulated by rule.

(v) The Transition is an event that causes a changing of a state to another. The transition only occurs if all rules relate to it return positive response. The notation of a Transition is: Ti $(S_k \rightarrow S_j; R_1, R_2, ..., R_n)$.

(vi) Finally, the expression below can resume the game representation: Game (Name; $E_1, E_2, ..., E_m; S_1, S_2, ..., S_n; T_1, T_2, ..., T_n; S_i, S_{f1}, S_{f2}, ..., S_{fn}$)

The Figure 18.1 shows a graphical model able to represent the dynamic part of a game. This graphic is a State Transition Diagram, which represents all game states and all possible transitions between the states.

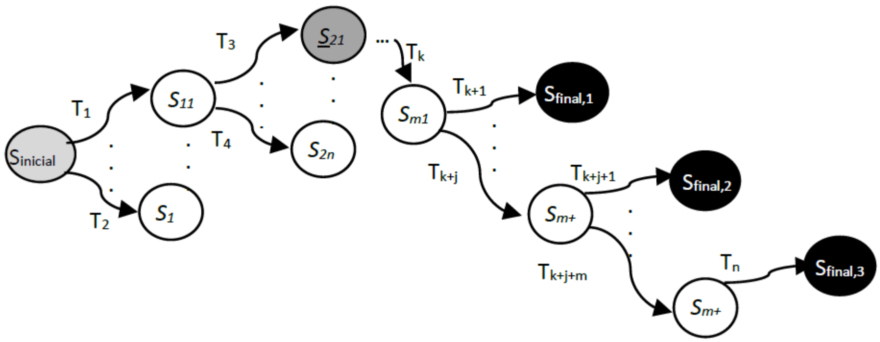


Figure 18.1 – Graphical representation of a game.

18.4 Results

This work created a software able to maps and simulates a game. The first task is the capture of game metainformation, saving these information on a software repository. The Figure 18.2(a) shows the interfaces responsible to map all states and transitions of the game. Observe it is possible to identify four kinds of represented states in the Figure 18.1, as well as transition.

The Figure 18.2(b) shows the second interface for registers the game rules, creating its knowledge base. In this case, the game creator chosen the Java

(a) (b) (c)

Figure 18.2 – (a) dynamic vision, (b) control vision and (c) the game simulation.

language to create the three first rules of the game and a logical postulate to create the last rule.

Finally, the Figure 18.2(c) shows the simulating screen will seeing by players in the WEB environment. In this form, the player informs its moves typing the new values to changeable attributes and clicking in the button transition. Each possible transition from a state corresponding to a button in the form. Besides the moves, this screen also shows on its top right the score of player.

18.5 Conclusions

This paper presented an approach to map and simulate a didactical game. The purpose is to provide a generic environment for creating games and play its on internet. The proposed model permitted the implantation of a software able to create and simulate a game. This work presented an example of how to create a game in the implemented software. The simulation of the game worked very well.

Finally, this work conclude that the implemented software can register and simulate a didactic game. As the teacher can create your own games, this paper also conclude that the software is a power resource to get better the didactic process in its courses.

Bibliography

1. BERNARD Simulação Gerencial. *Jogo de Empresa/Simuladores Gerenciais.* [2015?]. Avaiable in : <http://www.bernard.com.br>. Acessed in: fev. 2015.

2. OGG PEM. *Simulador para Pequenas Empresas.* [2015?]. Avaiable in: <http://ogg.com.br>. Acessed in: jan. 2015.

3. SIMULARE. *Simulação de Gestão de Negócios.* [2015?]. Avaiable in: <http://simulare.com.br/page/>. Acessed in: fev. 2015.

4. GRAMIGNA, M. R. M. *Jogos de Empresa.* São Paulo: Makron Books, 1993.

5. HAREL, D. Statecharts: A Visual Formalism for Complex Systems. *Science of Computer Programming*, v. 8, n. 3, p. 231-274, 1987.

6. RUSSELL, S.; NORVIG, P. *Inteligência Artificial.* Campus, 2013.

CHAPTER 19

Evolution of A Familiar Company Using Lean Project Concepts Aiming to Make Part of a Multinational Group

Eliaber de Sena Freitas[*], Luana Abade do Nascimento[♦] and Luiz Carlos de Campos[▲]

[*]Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: eliaber.sena@yahoo.com.br

[♦]Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: luuabade@gmail.com

▲Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: lccampos@pucsp.br

Abstract: This paper presents as the science application through Lean Project concepts can help and guide a company in its restructuration process. The analyzed company trades commodities and high technology orthopedic products used to wound treatment, compression therapy and orthopedics. The motivation for the project was due to the fact we would be able to see how processes involving areas of Lean Project and Production Planning and Control (PCP) are applicable in real companies and not just in academic examples or old cases of study. The changes and processes implemented in the company prepared the transition of a familiar structure to a multinational group with solid and trusty processes. To achieve the desired target in the organization, Lean Production and PCP concepts, besides a cultural change inside the company, were necessary to be successful implemented. Regarding the Lean Project the work was mainly emphasized in mitigate three of the six big wastes (inventory, waiting and overproduction) and became a company focused in customer needs. During the implementation of the process it was added in the organization several controls, processes, and Key Performance Indicator (KPI's) originated from PCP methodology, which are important highlight: production planning, production adherence and sales forecast. In the development of the research, a critical analysis over some challenges that appeared was made, looking for an active way to solve the problems, involving other required agents to analyze: commercial, manufacture, supply chain, statistic and graphic tools. After the process implementation and collected data our conclusion was that the familiar company had the habit of producing goods even thought they were not requested for the customer in that exactly time, instead of focus in the customer needs. Through the changes described above the company had a relevant increase in its revenues (due to the fact it had the goods requested for the clients available) and a decrease of back orders and inventory. The importance of this research is mainly in fact that it can be generalizable, serving as a model for other familiar or old vision companies that aim to improve their processes, restructuration or even have the intention of start an IPO (Initial Public Offering) implementation using this approach in their business.

Keywords: Familiar Company, Lean Production, Process Implementation, Production Planning and Control, Restructuration.

19.1 Background

The motivation of this paper is due to the fact we would be able to see how processes involving areas of Lean Project and Production Planning and Control (PCP) are applicable in real companies and not just in academic examples or old cases of study[1,2].

19.2 Purpose

The research purpose is to show the impacts of Lean Project, Production Planning and Control strategies in a company performance. In the scope of methodology application, the research results supplied data about company inventory level and service level provided to the costumers, and how they were optimized.

19.3 Design/Method

This paper shows the advantages for a company, acquired by the collected data in manufacture environment. Before the Lean Project strategies implementation, the company concerned was confronting a period of disorganization and a certain difficulty in attend the customer needs, preponderating the following doubts:

- What to produce?
- When to produce?
- How much to produce?

In order to solve this queries, it was adopted a methodology focused in Production Planning and Control (PPC) concepts, through the following stages: sales forecast, production planning and production adherence[3].

19.3.1 Sales forecast

Pursuing to understand in an accurate way the demand for the company products, it was utilized statistics models (Simple Exponential Smoothing and Holt's Exponential Smoothing) to determinate a sales forecast by product, considering a data base from the last twelve months.

19.3.2 Production planning

After sales forecast, the role was to direct the production according to the quantities presented in the forecast, besides considering back orders and safety stock. Initially, the planning started with sixty products, increasing further to the whole portfolio.

19.3.3 Production adherence

After the last two stages, emerged the necessity to measure the production adherence confronting the planned production with the actual, as detailed below:

$$PA = \frac{planned\ production - actual\ production}{planned\ production * 100\%} \tag{19.1}$$

19.4 Results

- Reduction of 88% in back orders.
- Increase of 64% in safety stock levels.

19.5 Conclusions

Through the research development, we can conclude the Lean Production concepts and methodology application are essential for company that desires to be competitive inside its field. Before the company production and commercial changes, it was unable to attend customer needs and even give a certain forecast about product deliveries. However, with organizational changes, it was possible an 88% reduction in back order, and a good product available and forecast. Therefore, the company achieved a better use of its production capacity, because instead of increase a useless stock for several products, it was able to concentrate the production capacity on back orders increasing its revenue and reducing stock costs. Due to these changes, the service provided for the company reached a higher level of attendance and client satisfaction, resulting in a preference gain among the clients, becoming a commodities market referential. It should be highlighted that during the structural change in the company, some internal conflicts happened due to the change in familiar vision that had been maintained for several years, and the organizational culture as a whole.

Bibliography

1. ALVES, A. C et al. Benefits of Lean Management: results from some industrial cases in Portugal. In: 6º CONGRESSO LUSO-MOÇAMBICANO DE ENGENHARIA (CLME2011)" A ENGENHARIA NO COMBATE À POBREZA, PELO DESENVOLVIMENTO E COMPETITIVIDADE", Maputo, 2011. *Proceedings...* Maputo: Edições INEGI, 2011, p. 1-9.

2. ALVES, A.C ET AL. (2013). Lean Engineering Education: bridging-the-gap between academy and industry. In: First International Conference of Portuguese Society of Engineering Education (CISPEE), Porto, 2013. *Proceedings...* Porto: IEEE, 2013, p. 1-5.

3. KING, C.J. Restructuring engineering education: Why, how and when? *Journal of Engineering Education*, Washington DC, v. 101, p.1-5, 2012.

CHAPTER 20

Discipline of Logistics: Approaches to Teaching, Learning and Results Evaluation

Marcos Lemos Afonso[*]

[*]Escola de Engenharia Elétrica, Mecânica e de Computação,

Universidade Federal de Goiás, Goiânia, Brazil

E-mail: afonso_ml@uol.com.br

Rafaela Morais Rosa[♦]

♦Faculdade de Informação e Comunicação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: rafaela.morais@gmail.com

Abstract: The Engineering Courses offer to its curricular structure the technical disciplines that allow to extend the necessary competences to the management of the supply chain. It is noteworthy that most curricula - Engineering Courses - do not offer disciplines of logistics and supply chain between compulsory and elective disciplines. Faced with this context or methodological challenge to create a stimulating and innovative environment - with the increase in efficiency in learning - that was chosen from games, for them they can experience the real reality with immersion and motivation. This paper presents the results of the Free Nucleus Logistics course offer in 2016, with an open enrollment for all interested parties, including other graduates besides Engineering at the Universidade Federal de Goiás. The teaching approach focused its action on the development of skills Of students to optimize the resources of the logistics in the productive system, teaching methodology with learning of exercises, bibliographical research, field research, preparation of texts for students Presentation in the classroom) and end of semester. In this work there is a strong relationship with the research carried out with the fundamentals of action research, with the field research carried out during the whole elaboration process,

but mainly, by team action in the construction of the game, with the prototype being delivered during a Event (previously scheduled), fact that a whole schedule (of each team) was adjusted in final delivery data, when the game rehearsed. The themes proposed for the elaboration of the topics related to the topics of the discipline's education - all students in the classroom and with broad participation of all enrolled students, that make it possible to apply the theoretical concepts specifically to the concrete cases identified by the students Doubts during all classes). In the elaboration of the games the students were able to insert into the structure - physical items of the games - the various aspects addressed in the room, even at different levels of complexity. All the prototypes were tested in an immersion environment, being perceived a high degree of motivation in the use of games.

Keywords: Engineering, Learning, Logistics, Methodology, Teaching.

20.1 Introduction

The study does an analysis of the methodology developed in the logistics discipline, centered on the creation of traditional games of boards, from the development, implementation and application of the games developed using the content addressed on the menu of the matter, which was offered as a free nucleus in 2016, having open enrollment for other graduations besides Engineering at UFG.

The survey conducted in the curricular matrices of the electrical Engineering courses, mechanics and computation of the UFG registers that their resumes do not offer disciplines of logistic and/or suplly chain between mandatory and/or elective disciplines, being the logistic discipline (object of this work) offered in the free nucleus (open enrollment for different graduations). The methodological challenge was to create an innovative environment aimed at facilitating the learning of enrollees.

Overall logistics involves all activities aimed at maximizing the use of resources available with competitive advantage[1]. Christopher highlights that logistics is the process of strategic management, acquisition, handling and storing of materials, parts and final stocks (and related information flows) through the organisation and its marketing channels, it is also "a guidance and a planning structure aimed at creating a single plan for the flow of products and information through a business" and thus maximizing profit by observing the cost-benefit ratio[2].

Logistic discipline used a gaming approach, being developed by the graduates – in a multidisciplinary team – during the academic semester[3].

20.2 Purpose

Analyze the results of gaming development as a learning tool, by providing a new methodology since the conception, development, implementation and application of games using the content addressed in the educational plan of the Logistics discipline, and also assess the efficiency of learning from the dynamic and challenging context of the final delivery of games that have been tested during the execution of the discipline.

20.3 Methodology

Research exploratory type, quantitative and documentary[4, 5]. As an instrument of data collection, an observation script was used with 7 closed questions with the scale of response in 3 levels (total - weight 3, partial - weight 2 and none (a) - weight 1).

The data collection was carried out in 5 games (all the games object of this analysis) developed in the discipline of Logistics: transport, handling and storage offered in 2016 at the UFG in Goiânia, having received the enrollment of 30 students.

The bibliographic research was used to substantiate the others[3-6].

20.4 Result

The analysis was conducted in the 5 games (total population) identified in this work with the lyrics, B, C, D and E. With the objective of evaluating the learning encompassed in each of the prototypes, seven criteria were used, namely: 1. Integration of items-(brand, board, rules, parts and others); 2. Level of stimulus for decision-making; 3. Clarity of the rules; 4. Innovative design; 5. Connection between game and reality; 6. intrinsic theoretical foundations; 7. Theme/Structure/other Inedition – (game presents some rarity).

The survey revealed that the integration of the game items was total and 100% of the games, partial at 0% and none at 0%. The stimulus level for decision-making was 80% total, 20% partial and 0% none. The clarity of the rules – in the 5 games – was considered total in 80% of the same, partial by 20% and none at 0%. The design was considered totally innovative in 40% of the games, partially innovative in 40% and nothing innovative at 20%. The survey revealed that the game's connection with reality was total in 100% of the games, partial at 0% and none at 0%. The theoretical foundations were fully perceived in 100% of the games, partially perceived at 0% and nothing perceived at 0%. The research revealed that some aspect of ineditism (rarity) was fully featured in 40% of the games, partially in 40% and nothing presented by 20%. The sum of all the criteria analyzed in the 5 games revealed that the game A reached 95% of the maximum expected, game B reached 100%, the game C reached 95%, the game D reached 90% and the game E reached 81%, as shon in Figure 20.1.

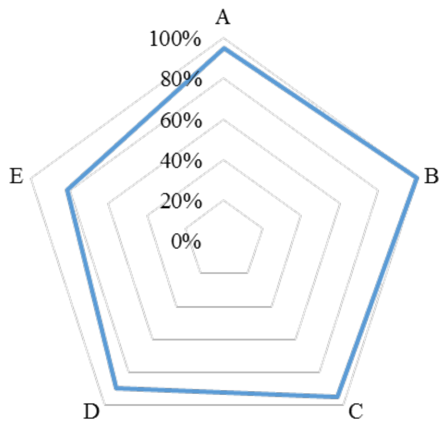


Figure 20.1 – Results of the individualized summation in the 5 games.

20.5 Conclusion

All games have fully accomplished the integration of items-(brand, board, rules, parts and others), connection between the game and the business reality and embark on the theoretical foundations intrinsically in the game. The absolute majority were able to stimulate the decision-making by the players and presented innovative design in some of the game's items. The absolute minority of the games did not show clarity in the rule of the game and ineditism of the theme and/or rarity. The results demonstrate that the methodology used with games managed to offer a pedagogical action with high efficiency in learning by students, as an alternative in Engineering courses[7].

Bibliography

1. DIAS, M. A. *Introduction to logistics: fundamentals, practices and integration.* São Paulo: Atlas, 2016.

2. CHISTOPHER, M. *Logistics and supply chain management.* São Paulo: Cengage Learning, 2015.

3. SANTOS, A. R. *Scientific methodology: the construction of knowledge.* Rio de Janeiro: DP & A, 1999.

4. LAKATOS, E. M.; ANDRADE, M. *Fundamentals of scientific methodology.* São Paulo: Saraiva, 2017.

5. FACHIN, O. *Fundamentals of methodology.* São Paulo: Saraiva, 2003.

6. CERVO, A. L.; BERVIAN, P. A. *Scientific methodology.* São Paulo: Prentice Hall, 2002.

7. VALDEZ, M. M. A. T. New methodologies in teaching and learning in the area of Engineering electrotechnology. Available in: <http://hdl.handle.net/10216/74589>Accessedin:05may2017>.

CHAPTER 21

Design Thinking Course

Getúlio Antero de Deus Júnior[*], Marcos Lemos Afonso[♦] and Ricardo Henrique Fonseca Alves[▲]

[*]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: gdeusjr@ufg.br

[♦]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: afonso_ml@uol.com.br

[▲]Escola de Engenharia Elétrica, Mecânica e de Computação,

Universidade Federal de Goiás, Goiânia, Brazil

E-mail: ricalves@posgrad.ufg.br

Abstract: The nature of core competencies in training engineers involves technical, affective, and attitudinal areas as well as the development of interpersonal skills to coexist in multidisciplinary teams. Depending on the area of Engineering, the elaboration of projects seeks to solve real problems and projects, which can lead to technical recognition by the professional and even the creation of networking opportunities. The affective and attitudinal changes can promote self-knowledge, coping with adverse situations, resilience, ability to take risks, commitment and responsibility. The development of interpersonal skills involves assertiveness, flexibility, communication and business. In the pursuit of essential competences, the objectives of the course of Design Thinking in the formation of Engineers are structured in general, cognitive and attitudinal. The discipline uses active methodologies with emphasis on Problem-based Learning (PBL) and Project Led Education (PLE). The Design Thinking course is being offered through three modules or training axes: (1) Art, Science, Culture, Innovation and Marketing; (2) Business Plan, Intellectual Property and Industrial Property; and (3) Design Thinking. Thus, the teaching approaches of the course are transformative since in addition to using the active methodologies PBL and PLE they still use Texts Study, Brainstorm, Conceptual Maps, Portfolio, Canvas, Problems Solution, Philips 66, Dramatization, Workshops, Middle Study, Teaching with Research, Product Development, Plant Patent, and Integration Conferences. The first offer of the discipline occurred in 2016, which allowed the achievement of unprecedented results. For example, the evaluation instruments of the teaching methodology approved by the Research Ethics Committee of the Universidade Federal de Goiás (UFG). In addition, an application of the evaluation instruments of the methodology of basic education for the reinforcement and understanding of the methodology by the professors, as well as being part of the continuous evaluation proposed by them of the course. It is important to emphasize that as teaching approaches have been adjusted in weekly meetings among professors so that the objectives are achieved in an increasing way as internal and external conditions for learning and outcomes related to the various factors that are due to work. However, the success of the provision of the discipline by two professors in different classrooms is related to the rigor of the follow-up of the Lesson Plan and the adjustments made during an offer of the Design Thinking course, as well as force of the parties involved.

Keywords: Engineering Education, Active Methodologies, Problem-based Learning, Project Led Education, Design Thinking.

21.1 Background

The nature of core competencies in the training of Engineers involves technical, affective and attitudinal areas, as well as the development of interpersonal skills to coexist in multidisciplinary teams. Depending on the area of Engineering, the elaboration of projects seeks to solve real problems and projects, which can lead to technical recognition by the professional and even the creation of networking opportunities. For example, Swart (2015) proposed the use of Project-Led Education (PLE) in case studies and practical workshops as pedagogies to solve problems in the Electrical Engineering Course[1].

Affective and attitudinal changes can promote self-knowledge, coping with adverse situations, resilience, ability to take risks, commitment and responsibility. The development of interpersonal skills involves assertiveness, flexibility, communication, and negotiation. Depieri and Lopes (2014) confirm the importance of students' perception of Engineering skills despite the low number of engineers per 10,000 inhabitants in Brazil when compared to other countries such as Korea, Finland, China, Japan , UK, among others[2].

In pursuit of these core competencies, the goals of the Design Thinking course in the training of Engineers are structured in general, cognitive and attitudinal aspects. The discipline uses active methodologies, with emphasis on Problem Based Learning (PBL)[3-5] and Project-Led Education (PLE)[6]. The

Design Thinking course is being offered through three modules or training axes: (1) Art, Science, Culture, Innovation and Marketing[7, 8]; (2) Business Plan, Intellectual Property and Industrial Property[8-11]; and (3) Design Thinking[12].

21.2 Purpose/Hypothesis

The Elective course Design Thinking uses active methodologies with emphasis on Problem Based Learning (PBL) and Project-Led Education (PLE).

Ribeiro (2005) proposes the use of three evaluation forms during the learning process through the PBL. The first evaluation form is the Performance Evaluation (AD), in which learners individually evaluate the performance of the PBL group after the execution of an activity. The second evaluation form is the Evaluation of the Educational Process (APE), in which students evaluate the problem and the educational process. Finally, the third evaluation form is the Instructional Method Assessment (AMI)[5].

The evaluation process consisted of calculating the arithmetic mean of the final grades of each module that could involve activities in the classroom, extra class activities, completion of the activities programmed through the PBL and PLE methodology, evaluation activities of the PBL and PLE methodology (AD, APE and AMI) and self-assessments made during the semester. Therefore, there was no traditional evaluations during the Design Thinking course.

21.3 Design/Method

The following contents are part of the Design Thinking discipline syllabus: Art, Science, Culture and Innovation; Market research; Marketing; How to build innovative value propositions (Canvas 1); Preparation of Business Plan (Canvas 2); Intellectual Property and Industrial Property; Design Thinking: prospecting, immersion, evaluation; Ideation and prototyping; Preparation of Industrial Property documentation; Development of products and/or services; Application of real problems and projects.

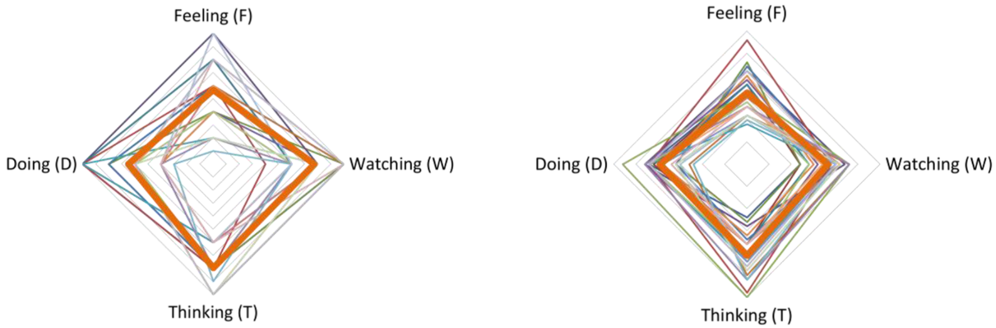
The offer of the Design Thinking discipline are transformative since it uses the active methodologies PBL[3-5] and PLE[6] and the following teaching strategies: Text Study; Brain storm; Conceptual map; Portfolio; Canvas; Problems solution; Philips 66; Dramatization; Offices; Middle study; Teaching with Research, Product Development; Drafting of Industrial Design; and Integration Samples.

For the teaching methodologies evaluation in the offer of the Design Thinking discipline , the following instruments were used: Kolb Learning Assessment; Performance Evaluation (AD); Evaluation of the Educational Process (APE); And Instructional Method Assessment (AMI).

21.4 Results

The first offer of the discipline occurred in 2016, which allowed the achievement of unprecedented results. For example, the evaluation instruments of the teaching methodology approved by the Research Ethics Committee of the Universidade Federal de Goiás (UFG).

The graphs presented in Figure 21.1 present the Kolb Learning Style Assessment[13] in one of the classes of the Design Thinking course in two ways: (a) direct application; and (b) using a more elaborate methodology proposed in[14].



(a) (b)

Figure 21.1 – Evaluation of the Kolb Learning Style in one of the classes of the Design Thinking course: (a) direct application and (b) application using the methodology proposed in[14].

In the case of direct application, learners have identified the order of their learning styles freely only making a choice in the proposed scale for each of the four learning styles: Thinking (T), Watching (W), Doing (D) and Feeling (F). Using the methodology proposed in[14], learners performed assignments in order of importance in four columns (following row by row) to choose words that best characterize their learning style, each of the four words chosen having a weight ranging from 1 (lowest) to 4 (highest). In this case, the sum of the points made it possible to find the order in the learning scale: Thinking (T), Doing (D), Watching (W) and Feeling (F).

21.5 Conclusions

The research revealed that the learning style most recognized by the learners is Thinking (T), being evidenced in both cases free application as well as in the evaluation methodology proposed by[14].

It is important to emphasize that as teaching approaches have been adjusted in weekly meetings among professors so that the objectives are achieved in an increasing way as internal and external conditions for learning and outcomes related to the various factors that are due to work.

However, the success of the provision of the discipline by two professors in different classrooms is related to the rigor of the follow-up of the Lesson Plan and the adjustments made during an offer of the Design Thinking course, as well as force of the parties involved.

Bibliography

1. SWART, A. J. Distance Learning Engineering Students Languish Under Project-Based Learning, But Thrive in Case Studies and Practical Workshops. *IEEE Transactions on Education*, Texas, v. 59, n. 2, p. 98-104, may 2016.

2. DEPIERI, A. A.; LOPES, R. D. Students' Skills Perceptions for Engineering. In: IEEE Global Engineering Education Conference (EDUCON), Instanbul, 2014. *Proceedings...* Instanbul: IEEE, 2014, p. 1-6.

3. de Campos, L. C.; Dirani, E. A. T.; Manrique, A. L. Challenges of the Implementation of an Engineering Course in Problem Based Learning. In: DE CAMPOS, L. C. et al. (Org.) *Project Approaches to Learning in Engineering Education: The Pracice of Teamwork.* Rotterdan: Sense Publishers, p. 5-14, 2012.

4. TAVARES, S. R.; DE CAMPOS L. C.; DE CAMPOS, B. C. O. Análise das Abordagens PBL e PLE na Educação em Engenharia com Base na Taxonomia de Bloom e no Ciclo de Aprendizagem de Kolb. *International Journal on Alive Engineering Education (IJAEEdu)*, Goiânia, v. 1, n. 1, p. 37-46. june 2014.

5. RIBEIRO, L. R. de C. *Aprendizagem Baseada em Problemas (PBL)*. São Carlos: EdUFSCar, 2010.

6. TAVARES, S. R.; DA SILVA, L. P.; DE CAMPOS, L. C. The Perceptions of Engineering Teachers on a "Practice What You Preach" PLE Training Program.

International Journal on Alive Engineering Education (IJAEEdu), Goiânia, v. 1, n. 2, p. 17-26. june 2016.

7. STALLABRASS, J. *Contemporary Art: A Very Short Introduction.* New York: Oxford University Press, 2006.

8. KOTLER, P.; ARMSTRONG, G. *Principles of Marketing.* Harlow: Pearson Education Limited, 2015.

9. OSTERWALDER, A.; PIGNEUR, Y.; CLARK, T. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers.* New Jersey: John Wiley & Sons, Inc., 2010.

10. OSTERWALDER, A. et al. *Value Proposition Design: How to Create Products and Services Customers Want.* New Jersey: John Wiley & Sons, Inc., 2014.

11. ATTORNEY, D. P.; ATTORNEY, T. T. *Patent It Yourself: Your Step-by-Step Guide to Filing at the U.S. Patent Office.* Berkeley: NOLO, 2016.

12. BROWN, T. *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation.* New York: HarperCollins Publishers, 2009.

13. KOLB, D. A. *Experiental Learning: Experience as the source of learning and development.* New Jersey: Prentice Hall, 1983.

14. BERNDT, A.; NAGELSCHMIDT, A. M. P. C. *Estude e aprenda.* São Paulo: Homines, 1997.

CHAPTER 22

Institutional Evaluation Perceptions of UFG Engineering Students

Rosângela Nunes Almeida de Castro[*] and Getúlio Antero de Deus Júnior[♦]

[*]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: rosangela_castro@ufg.br

[*]Escola de Engenharia Elétrica, Mecânica e de Computação,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: gdeusjr@ufg.br

Luis Rodrigo Fernandes Baumann[▲]

[▲]Instituto de Matemática e Estatística,
Universidade Federal de Goiás, Goiânia, Brazil

E-mail: fernandesbaumann@gmail.com

Abstract: The establishment of the Sinaes (Sistema Nacional de Avaliação da Educação Superior – National Higher Education Evaluation System), law nº 10,861 of April 14, 2004, has intensified the debate in the academic community on Higher Education, University and Institutional Evaluation. In relation to Institutional Evaluation, the Universidade Federal de Goiás (UFG) comes following a natural process of evolution and improvement. Deployed formally in 1994, has been going through significant changes resulting from periodic revaluations. In 2015, sensitive to the need for continuous improvement and that the evaluation has received increasingly highlighted in the context of the search for proposals and solutions, the CPA (Comissão Própria de Avaliação – Commission of Evaluation) of UFG submitted to the academic community a new project of institutional evaluation. In this new institutional evaluation project, evaluation processes are involved the entire academic community, in order to strengthen actions in favour of quality, offering multiple analyses

able to subsidize the management of UFG. By involving the entire academic community, provides a complete and complex feedback about the institutional reality. This paper presents the undergraduate students perceptions of the Escola de Engenharia Elétrica, Mecânica e de Computação (EMC) of Universidade Federal de Goiás (UFG) on the academic environment in which they perform. From the assumption that self-knowledge is the first step towards the pursuit of improvement, not only institutional, but also of institutional actors, in 2016, UFG students evaluated the institution, themselves and their teachers. The Institutional Evaluation presents objective questions about academic policies, management policies and infrastructure. The self-evaluation of the students presents questions about their academic performance, interpersonal relationships, respect and compliance with institutional rules. The teachers were evaluated by the students on didactic performance issues, interpersonal relationships, respect and compliance with institutional rules. From the above and relevant literature review, this work presents the question: How to relate the dimensions assessed and UFG courses from the students' perception of EMC on the academic environment in which they are inserted? So, this paper aims to identify possible common factors (dormant), interests, weaknesses, potential of EMC courses, as well as of the institution, and from these, guide future actions in order to promote the improvement of the University.

Keywords: Institutional Evaluation, Engineering Education, Commission of Evaluation, Teaching Evaluation, Interpersonal Relationships.

22.1 Background

The establishment of the Sinaes (Sistema Nacional de Avaliação da Educação Superior – National Higher Education Evaluation System), law nº 10,861 of April 14, 2004, has intensified the debate in the academic community on Higher Education, University and Institutional Evaluation[1].

In relation to Institutional Evaluation, the Universidade Federal de Goiás (UFG) comes following a natural process of evolution and improvement. Deployed formally in 1994, the evaluation has been going through significant changes resulting from periodic revaluations[2-4].

In 2015, sensitive to the need for continuous improvement and that the evaluation has received increasingly attention in the context of the search for proposals and solutions, the CPA (Comissão Própria de Avaliação – Commission of Evaluation) of UFG submitted to the academic community a new project of institutional evaluation. The EMC was one of the UFG academic schools that was submitted to this evaluation process and this work presents a briefly results of this evaluation methodology.

22.2 Purpose

This paper aims to identify possible common factors, interests, weaknesses, potential of EMC courses, as well as of the institution, and from these, guide future actions in order to promote the improvement of the University.

22.3 Method

In 2016, the CPA has made available to undergraduates of UFG three evaluation instruments: Institutional Evaluation Questionnaire, Student Self-evaluation Questionnaire and Teacher Evaluation Questionnaire (Available in portuguese: <https://cavi.prodirh.ufg.br/p/742-instrumentos-de-avaliacao> .Dateofaccess:may,2,2017)>.

The questionnaires were made available in computerized systems of UFG for four weeks. These questionnaires were answered voluntarily and the anonymity was guaranteed.

The questions used in this research were based on the numerical scale according to the agreement with the assertive: zero (“totally disagree”) to 10 (“totally agree”), allowing the possibility to respond to the question “does not apply”.

The Institutional Evaluation Questionnaire consists of fifteen questions, aimed at diagnosing the institution in relation to Academic Policies, management and physical infrastructure. Student Self-Evaluation Questionnaire consists of five questions about their academic performance, interpersonal relationships, respect and compliance with institutional rules. Teacher Evaluation Questionnaire has nine questions about educational performance, interpersonal relationships, respect and compliance with institutional rules. At the end of each questionnaire there is a space for comments, which gives a qualitative aspect to the process[5].

22.4 Results

In UFG, 11,603 students participated in the institutional evaluation, representing 44% of the total number of students enrolled in undergraduate courses at the institution. In the case of EMC students, the participation was of 500 Engineering students, which represents 49,95% of the enrolled. Given that the evaluation is voluntary, it can be inferred that there has been a satisfactory participation, above average for the participation of other UFG courses students.

In general, the perception of the students was favorable. A balance in the evaluations made by EMC Engineering students and other students of the UFG is visible. Figure 22.1 presents the average of each institutional evaluation questionnaire response.

The results of the fifteen questions averaged between 5.69 and 8.06. The question that addressed the libraries was the best evaluated. The EMC Engineering students attributed the second highest score to physical and digital library collection. On the other hand, the infrastructure-related questions (11 and 15) had the lowest averages deserving greater attention of the managers of the institution.

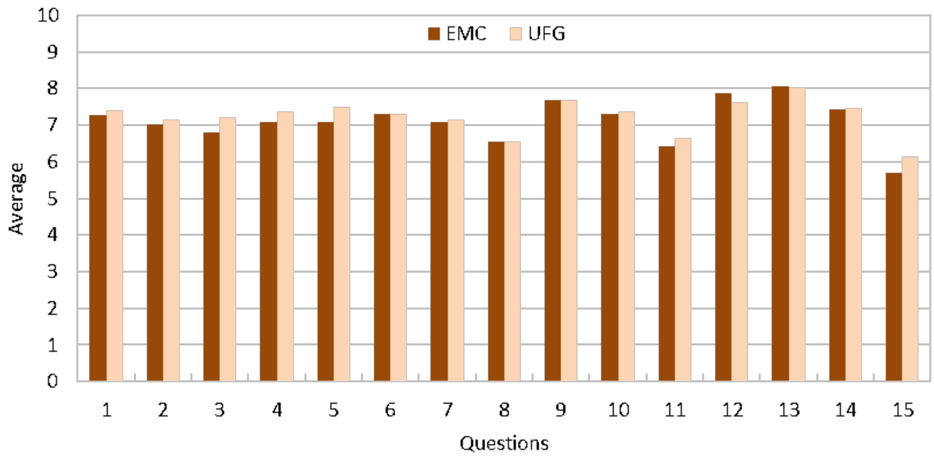


Figure 22.1 – Results of institutional evaluation by students (2016).

In relation to student self-evaluation, the results of the five questions averaged between 7.65 and 9.58 and standard deviations did not exceed 1.80, showing that there was no high dispersion in the notes conferred by the students. In General, students were positively in self-evaluation. However, EMC students' self-evaluation presented below-average grades than the others UFG students.

The results of the teachers' evaluation by the students averaged between 7.68 and 9.16. An important contribution is a comparison of the individual performance in relation to the average performance of UFG teachers. It is up to the teacher to check if his/her evaluation matches or not the average percentage assigned to the UFG teachers and case deems necessary, improve his/her performance.

22.5 Conclusions

This work concluded that the evaluation should be made of various procedures and instruments, in the form of studies, discussions regarding all dimensions and course structures. The reports generated from the evaluative models, of which EMC was submitted, provided a set of information able to diagnose the weaknesses and strengths.

The perception of Engineering students ratifies that EMC is delivering with its mission, contributing to the social development, from the understanding of education as a broader education complex.

Bibliography

1. MINISTÉRIO da Educação. *SINAES: Sistema Nacional de Avaliação da Educação Superior: Da Concepção à Regulamentação*. Brasília: 2004, pp. 57.

2. COMISSÃO de Avaliação Institucional. *Avaliação Institucional: Uma Mudança em Curso*. Goiânia: CEGRAF, 2000.

3. COMISSÃO de Avaliação Institucional. *Avaliação Institucional: Uma Prática de Gestão*. Goiânia: CEGRAF, 2006.

4. COMISSÃO de Avaliação Institucional. *Avaliação Institucional: Renovação e Integração*. Goiânia: CEGRAF, 2015.

5. COMISSÃO de Avaliação Institucional. *Instrumentos de Avaliação da Comissão de Avaliação Institucional*. Available in: <https://cavi.prodi-rh.ufg.br/p/742-instrumentos-de-avaliacao>. Acessed in: 2 may 2017.

CHAPTER 23

The Perceptions of Engineering Teachers on A "Practice What You Preach" PLE Training Program

Samuel Ribeiro Tavares[*] and Léa Paz da Silva[♦]

[*]Universidade Nove de Julho, São Paulo, Brazil

E-mail: samueltavares@yahoo.com

[♦]Universidade Nove de Julho, São Paulo, Brazil

E-mail: leapazsilva@gmail.com

Luiz Carlos de Campos[▲]

▲Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: lccampos@pucsp.br

Abstract: This study means to contribute to the theoretical foundations and practical applications of the PLE (Project-Led Education) methodology, which is still very incipient, and requires much discussion about how and with what results it has been being used in Engineering programs throughout the world. This paper offers a conceptual model of Engineering teachers' necessary competencies in PLE developed by eight teachers from one of those three Universities studied by Tavares & Campos (2013), who decided to prepare themselves for the PLE methodology new teaching roles, through a training program designed on the basis of PLE methodology itself, which would allow them to experience the PLE methodology from their students' perspective. A synthesis on the teachers' perceptions about the training program, obtained through a Likert scale questionnaire, and confirmed through observation and unstructured interviews, indicated that a teachers training based on the PLE methodology can be an effective way for Universities to help them understand students' and teachers' roles in this new educational methodology.

Keywords: Engineering Teaching, Engineering Learning, Problem-Based Learning, Project-Led Education, Teachers Training.

23.1 Background

Informal talks with many of the teachers who took part in the research indicated that they (almost secretly) felt unable to adequately implement the PBL and PLE methodologies' theory and practice in their classes, and, among the possible reasons for this, it stood out their perception that it was because they had been taught in the traditional way.

Exploring this point a little further, it was common ground that, as students, they had not been stimulated to comprehensively acquire Knowledge; that they had always worked alone or in ill-formed groups; and that they lacked the experience of critical thinking and problem solving, together with sharing common objectives and results (as required in the PBL and PLE methodologies), and so, as teachers, the concept of tutoring (supporting students' cognitive/social skills development) was almost alien to them.

This led the authors to the idea of creating an opportunity where some of those teachers could practice what they were preaching in their classrooms, and to experience the PLE proposal as students, so that they could become aware of the opportunities and difficulties of intense team work, strict timelines, real life problems and interdisciplinary knowledge.

23.2 Purpose/Hypothesis

The purpose of this paper is to report the experience of preparing eight teachers from one of the three Universities studied by Tavares and Campos (2013) to take on their new roles in the PLE methodology, through a training program designed on the basis of the PLE methodology itself, in order to provide them with the experience of practicing what they preach.

The main research question was “Can a teachers training program based on the PLE methodology be an effective way for Universities to help them understand students’ and teachers’ roles in this new educational methodology?”

23.3 Design/Method

As method of approach[1] this study was developed under the inductive method[2]; as method of procedure[3], this investigation embraced the monographic method[2]; as method of investigation[4], this research adopted the case study[2].

From among the different techniques for data collection, this study relied on observation, unstructured interviews and a Likert scale closed-question questionnaire[5]; and, with regard to the techniques for data analysis, mainly the quantitative (the objective numerically expressed analysis of observed phenomena)[6] treatment was applied.

For the organization of the training program Weenk and friends' principles[7] were followed, since they provide Engineering teachers with the opportunity of experiencing PLE learning from their students' viewpoint: in a five session course participants underwent teamwork project development and management, whose final deliverable was the presentation of a conceptual model of Engineering teachers' necessary competencies in PLE.

23.4 Results

Following the PLE methodology – marked by mutual cognitive and social interaction – participants, after collecting and analyzing data and information that could lead to the development of a conceptual model of Engineering teachers' necessary competencies in PLE, arrived to the idea expressed in Figure 23.1.

Results of the answers provided by the participants in the Likert scale closed-question questionnaire are showed in Figure 46.1:

Analysis of the answers in the Graph of the Figure 23.2 revealed that: A) 70% of the participants totally agreed that the training program was designed to ensure content integration (questions 1, 2, 3); B) 75% of the participants totally agreed that the training program was guided by the project management methodology (questions 4, 5, 6); C) 85% of the participants totally agreed that

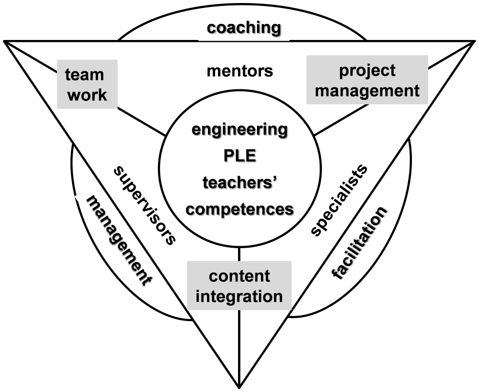


Figure 23.1 – Engineering teachers' necessary competencies in PLE.

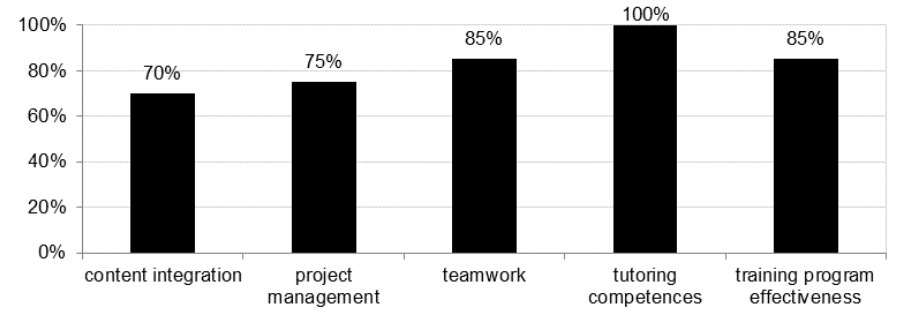


Figure 23.2 – Participants' perception on the task they performed.

teamwork was an essential part of the training program (questions 7, 8, 9); D) 100% of the participants totally agreed that the tutor had to exercise the competences of coaching, facilitation and management in the training program (questions 10, 11, 12); and E) 85% of the participants totally agreed that the training program was an effective way to understand learning and teaching in the PLE methodology (questions 13, 14, 15).

Participants' main ideas collected in the unstructured interviews general guidelines are: A) class time devoted to application of concepts by the participants and more time for one-on-one teacher-participant interaction are the most positive aspect(s) of the educational approach adopted by the training course to the PLE methodology; B) limited time frame for the scale of the task is the least positive aspect(s) of the educational approach adopted by the training course to the PLE methodology; and C) adjustment of time frame to the scale of the task is a suggestion for improving the educational approach adopted by the training course to the PLE methodology.

23.5 Conclusions

In face of the collected data, it is possible to infer that the answer to this research's main question is yes, a teachers training based on the PLE methodology can be an effective way for Universities to help them understand students' and teachers' roles in this new educational methodology.

Bibliography

1. MARCONI, M. A.; LAKATOS, E. M. *Metodologia do trabalho científico.* São Paulo: Atlas, 2006.

2. TAVARES, S. R.; CAMPOS, L. C. A survey on the synergy between teaching and learning approaches in Brazilian Engineering Schools. In: 5th International Symposium on Project Approaches in Engineering Education: Closing the Gap between University and Industry. Eindhoven: PAEE, 2013.

3. BATISTA-DOS-SANTOS, A. C.; ALLOUFA, J. M. L.; NEPOMUCENO, L. H. Epistemologia e metodologia para as pesquisas críticas em Administração. *Revista de Administração de Empresas*, São Paulo, v. 50, n. 3, p. 312-324, jul./set. 2010.

4. VERGARA, S. C. *Métodos de pesquisa em Administração.* São Paulo: Atlas, 2005.

5. MARCONI, M. A.; LAKATOS, E. M. *Técnicas de pesquisa.* São Paulo: Atlas, 1990.

6. GIL, A. C. *Didática do ensino superior.* São Paulo: Atlas, 2006.

7. WEENK, W.; GOVERS E.; GLAS, H. Training in project-based education: practice as you preach. *European Journal of Engineering Education*, v. 29, n. 4, p. 465-475. 2004.

CHAPTER 24

Development of A Modular PLC Using A Low Cost Microcontroller Architecture

Natã Franco Soares de Bem[*], Sâmia Melo Rogel[♦] and Anísio Peixoto Milani[▲]

[*]Grupo PET de Controle e Automação, Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: natan.franco.s@gmail.com

[♦]Grupo PET de Controle e Automação, Centro Federal de Educação

Tecnológica de Minas Gerais,
Leopoldina, Brazil

E-mail: samiamr5@yahoo.com.br

▲Grupo PET de Controle e Automação, Centro Federal de Educação
Tecnológica de Minas Gerais,
Leopoldina, Brazil

E-mail: anisiomilani@hotmail.com

Lindolpho Oliveira de Araújo Junior▼

▼Engenharia de Controle e Automação,
Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: lindolpho@leopoldina.cefetmg.br

Abstract: Programmable Logic Controllers (PLC) are computer-like devices used to control and monitor various procedures, being an efficient technology within automation and industrial processes. The main differences between them lay on the lack of friendly interface and peripherals and the languages used to program and operate them. It uses special languages, one of which is Ladder Language mainly employed due to its easiness, conciseness and robustness. Although very common in the industry sector, its teaching, however, faces

some obstacles, mainly due to the price of the hardware or the software license. The need to find an accessible solution to this problem, without compromising the quality of the knowledge, has brought some Programmable Logic Controllers technologies up to teach young technicians and Engineering students by using microcontrollers as the hardware while still using Ladder language. Due to the shortage of a suitable PLC-like structure, this paper studies the application and implementation of an open source and hardware, modular and low cost PLC to be used in automation and industrial classes. We developed I/O modules to work with the main processor module, being able to interchange them, allowing the students to build different configurations based on the needs. All the modules are optically or magnetically insulated to protect the processor. The software used to program and upload the files to the PLC-like architecture are open source and free. The modular structure uses an ATMEL8L processor, similar to ones found in Arduino®. Results show the validation of the hardware and software architecture, with the most used functions in PLCs being tested, such as I/O, comparators, timers and counters. This allows students to be in touch with active teaching methodology, as the students become able to understand not only how to program PLC, but also how it works and controls processes. There is the possibility to build new knowledge up from established know-how, besides being more affordable and easy to implement than the industrial solutions available currently. We would like to thank CEFET-

MG and FNDE for their support in this project.

Keywords: Automation, Ladder Language, Low Cost, Microcontrollers, Programmable Logic Controllers.

24.1 Background

A PLC is very similar to a computer, although the main differences lie in the lack of friendly peripherals and interface. Though, what it lacks in friendly peripherals, it compensates with the common and handy possibility of adding modules, such as more digital or analog inputs and outputs and communication protocols[1].

Yet, because of the difficulty and the failure to teach properly and throughout all the course of the university or vocational degree, considerably number of students do not have the full knowledge to fully develop a ladder program. Besides that, it is known that PLCs have a considerable high cost and, because of that, it becomes rather difficult to schools and/or universities to own adequate quantity for every class, that is, the high cost leads to distress at teaching industrial control.

Therefore, this article will have as main goal to present the development of a device with applicability compatible to PLCs and, with a bigger advantage, that is a smaller cost. When using a microcontroller as the processor such as ATMEGA, and building the modules, the price of the application can be reduced to a fraction of the price of an ordinary PLC.

24.2 Purpose/Hypothesis

Due to the scarcity of a PLC-like structure, this article focuses on the application and implementation of an open-source PLC and modular, low-cost hardware for use in automation and industrial classes.

24.3 Design/Method

The main module is the CPU, which contains the microchip ATMEGA8L and its connections for transferring the programs to it. There are several input and output modules, designed with different types of electronic devices, such as transistors, relays and optocouplers, as shown in Figure 24.1.

Such inputs and outputs modules are designed to allow the device to work with analog and digital signals. Also some of these modules as input (OpAmp and Transistor) convert the voltage to a lower level from the process in a way that the ATMEGA can safely work with it. In the same way, when those modules are organized as output, they elevate the voltage to a process level.

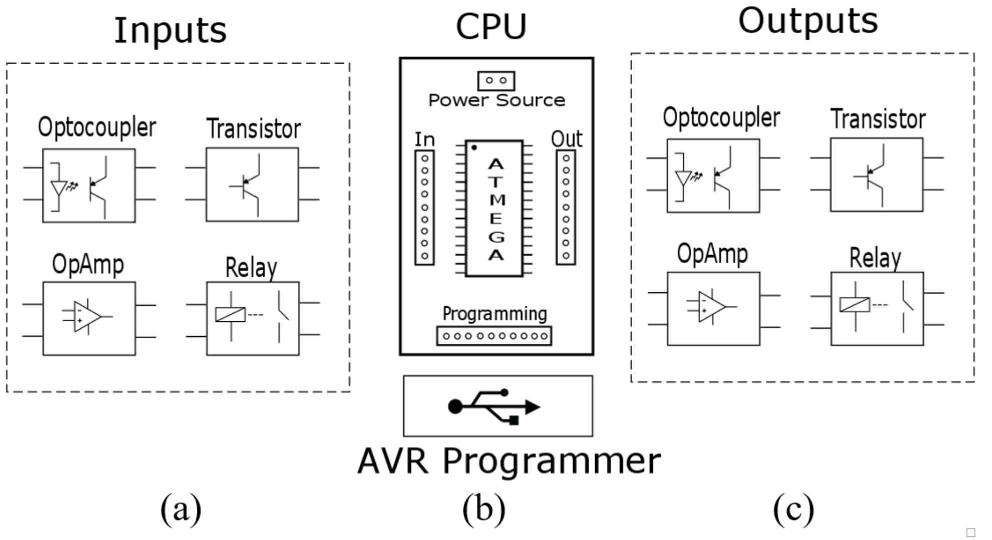


Figure 24.1 – Schematic of the project. a) In the left, there are the input modules, b) In the middle it is represented the main module, which contains the microprocessor ATMEGA8L and c) in the right the output modules.

For programming in Ladder, it is used the freeware LDMicro. LDMicro allows the user to choose the microcontroller and it shows all the available pins for the chip[2]. All those available pins can be set as inputs or outputs, depending on the need for the circuit. This software is able to export the Ladder diagram as a hex file. An AVR burner (eXtreme Burner) is used to transfer from the computer to the CPU module (ATMEGA8L) using a USB programmer (USBAsp), as is demonstrated in Figure 24.2.

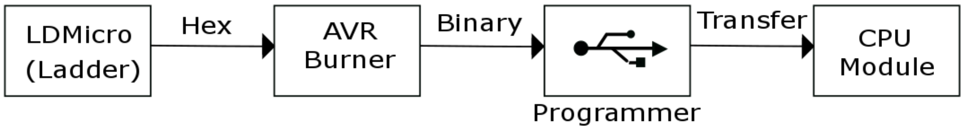


Figure 24.2 – Programmer and transfer process of the Ladder files to ATMEGA.

24.4 Results

The architecture designed works neatly with the microprocessor used. All basic functions in LDMicro have been tested and validated. Functions tested include: make and break contacts, coil, timer, counters and seals for contacts. LDMicro allows the user to select the microprocessor in use, showing the pins available for connecting inputs and outputs. Furthermore, it can export the Ladder diagrams as hex files, for burning in the microchip. There are several AVR burners, most of them free and all of them can transfer the hex file. In this project eXtreme Burner was preferred due to its GUI interface. A USBAsp programmer was used as transfer means for the microchip.

24.5 Conclusions

This affordable PLC can be fabricated with 20 dollars, which is about 10 times cheaper than standard PLC available today. The developed PLC can be used in a variety of classes to teach different approaches using the same hardware. It allows students to learn about programming in Ladder and how PLC works from inside out. It can also be used to teach microcontrollers and its languages, such as C for microcontrollers and even Assembly. Because of its open, modular architecture, students can upgrade the inputs and outputs modules, creating different versions of them, enabling them to fully understand those concepts.

Future work include the development of more modules, such as small modules of processes to be controlled and different types of voltage levels for inputs and outputs.

Bibliography

1. STRASSER, T.; FROSCHAUER, R. Autonomous Application Recovery in Distributed Intelligent Automation and Control Systems. *IEEE Transactions on Systems, Man, and Cybernetics - Part C: Applications and Reviews*, v. 42, n. 6, p. 1054-1070. nov. 2012.

2. WESTHUES, J. *LDMicro*. Available in: <http://cq.cx/index.pl>. Accessed in: apr. 2017.

CHAPTER 25

Prototype of A Low Cost Neonatal Incubator Using the Arduino Platform and A Temperature Monitoring System from An Android App

Flávia de Cássia Martins Ribeiro[*], Kamilla Paixão Castro[♦], Jean Daniel Foro Ferreira[▲], Carolina Gomes da Silva[▼] and Wellington da Silva Fonseca[○]

[*]Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: flaviaribeiro_27@yahoo.com.br

♦Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: kamillapcastro@gmail.com

▲Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: jdferreira1512@gmail.com

▼Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: fonseca@ufpa.br

Abstract: The neonatal incubator is a developed project that has the purpose of to expand skills from the technical knowledge in Engineering and it is a challenge if we consider the needs in the health technology field. Thus, developing and executing strategies that optimize the learning process is the utmost importance to provide to the students some skills as pro-activity. Emphasizing the need to develop equipment for the improvement of medicine and biological sciences in general, we have that, acquire equipment capable of contributing to the technological evolution in the medical field has been comprehensive, because the advances of biological systems and apparatus that help the health professional became common worldwide. However, in general, medical equipments are really expensive. In view of this problem and

the need for a new technological approach, a search was made to find some economically viable components in order to make easier the access for some professionals interested in technologies which could turn the diagnoses more fast and effective. With this project, we intend to explore several concepts of courses from the Biomedical Engineer department of UFPA (Universidade Federal do Pará), as well as to encourage the knowledge and development of new technologies. This article presents a prototype of a low cost neonatal incubator coupled to a newborn body temperature monitoring system from an android mobile application. The prototype was developed by a software, it has been tested and it follows some technical standards of installations and works from a dome made of acrylic with several intelligent sensors such as temperature and humidity (DHT11), piezoelectric sensor and sensor Of skin, those sensors contribute to increase the incubator's performance. The control of these sensors is made by a Arduino platform which is currently considered easily accessible for the creation of projects and prototypes for the insertion of knowledge in Engineering. In addition, the Arduino enabled the monitoring process in a simplified way, a example of that is the creation of mobile applications in the Android language. For monitoring, the knowledge about the temperature of a newborn is extremely important because the baby needs a specific care, such as reading of weight and monitoring of temperature and pulse, which must be done constantly. The neonatal incubators for newborns are essential for this process, therefore, the development of the low cost prototype aims to make the measurements minimally invasive for the newborn, which helps in the treatment and recovery, and also contribute to an low and effective investment.

Keywords: Neonatal Incubator, Health Technology, Low Cost Prototype, Arduino, Engineering Education.

25.1 About low cost neonatal incubator

The use and creation of health technology have big importance for the realization of the comprehensive activities in health field, encompassing a set of skills to promote the health, rehabilitation, prevention and treatment of diseases. In this perspective, a multi-professional presence is so important, being one of the main the engineer, in special the Biomedical Engineer.

Like this, this work's objective is to show a low cost neonatal incubator with a temperature monitoring system from an android mobile application, idealized by UFPA's Engineer Biomedical graduating. The project was direct for a conception of an incubator because of the equipment importance on neonatal field. Since this is a device specially designed to provide the newborn ideals when suitable conditions when have difficulty adapting to the external environment.

For monitoring, the knowledge about the temperature of a newborn is extremely important because the baby needs a specific care, such as reading of weight and monitoring of temperature and pulse, which must be do constantly. The neonatal incubators for newborns are essential for this process; therefore, the development of the low cost prototype aims to make the measurements minimally invasive for the newborn, which helps in the treatment and recovery.

25.2 Methods

The project was developed for a neonatal assistance to offer a low cost incubator that offer technologies to facilitate the newborn monitoring, diagnosed by temperature e humidity (DHT11), skin sensor. The monitoring will be made by an Android Mobile application.

A software developed the prototype, it has been test and it follows some technical standards of installations and works from a dome made of acrylic. This information is essential for monitoring the neonatal while in the incubator.

25.3 Design software on 3D

A software was use, a 3D modeling platform made the acrylic dome vision possible and the sensor storage. This sensor was severally important to a newborn monitoring on the low cost incubator, because sensor was necessary for development of the incubator control system. For temperature and humidity control, DHT11 (controlled by Arduino platform) was use to read temperatures and humidity. In practical terms, Arduino is a little computer programed to process inputs and outputs between device and the components connected to it[1]. The internal circuit make the sensor readings and communicate with Arduino. Especially designers and artists that want to create easily prototype, but do not need a deep understanding about the technical details behind your creations[1] use the Arduino in so many educational programs around the world. Besides that, a LCD monitor 16x2 is also part of the assembled circuit; its objective is to reach the reading of the circulating temperature for the newborn and to assist the health professional so that he is aware of the temperature control of the newborn. In picture next, this is a software of incubator and your system control built for arduino platform.

The Figure 25.1 shows the incubator and your system control built for Arduino. The Figure 25.2 shows the prototype incubator on software and the Figure 25.3 shows the 3D APP Android incubator neonatal.

An early warning system was also develop for accessibility in the neonatal ward. The Android application, called “Baby Control”, aims to send information about the temperature of the RN via Bluetooth for users who are monitoring the babies on their shift. A quick and If there is any abrupt change in temperature, the application prompts the user to check the Neonate. “Help” windows are

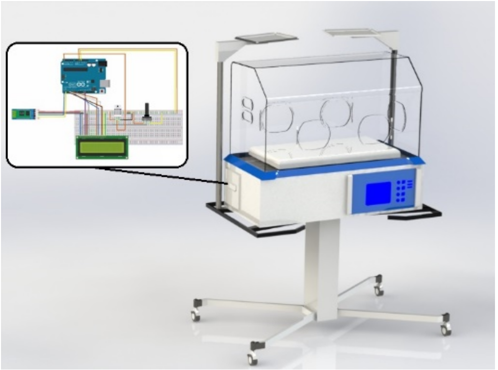


Figure 25.1 – Incubator and your system control built for Arduino.

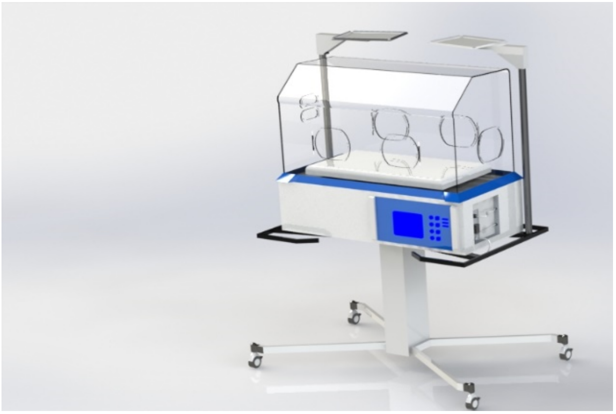


Figure 25.2 – Prototype incubator on software.

also insert into the application so that it use correctly.

Figure 25.3 – 3D APP Android incubator neonatal.

25.4 Conclusions

In our daily life in Biomedical Engineering, we find several problems that can be monitor and even solved. The technology ends up being restrict by the lack of professionals in the technological area. Health informatics[2] is a branch of the course with the objective of training and encouraging students to develop software,

Which facilitated the creation of the application for temperature monitoring. Neonatal incubators have a high price on the market and for this reason; it has been the inspiration for the development of a low-cost prototype that can be use in the best way for newborns and their accompanying professionals.

For future improvements, other sensors are expect to be more precise and accurate in relation to numerical values. As an NTC temperature sensor, a thermocouple (electronic component capable of reading the immediate temperature of the circuit in question) and modifications in the application according to its precise values.

Bibliography

1. DA SILVA, F. I.; SCHERER, D. Praxedes: Protótipo de um kit educacional de robótica baseado na plataforma Arduino. *EaD & Tecnologias Digitais na Educação*, Dourados, v. 1, p.44-56, 2013. Avaiable in: <http://ojs.ufgd.edu.br/ojs/index.php/ead/article/view/2654/1492>. Acessed in: jan. 2017.

2. Alves, R. M. et al. Uso do hardware livre Arduino em ambientes de ensino-aprendizagem. *Jornada de Atualização em Informática na Educação*, Porto Alegre, v. 1, p.162-187, 2013. Avaiable in: <http://br-ie.org/pub/index.php/pie/article/view/2346/2101>. Acessed in: feb. 2017.

CHAPTER 26

Application of The Flipped Classroom, Jigsaw Classroom and PBL Methodologies in An Electrical Engineering Course

Wellington da Silva Fonseca[*], Carolina Gomes da Silva[♦], Alan Sovano Gomes[▲] and Suzana Cescon de Souza[▼]

[*]Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: fonseca@ufpa.br

[♦]Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: c.gomes@outlook.com.br

▲Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: alan.s.gomes@ieee.org

▼Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: suzana3195@hotmail.com

Abstract: This paper intends to demonstrate an application of three learning methodologies – Problem Based Learning (PBL), The Jigsaw Classroom and Flipped Classroom – in an Electrical Materials I class, present in the fourth semester curriculum of the Electrical Engineering Course at the Universidade Federal do Pará (UFPA). Such an application was considered innovative because, besides stimulating proactivity, it was able to intercalate several methodologies that show to the students, in a practical way, how to apply the theoretical knowledge acquired in class in common problems and projects find in Engineering. During the course, each evaluation (in a total of four) involved unique characteristics of the used methodologies, but traditional tests, about the course content, were still being applied by the teacher. Another measure adopted was the choice to use a main object of study, this being the transformer, extremely used and necessary equipment in electrical power systems, an electrical Engineering actuation field. Thus, during this work elaboration, a bibliographical research was done about these methodologies, besides a study about how the discipline in question was previously taught and the differences between his content at UFPA and other universities. After the last evaluation and the dissemination of the grades obtained by the students, an opinion survey was conducted (using the Likert scale) as a way to obtain a return about the level of acceptance regarding the way in which the discipline was presented. In addition, discursive questions were asked so that the students could give their opinion in a critical way, which would be considered for a better implementation in the subsequent classes. Finally, it is worth emphasize that the technique used during the course culminated in the production of articles written by the class, in order to exercise the scientific writing of the students. The set of these attributes contributed to the development and improvement of necessary skills that must be worked in an engineer's formation at the present time.

Keywords: Active Learning, Electrical Engineering, Flipped Classroom, Jigsaw Classroom, Project Based Learning.

26.1 Background

The learning quality of university students can be optimized through the use of teaching techniques that deviate from the traditional model (with the students being the passive agents in the teaching-learning dynamics). The scientific literature shows several cases in which methodologies that focus on proactivity have provided good results, such as: group skills development, the realization of projects which show practical applications of the subjects in question and a better content assimilation, according to what students report[1-3].

This work is a case study of the Electrical Materials I module, taught in the second semester of 2016. The group had 39 students from the Electrical Engineering course present in the Universidade Federal do Pará. The teacher in charge of the classes aimed to merge three types of methodology, these being: Project-Based Learning (PBL), Flipped Classroom and Jigsaw Learning. These methodologies will be described during this work.

26.2 Purpose/Hypothesis

The objective of this work is to describe the application and results of the PBL, Flipped Classroom and Jigsaw Classroom methodologies, since the practice was considered innovative when it merged several teaching techniques into a discipline that, within the UFPA Electrical Engineering course, was always teached in the traditional way.

During the semester, it was attempted to show the students practical applications in which concerns the Electric Materials I Module. To accomplish that, it was used of a main study object, the transformer, since it has, in its composition, materials with strong dielectric, conductive and ferromagnetic properties, for example[4, 5]. In addition, this equipment is widely used in electrical power systems, strong actuation field in the Electrical Engineering area.

It is worth pointing that the mentioned methodologies were applied in a way to be adapted to the module's reality, seeking to maintain the elementary characteristics of each one.

26.3 Design/Method

On the first day, the teacher asked the class to divide into groups and explained how would be their evaluation, which was divided into two tests, a seminar and a project (about which they should write an article and do an oral presentation). In the project, the students should, in some way, model the object of study chosen, taking into account, mainly, the electrical properties of the materials that compose the transformer.

After the division of groups, each student was also responsible for a specific theme, which resulted in the assembly of new groups (secondary groups) with students who had the same theme in common. After the study of these subjects, which related to the types of materials from the electromagnetic point of view (diamagnetic materials, conductors, dielectrics, among others), the main groups were built once again, each member being considered “specialist” in a given theme, which proved to be important for the final work, encouraging teamwork. This technique is called the Jigsaw Classroom[2].

With the seminars, the students did researches and presentations about the module’s content before the teacher’s lesson, causing the class to have a previous understanding about the topics of the module, besides the more active role students acquired at the classroom. This approach is known as Flipped Classroom[3].

In order to focus the student as the active agent in learning process, the PBL method was also used during Electrical Materials I module. This methodology uses a project approach, where the teacher and /or a tutor guide the students using the necessary didactic resources for each situation. With the proposal made for the final evaluation, students were motivated to look for more information on transformers, so that they could find efficient project design solutions, with each team elaborating their solution[1].

26.4 Results

The studies’ results were analyzed using an opinion survey in a Likert scale of five alternatives, which shows the degree of acceptance of the respondents about any proposed statement. The survey was divided into four parts: one about the Jigsaw methodology (questions 1 to 5); one about the PBL (6 to 10); one about the Flipped Classroom methodology (11 to 15) and one with general questions (16 to 20). Before the first three parts, there was a text explaining briefly each of the methodologies. The survey involved general questions (whether the students had identified the use of methodologies or not, whether their application was valid in the subject, if there was an improvement on the class dynamics, among others), with the last two questions (19 and 21) being discursive, so that the students could express their opinion about the module (pros and cons) and to report if they had any previous experience of this kind at some earlier point at UFPA's Electrical Engineering course. 14 out of 39 students decided to answer the survey.

After the survey analysis, it was possible to imply that the used techniques were quite adequate and well accepted by the students, who reported that few modules during their graduation were taught differently of the traditional way. According to the undergraduates, classroom performance was better, as was the assimilation of content and the development of skills essential to an engineer, such as problem solving, teamwork and proactivity. Some students also reported that they would like to have had more expository classes and more exercise resolutions, but even so, they recognized that the methodologies cited have yielded advantageous experiences. Finally, it was observed that the application of these methodologies instigated the students to produce their own elaborated scientific knowledge among their competences, promoting benefits for their academic life.

26.5 Opinion Survey

1) Do you identify the use of this methodology in the Electrical Materials I module?; 2) It is valid the use of this methodology in the Electrical Materials I module; 3) It is possible to work more independently in the Jigsaw Classroom format than in the traditional methodology; 4) The Jigsaw Classroom leaves the work very dependent on the performance of the other members of the group; 5) The distribution of roles among the participants of the base groups facilitated the realization of the final project requested by the teacher; 6) Do you identify the use of this methodology in the Electrical Materials I module?; 8) The application of the PBL methodology can positively influence learning; 9) Project design assists student pro-activity; 10) This methodology provides a practical overview an Engineering project development; 11) Do you identify the use of this methodology in the Electrical Materials I module?; 12) It is valid the use of this methodology in the Electrical Materials I module; 13) This methodology improves the class dynamics, since the students, after making the presentations, already have a theoretical background and doubts about the

topics to be taught; 14) The student acquires more autonomy in the learning process from the Inverted Classroom methodology; 15) It is possible, using this methodology, to perceive which students really have some difficulty in the subjects, being able to draw the profile of each student and give more attention to the one that really needs; 16) The timetable of the course was adequate for the presentation of all the works, projects and lessons; 17) The evaluations were considered appropriate for this module; 18) The use of different teaching methodologies provided a more complete experience in relation to knowledge production; 19) Among the modules you have studied so far, have you identified the use of these methodologies? Which (modules and methodologies)?; 20) How was your experience during the Electric Materials I module (with the methodologies used) and what need to change?

Bibliography

1. SILVA, S. P. ET AL. A responsabilidade socioambiental estimulada através da metodologia PBL: Uma experiência na região amazônica no ensino de engenharia. IV International Symposium on Project Approaches in Engineering Education PAEE, São Paulo, july 2012. *Proceedings...* São Paulo: School of Engineering of University of Minho, p. 263-267, july 2012.

2. FATARELI, E. F. et al. Método cooperativo de aprendizagem jigsaw no ensino

de cinética química. *Química Nova na Escola*, São Paulo, v. 32, n. 3, p. 161-168, aug. 2010.

3. BERGMANN, J.; SAMS, A. *Flip your classroom: Reach every student in every class every day.* Illinois: International Society for Technology in Education, 2012.

4. LIMA, D. S.; FONSECA, W. S. A Importância do Engenheiro em Utilizar Métodos Computacionais para Análises de Estados Transitórios em Transformadores. In: Congresso Brasileiro de Educação em Engenharia. Juiz de Fora, sept. 2014.

5. FONSECA, W. S.; LOPES, A. C.; NUNES, M. V. Modelagem de esforços eletromecânicos de transformador de núcleo amorfo através do método de elementos finitos. In: IEE/PES Transmition and Distribuition Conference and Distribution Latin America, São Paulo, nov. 2010. *Anais...* São Paulo IEEE, p. 1-6, nov. 2010.

CHAPTER 27

Jigsaw Learning: An Active Learning Strategy for Large Groups

Mairlos Parra Navarro* and Angelo E. Battistini Marques♦

*Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: prof.mairlos@usjt.br

♦Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: prof.battistini@usjt.br

Abstract: This paper describes the application of educational dynamic known as "Jigsaw Learning" in Engineering Courses, presenting the results achieved in

practice with several groups, since initial to more advanced series. A good professional performance requires, on the part of the students, some attitudes and postures that must be exercised within the academic environment, and that go beyond the contents (approached either in practical or lecture classes). Providing opportunities to simulate, experiment and evaluate some practices and situations are part of the school's role in educating Engineers. The application of the Jigsaw Learning technique can enable students to understand, practice, and improve in skills and attitudes considered important in the Engineering career, in addition to the content being developed. This practice seems to reinforce the effectiveness of peer instruction, since much of the methodology provides interaction between the students, allowing each one to assist in the construction of knowledge. Its execution is also highlighted by the effective application of active learning, since the students have an active posture in relation to the topic studied, seeking knowledge by their own resources and also in the interaction with colleagues and teachers, bases for a socio-constructivist learning. Jigsaw Learning is an active learning practice that performs well when working with large groups of students, unlike most active methodologies, which are most effective with small groups. In the applications described, this methodology was carried out with groups of 60 to 100 students. The results obtained in the proposed discussions, textual productions and reviews appear quite satisfactory and, in several cases, surpassing expectations in a positive way when compared to traditional approaches to the same concepts. The change in the role played by the student (and therefore by the teacher) during the practice of this activity seems important for a greater engagement of classes and better academic results.

Keywords: Active Learning, Interdisciplinary Teaching Approaches, Jigsaw Learning, Project-Led Education.

27.1 Background

Most of active methodologies models adopted in higher education institutions often show difficulties when applied with a large number of students. In this article we propose a way of working with large numbers of students in classrooms through the dynamics known as “Jigsaw Learning”.

The dynamics was created in the 70’s by Elliot Aronson[1] in an attempt to integrate classes with students from different ethnicities. The utilization of this methodology during lessons allow groups of students to study a topic having different views on it. So the subject and/or topic studied should be clearly stated, as well as bias that students are expected to work on.

27.2 Purpose/Hypothesis

The Jigsaw class is a learning methodology that combines three different elements:

1. Active learning[2];
2. Collaborative learning[3]; and
3. Peer instruction[4].

In this teaching model students experience different ways of learning and content approaches, passing through reading, discussion, writing, presentations and then ending with a final report.

The consultation materials prepared by the teacher (in the form of a portfolio) as well as the orientation in the discussions will be very important to reach the proposed objective.

27.3 Design/Method

The teacher should prepare in advance the reference materials that each group will receive for study, creating a mosaic of contents, which will be assembled by the students, through the activities developed. Each group (which happens to be called "specialist") receives different texts that approach the same theme under certain particular (specific) optics. All group members should study the material assigned to their group.

After reading and studying, students are asked to discuss the group text and come to their conclusions. Each individual student is now asked to produce three (3) texts:

1. Summary of the text: report, without value judgment.

2. Group opinion and conclusion after discussions.

3. Own opinion about what he studied, indicating agreement and disagreement with both the text received and the conclusion of the group.

With individual production in hand, the groups are then reorganized, so that there is at least one “expert” member in each new group formed.

In this new group, called the “construction group”, each of the students should make an exposition of the topic they studied previously to the other members, so that everyone becomes familiar with all the topics (and biases) studied.

At the end of the presentations, a round of discussion and debate takes place, building the general understanding. This group understanding is built after exposing the different forms of external approaches (texts previously distributed) and the individual collaborations brought by the students. Figure 27.1 shows the specialist and the construction groups formation.

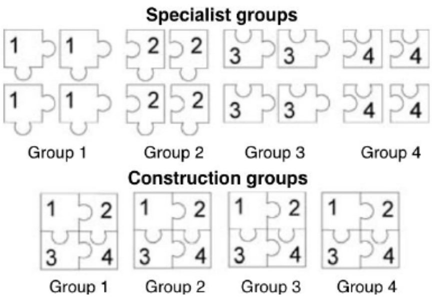


Figure 27.1 – Specialist and construction groups formation.

The group should jointly develop, in written form, a general summary on the topic addressed. Each group (jigsaw group) presents to the other groups and to the teacher their own conclusions regarding the subject studied. At the end of the presentations, the group delivers its abstract accompanied by texts produced individually by each of its members[2].

The teacher conducts a general closing discussion, eventually reinforcing some important aspect.

27.4 Results

The dynamics were applied in classes of beginning students (2nd semester) and also with students in the final stages of the course (9th semester). In both cases, the results were positively surprised by the quality of the final exposures performed. The knowledge was later tested in the form of tests and compared the results with those obtained by classes in which lectures were given. The comparative results showed a yield of 6 to 10% higher in the groups that used active methodologies[5], showing that the methodology is highly effective.

27.5 Conclusions

This described application of the Jigsaw technique was the one conceived by Aronson but there are variations that can be applied, such as changing building groups to a second round of questions. It is important to emphasize that we can build dynamics that are adequate and efficient, especially when applied to large groups.

Bibliography

1. ARONSON, E. *The Jigsaw Classroo.*. Oxford: Sage, 1978.

2. MEYERS, C.; JONES, T. B. *Promoting Active Learning. Strategies for the College Classroom.* San Francisco: Jossey Bass Ed., 1993.

3. DiPietro, M. et al. *How learning works.* San Francisco: Jossey Bass Ed., 2010.

4. MAZUR, E. *Peer Instruction.* Ballroom A, Harre Union: Harvard, 2013.

5. GOLDBERG, D. E.; SOMERVILLE, M. *A whole new Engineer.* Massachusetts: ThreeJoy Associates, 2014.

6. BRANDSFORD, J. D. et al. *How people learn - Brain, Mind, Experience and School.* Washington: National Academic Press, 2000.

CHAPTER 28

Canvas for Educational Project

Mairlos Parra Navarro[*] and Angelo E. Battistini Marques[♦]

[*]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: prof.mairlos@usjt.br

[♦]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: prof.battistini@usjt.br

Abstract: Inspired by business model canvas and aiming a visual planning method, it was developed a canvas for educational applications, particularly efficient in the elaboration of interdisciplinary projects but that also can be used for planning classes or even at elaboration of competence-based curriculum

matrices. Canvas are visual tools that help in the elaboration and structuring of ideas. Originally designed to create and structure innovative businesses, they obtained great visibility through Osterwalder and Pigneur work. Nowadays these tools gained several variations that seek to cover areas involved in the formation or structuring of an enterprise, trying to do so in a creative, participatory and comprehensive manner. The Educational Canvas goal is to organize and make clear, both for teachers and students: educational objectives, knowledge addressed and demanded skills during activities. That goal is possible to achieve by relating developed activities with the respective contents, trying to clarify and emphasise their relationships and also by planning evaluations, activities and deliverables students should do. The active student's participation in practical pedagogical activities is extremely important for competencies development such as proactivity, ability to work in a team (involving respect, leadership, organization), planning, observation of phenomena, as well as facilitating the connection of knowledges in several areas that is an eminently interdisciplinary activity. Therefore, it is important to know beforehand what pedagogical objectives are to be achieved with a given project, what are the contents and skills to be developed, which, in turn, allows for greater clarity in evaluating achieved results. Because of its visual characteristic and the fact that it favors interactions, the canvas offers a good response when applied with interdisciplinary groups, allowing teachers and coordinators to work synchronously (wo king together) or asynchronously (each one on its own time), expanding possibilities of collaboration in the planning of proposed project or activity. This educational model canvas seeks to encompass important aspects of a project, by using the approach proposed by Drexler and Sibbet. First, the "Why" of the project, justifying its importance, put in a very brief and direct way, then comes definition of the public involved ("To whom"). The project theme (that involves other areas and activities) should be defined only at the end of this planning stage and should take into account the Knowledge, Attitudes and Skills that are intended to develop during the proposed activities of the project. The central part of the canvas (the last to be made) defines the practical aspects of the project: the curricular components involved, its contents (which can be rearranged and adapted according to the project proposal), the ways of approaching each content, planning of the appropriate assessment (according to the proposal) and deliveries that students must perform during and after the activities.

Keywords: Active Learning, Education Model, Engineering Education, Project-Led Education, Canvas.

28.1 Background

Interdisciplinary Projects (IP) discipline was introduced in São Judas Tadeu University courses in 2016 curricula reform. This discipline appears in all semesters (except in the last two, when the Completion Works are carried out), IP subject aims to put the student in contact with the professional reality, connecting knowledge developed by the other disciplines of the semester through the practice of projects[1].

The course consists in classes of four hours taken weekly: two hours accompanied by the teacher and two hours of autonomous studies, in which students must develop their projects, working as a team with tasks defined by the teacher in the follow-up class throughout the semester.

28.2 Purpose/Hypothesis

Educational model canvas (Educanvas) proposed in this article was created as a mechanism of support and guidance for teachers and course coordinators alike. This Educanvas has the purpose of creating appropriate educational projects to the learning level of the students and giving meaning to the content that is being presented in each semester.

The Educanvas model was constructed inspired in the Business Model Canvas proposed by Ostenwalder and Pigneur[2] and consists in a structured visual map to allow visualization of several aspects that make up a project with educational objectives.

28.3 Design/Method

Educanvas should be built collectively by three groups: 1. teachers who will guide and conduct the course, 2. teachers from other semester disciplines, who have the vision of the contents to be developed and 3. course coordinator, who has the vision of the objective of each semester as well as course objectives.

The completion of this document seeks to encompass important aspects of a project (Finocchio[3]), using the approach proposed by Drexler and others[4]. "WHY" is the main focus, summarizing the project (or course) importance, which should be clear to all teachers and students. Then it defines public involved ("TO WHOM"). After that should be defined the expected students competences ("WHAT"), expressed by Knowledge, Skills and Attitudes that are intend to develop with that project. So should be declared stages of execution and evaluation of the project, wich will occupy the central part of the canvas defining practical aspects of the project: the curricular components involved, its contents (which can be rearranged and adapted according to the project proposal), planned approaches to the contents (proposed activities), the appropriate evaluation and the deliveries (products and services) wich students have to execute in the activity. Figure 28.1 shows "HOW" to develop the project.

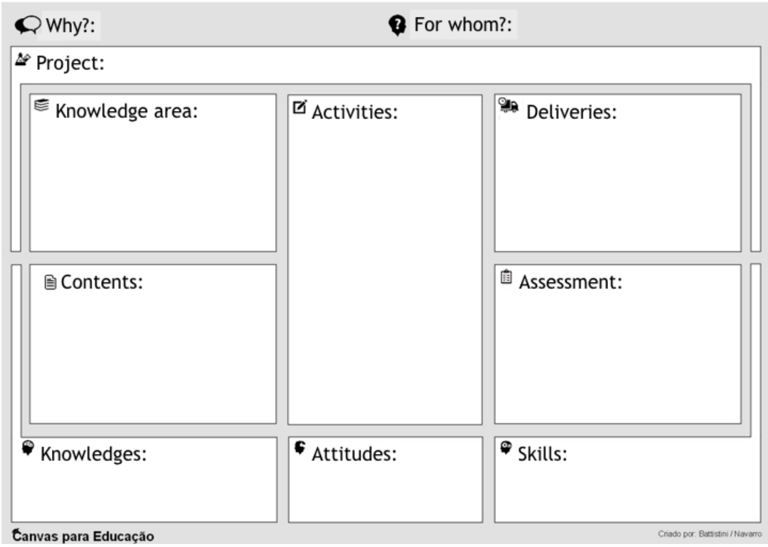


Figure 28.1 – The EduCanvas.

28.4 Results

In each semester Educational Model Canvas has been applied in several Engineering courses projects planning and also in the preparation of projects proposals in other areas such as health, administration and social communication.

The main aspect observed was the ease with which projects themes turns out to be clear and simple for all involved. Often, theoretical disciplines adjust their content, forms of approaches and examples, in order to contribute to the project, increasing its meaning for the student.

Some teachers who knew this method have, on their own initiative, used Educanvas in individual planning, reporting the importance of looking at the discipline with a broader context. They also notify that assessments objectives become clearer for both teachers and students.

28.5 Conclusions

Educanvas has been used in many courses besides Engineering and also in disciplines that develop some kind of projects and other practical activities other than Interdisciplinary Projects (IP) and has been considered very useful. For a new course approach, new methodologies and new project tools are needed. Education by projects will be of greater importance once these projects are aligned with the content addressed allowing students to apply knowledges, skills and attitudes in order to develop them.

Bibliography

1. ÂNIMA Educação. Projeto Acadêmico Ânima (Ânima Academic Project). Belo Horizonte: Internal publication, 2016.

2. OSTERWALDER, A; PIGNEUR, Y. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers.* Ne Jersey: John Wiley & Sons, Inc., 2010.

3. FINOCCHIO JÚNIOR, J. *Project Model Canvas: Gerenciamento de Projetos sem Burocracia.* Rio de Janeiro: Alta Books, 2013.

4. DREXLER, A.; SIBBET, D.; FORRESTER, R. *The Team Performance Model.* New South Wales: Grove International, 1996.

CHAPTER 29

Electric Floor: A CDIO Project for First Year Students

Bruno Malagone[*], Cleiton Marques[♦], Victor Alves[♦] and Angelo E. Battistini Marques[▾]

[*]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: brunomalagone@gmail.com

[♦]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: cleiton2210@gmail.com

[▴]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: victoralvesmoura@hotmail.com

▼Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: prof.battistini@usjt.br

Abstract: In this work we show the "Electric Floor", a device capable of transforming energy from the movement of the steps into electrical energy. It generates electricity when someone or something presses it, and can store that energy in batteries to be used when necessary, for example, if installed in the street, produce spare energy from street lighting or traffic signals, using a simple, clean and renewable energy. The developed prototype consists of a board that, when stepped, causes gears coupled to the lower part of the floor to turn, together with a system of turnstiles similar to those of bicycles, connected to a simple generator, producing energy every time it is pressed. From the small built prototype, it can be observed that it has the capacity to generate enough energy to supply a small quantity of LED lamps. It has been shown that it is feasible to build a system capable of supplying a traffic signal or a street lighting system, making it necessary to build a more robust and resistant set. Among other student creations, this device was conceived and built as part of "CDIO Project", developed in the second semester of Engineering Courses. Aiming an integral training to respond needs of future Engineering professional, Sao Judas Tadeu University (SP) adopted a methodology known as CDIO (Conceive -

Design - Implement - Operate) in the initial semesters with the goal of instilling Engineer students, from the beginning of the course, with projects following a methodology that is both simple and complete. In the year 2016, students were motivated to propose solutions for the energy supply as a theme of the project. The CDIO methodology allows the development of various skills such as teamwork, planning and organization in the development of projects, as well as aspects related to the theme, such as energy forms, conversion and energy production, including aspects such as sustainability, clean energy and social responsibility.

Keywords: Active Learning, Project-Led Education, CDIO, Alternative Energy, Electric Floor.

29.1 Background

In this paper we present the work developed at the Interdisciplinary Project subject, teached at the second semester of Electric and Computing Engineering Undergraduate Programs. The development of this project were done using the methodology called CDIO (Conceive-Design-Implement-Operate)[1, 2]. The proposal was steered towards a thematic strand that approaches solutions to clean power generation systems. Having then this approach, energy theories and its generation mechanisms were studied and from this on, the students, in groups of maximum six individuals designed the project to be built until the end of academic semester. This prototype was conceived by exploitation of energy produced by steps, transforming into electric power.

29.2 Purpose/Hypothesis

Progress and technology bring greater and evident need for energy. The large consumption of electricity used to light houses, industries, electronics, street lighting, and feed information exchange systems is increasing, especially large urban agglomerations.

Aiming to minimize these costs and generate clean and renewable energy are among the major challenges faced in 21st century.

29.3 Design/Method

To develop the project, CDIO methodology was presented to the groups[2]. Through weekly schedules and follow-ups, this methodology consists of dividing a project into stages to be developed in four parts, in order to make the work more organized.

The first step, Conceive, consisted in understanding the proposed theme “Innovative Solutions for Energy” and thinking about a possible prototype to be constructed. The conceived project showed in this paper is to take advantage of the energy generated by people walking in the street and transforming it into electric power[3, 4, 5].

The second stage, Design, consisted of several researches on the project, such as circuits, components and materials. In this step a cost estimate for the prototype was made.

The third step, Implement, was to build and test the circuits to check for possible research errors and unforeseen events.

The last part, Operate, consisted in finalizing the construction of the prototype and implementing in an energized system, in the first prototype the group used a remote control car with rechargeable batteries to simulate the charging system. Figure 29.1. shows the internal parts of the electric floor.

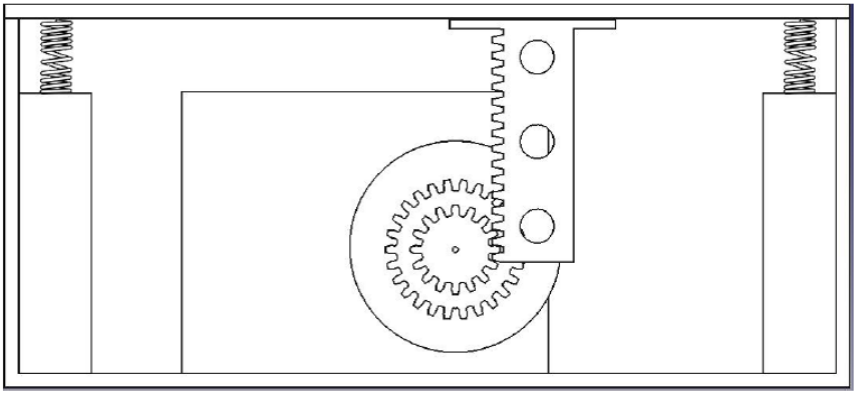


Figure 29.1 – Internal parts of the electric floor.

System assembly is relatively simple. When floor is pressed by a step, a rack causes a gear coupled to a motor to rotate, generating a small amount of energy, soon after the springs in the corners of the plate cause the system to return the original form to be pressed again. In order for the engine not to make a sudden stop when people stop pressing, a bicycle ratchet is attached to the gear, which causes the motor to continue its movement even after it has been pressed.

29.4 Results

After assembling the prototype, it was confirmed that the bicycle ratchet makes the motor spin faster, making it more efficient. We consider this prototype as a single energy cell. This only cell would not be able to provide enough electricity for many purposes. It would take several more similar cells, turning at the same time, to light a lamp, for example. The design would be much better applied charging batteries, in the event of an electrical failure, in places like malls, where there is a lot of movement.

Bibliography

1. CRAWLEY, E. F. *THE CDIO SYLLABUS (A statement of goals for undergraduate Engineering Education)*. Massachusetts: MIT - Department of Aeronautics and Astronautics, jan. 2001.

2. CRAWLEY, E. F. ET al. THE CDIO SYLLABUS v2.0 (An updated statement of goals for undergraduate Engineering Education)"; In: 7TH INTERNATIONAL CONFERENCE ON CDIO, Copenhagen, jun. 2011.

3. FELIPE, L. *Mini Gerador de Energia Portátil! – Como Fazer!* [2016?]. 1 video. Avaiable in: <https://www.youtube.com/watch?v=BpXRq7eFiPY>. Accessed in: 31 May 2017.

4. MANUAL do Mundo. *Como Gerar Energia Jogado Futebol.* Avaiable in: <http://www.manualdomundo.com.br/2015/11/como-gerar-energia-jogando-futebol/ >. Accessed in: 31 May 2017.

5. BLOG Vida em Silício. *Como Fazer um Mini Gerador de Energia.* Avaiable in: <http://roboticagyn.blogspot.com.br/2016/05/mini-gerador-de-energia-realmente.html>. Accessed in: 31 May 2017.

CHAPTER 30

Wave Power Plant Prototype: A CDIO Project for First Year Students

Beatriz Sanches dos Santos[*], Eduardo Albuquerque[♦], Hélio de Almeida Júnior[▲], Letícia Bastos da Silva[▼], Samantha Ferreira de Matos[○], Vitor Hugo da Cunha Silva[✡] and Angelo E. Battistini Marques[◘]

[*]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: sanchezbeatriz@hotmail.com

[♦]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: eduardo.a.a_@hotmail.com

[▲]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: helioj849@gmail.com

▼Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: leticiabastosferreira@gmail.com

○Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: samantha_sfm@hotmail.com

✲Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: vitorhugo.cunhasilva@yahoo.com.br

◘Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: prof.battistini@usjt.br

Abstract: This work describes the construction of a Wave Power Plant Prototype, that consists in the use of the mechanical energy produced by the ocean waves to generate electric power. This work is a part of a "CDIO Project", proposed in the initial semesters of Engineering Courses at Universidade São Judas Tadeu (SP). By using CDIO (Conceive-Design-Implement-Operate) technique, first year Engineering students conceived and developed prototypes according to the thematic axis "Innovative Solutions for Energy". The CDIO technique was adopted with the goal of motivate students to work following a simple and complete project methodology. CDIO technique shows to be very suit-

able for beginner students (due to its simplicity), but also interesting to be used for students in more advanced stages, because of its completeness. In addition to that, CDIOs approach allows students to learn aspects related to the subject, such as the generation and the use of different forms of energy, its conversion, production and transmission, including aspects such as clean power, sustainability and social responsibility. CDIO also allows students to improve several skills, including, but not only, the ability of teamwork, project planning and organization. As result of students work, they were asked to build a prototype to demonstrate their conception. The Wave Power Plant was built from a floating system coupled to a fixed rod in which are placed two magnets with inverted polarities, in order to repel. The bottom magnet is attached to the buoy, and movesvertically along with the float, accompanying waves movement. As the bottom magnet moves, it repels the upper magnet, which acts as a magnetic core, moving inside a fixed coil, producing, by means of electromagnetic induction, the electrical voltage between its terminals. In the built prototype, the demonstration of the power generation was made using a set of LEDs, which were triggered as the mechanical waves were produced in a small artificial tank. Although the prototype was built on a small scale, the system proved to be efficient in generating small amounts of energy, however a commercial development is not viable due to elevate material and assembly costs.

Keywords: Active Learning, Alternative Energy, CDIO Project, Project-Led Education, Wave Power Plant.

30.1 Background

The work presented in this manuscript was built at the Interdisciplinary Project subject, teached at the second semester of Civil Engineering Undergraduate Program. The development of this project were done using the very known methodology called CDIO (Conceive-Design-Implement-Operate)[1, 2]. The proposal was steered towards a thematic strand that approaches solutions to clean power generation systems. Having then this approach, energy theories and its generation mechanisms were studied and from this on, the students, in groups of maximum six individuals designed the project to be built until the end of academic semester. The use of Ocean Waves to generate power was one of the proposals built by a specific group of students.

30.2 Proposal/Hypothesis

The goals of this project were: Present a clean and renewable way to produce energy. Context and characterize this form of power so its production. To verify if it's possible to use Wave power plants in Brazil and also in the coasts around the world as well as the environmental, social and economical impacts this solution may cause[4].

Using the ocean waves movement[3], a coil-magnet system is attached to a float through a rigid rod.

The wave's motion displaces the magnet inside a fixed tube, this last connected to a coil, producing electric current, as illustrated in figure 30.1.

30.3 Design/Methodology

For the prototype functionality, some materials were used to demonstrate the generation of electric power from Ocean Waves as: neodymium magnet, plastic pipe, LED lamps and copper coils. The system was built in a small scale model, the waves movement were simulated by mechanical displacements inside a plastic recipient. As soon as the waves were created, the float moved vertically in the plastic pipe which has the magnets. The bottom magnet is attached to the float's rod and magnetically repeals the upper magnet this last that moves inside the coil. From this movement induced electric voltage is resulted (V).

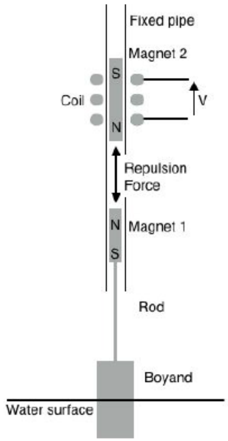


Figure 30.1 – Wave power plant schematic.

30.4 Results

From the tests results, it was observed the necessity of a high mechanical force magnitude to generate the artificial ocean wave so the prototype could work properly. Even though, the prototype showed to be functional and achieved the proposals, especially the one of showing the possibility of ocean waves power generation. With this model, it was able to turn a group of LEDs on.

30.5 Conclusions

The use of ocean wave's movement to generate electric power has a benefic potential to our planet due to its renewable and non pollutive characteristics, but its way of production is not economically suitable. The viability of concluding the final equipment, in a short time, is unlikely even Brazil having a large coast extension. The costs of equipment, assembly and maintenance are high and the investment is not yet justified. However, the prototype assemble was very useful once a vary of concepts were developed: electric energy generation, energy conversion and also important aspects in the model creation to guarantee the prototype's functionality.

Bibliography

1. CRAWLEY, E. F. *THE CDIO SYLLABUS (A statement of goals for undergraduate Engineering Education)*. Massachusetts: MIT - Department of Aeronautics and Astronautics, jan. 2001.

2. CRAWLEY, E. F. ET al. THE CDIO SYLLABUS v2.0 (An updated statement of goals for undergraduate Engineering Education)"; In: 7TH INTERNATIONAL CONFERENCE ON CDIO, Copenhagen, jun. 2011.

3. SUA Pesquisa.com. *Energia renovável: usinas maremotrizes.* Avaiable in: <http://www.suapesquisa.com/energia/energia_mares.htm>. Accessed in: 23

apr. 2017.

4. BLOGS pini. *Energia Maremotriz: Guia Básico.* Avaiable in: <http://blogs.pini.com.br/posts/tecnologia-sustentabilidade/energia-renovavel-usinasmare-motrizes-344851-1.aspx. Accessed in: 23 apr. 2017.

CHAPTER 31

Charging Device for Electric Vehicles: A CDIO Project for First Year Students

João Augusto Zimmer Rocha[*], Igor Vicente Quadros[♦] and Angelo E. Battistini Marques[▲]

[*]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: jaozimmer@gmail.com

[♦]Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: igorvquadros@gmail.com

▲Universidade São Judas Tadeu, São Paulo, Brazil

E-mail: prof.battistini@usjt.br

Abstract: In this paper we describe a simple and innovative device for charging batteries in electric vehicles. The work was made by using the CDIO (Design-Conceive-Implement-Operate) technique, adopted in the second semesters of Electrical and Computing Engineering Courses at Universidade São Judas Tadeu (SP). It was proposed a thematic axis, “Innovative Solutions for Energy”, from which students conceived, developed and implemented prototypes related to the theme. The CDIO technique was adopted with the objective of motivating the students to work following the methodology that is both simple and complete, proving to be very suitable for beginner students (for its simplicity), but also can also be used for students in more advanced stages, for its completeness. In addition, CDIO methodology allows to improve several skills, such as the ability to work in teams, planning and organization throughout the development of projects, as well as aspects related to content related to the theme, such as the use of different forms of energy, conversion, production and transmission of energy, including aspects such as clean energy, sustainability and social responsibility. Among others projects, a group of students developed a prototype for charging electric vehicles. The device is done using transformers, in order to facilitate the electric contact of the vehicle with the

power source. The primary transformer winding is fixed and connected to the power source. The secondary winding is located in the vehicle, as well as the electronic circuit que converts the AC signal to DC in order to charge the batteries. This eliminates the need to connect the car to the power source by means of sockets, requiring only an approximation of the secondary to primary winding for charging the vehicle. The prototype was built by using the miniature car driven with common rechargeable batteries (1.5 V). Charging was done by means of a transformer with the primary winding fixed and connected directly to the electric grid AC power and the secondary winding together with the battery charging circuit placed in the car itself, Which has undergone various adaptations to suit the charging method. The operation of the prototype showed the efficiency of the energy transmission between the transformer windings was satisfactory and it is possible to implement and it is therefore possible to be produced for commercial scale use. To do so, it is still necessary to improve the electromagnetic core of the transformer, for greater efficiency.

Keywords: Active Learning, Alternative Energy, CDIO Project, Electric Cars, Project-Led Education.

31.1 Background

In this paper we present a project developed as part of the discipline of Interdisciplinary Projects, in the second semester of Electrical and Computing Engineering courses at São Judas Tadeu University (SP) Technique known as CDIO (Conceive - Design - Implement - Operate)[1] was used to implement a complete project methodology, suitable for both beginners and advanced students. We also used a thematic axis, "Innovative Solutions for Energy", in order to stimulate students to think about the theme and offer possible solutions. Before this theme, students review concepts like energy principles, energy generation and conversion. Working in groups up to six students, they propose a construction of a prototype. One of the groups conceived the idea of facilitate the charging process for electric vehicles[2].

31.2 Propósito

Currently, in the search for the use of clean and renewable energy sources for use in automotive vehicles, electric energy has proved to be a very suitable alternative[3]. With the current development of the industry, new studies and ideas have been developed to make these vehicles viable for large-scale use. The objective of this work was to create an alternative way to charge the batteries, which is both efficient, simple and inexpensive.

In this project, we opted for the proposal of a charger made by means of a transformer[4], consisting in the primary winding connected to the power source and a secondary, located in the vehicle, connected to an electronic charging circuit. In order to load the vehicle, it is sufficient to approach the vehicle to the primary winding, as shown in figure 31.1.

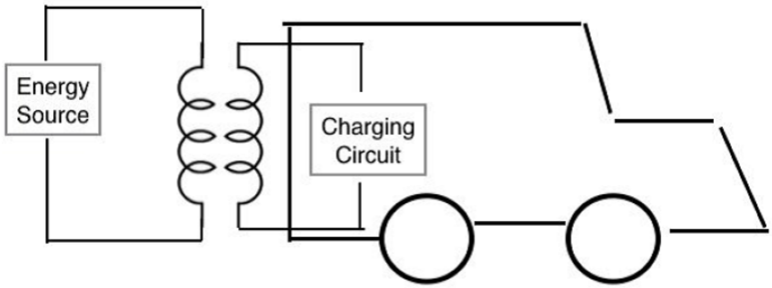


Figure 31.1 – Schematics of charging device.

31.3 Design/Method

To develop the project, CDIO methodology was presented to the groups the. Through weekly schedules and follow-ups, this methodology consists of dividing a project into stages to be developed in four parts, in order to make the work more organized.

The first step, Conceive, consisted in understanding the proposed theme "Innovative Solutions for Energy" and thinking about a possible prototype to be constructed.

The second stage, Design, consisted of several researches on the project, such as circuits, components and materials. In this step a cost estimate for the prototype was made.

The third step, Implement, was to build and test the circuits to check for possible research errors and unforeseen events.

The last part, Operate, consisted in finalizing the construction of the prototype and implementing in an energized system, in the first prototype the group used a remote control car with rechargeable batteries to simulate the charging system.

31.4 Results

The charging system achieved was very close to the expected, because it is a prototype on a small scale and without much precision in the assembly. With an efficiency of approximately 90%. Tests were carried out in four rechargeable batteries of 1.5 V, the circuit used in the power supply of the cart was as follows:

Because it is a prototype, just to exemplify the idea, the circuit is quite simple which does not show a real situation perfectly, where there would be other systems and possible external interferences, which could be easily solved with a detailed study.

31.5 Conclusions

This charging system showed to be effective, practical, simple and viable. In order for the system to be implemented in real large-scale electric cars, adjustments such as the alignment of the transformer windings will be necessary for better transmission of energy, with minimum losses, as well as tests and adjustments to higher energies.

Bibliography

1. CRAWLEY, E. F. *THE CDIO SYLLABUS (A statement of goals for undergraduate Engineering Education)*. Massachusetts: MIT - Department of Aeronautics and Astronautics, jan. 2001.

2. ABB no Brasil. *Tecnologia da ABB para alimentar o primeiro ônibus elétrico com carga rápida de alta capacidade do mundo.* Avaiable in: <http://www.abb.com.br/cawp/seitp202/019d1909d5a3ae7683257b7a006e9638.aspx>. Accessed in: 25 apr. 2017.

3. SECRETÁRIA do Meio Ambiente SP. *Emissões Veiculares no Estado de São Paulo - 2015.* São Paulo: CETESB, sept. 2016. Avaiable in: <http://cetesb.sp.gov.br/wp-content/uploads/sites/35/2013/12/RelatorioEmissoesVeiculares-2015-subst-201016.pdf>. Accessed in: 25 apr. 2017.

4. BRAGA, N. C. *Enrolamento de Pequenos Transformadores e Bobinas (ART2369)*.

Avaiable in: <http://www.newtoncbraga.com.br/index.php/eletronica/52-artig-os-diversos/10414-enrolamento-de-pequenos-transformadores-e-bobinas-art 2369>. Accessed in: 25 apr. 2017. </index.php/eletronica/52-artig- os-diversos/-10414-enrolamento-de-pequenos-transformadores-e-bobinas-art 2369> Access apr, 25, 2017.

CHAPTER 32

3D Virtual Laboratory for Learning Environments: A New Learning Object

Vinícius Ferreira da Silva Bianchi Grilo[*], Paulo Pinheiro Junqueira[♦], Fabiano Pereira Bhering[▲] and Lindolpho Oliveira de Araújo Júnior[▼]

[*]Departamento de Elétrica e Eletrônica,
Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: ferreira_vinicius@icloud.com

[♦]Departamento de Elétrica e Eletrônica, Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: pauloppj@hotmail.com

▲Departamento de Computação e Mecânica,

Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: fabianobhering@cefetmg.br

▼Departamento de Elétrica e Eletrônica,

Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: lindolpho@leopoldina.cefetmg.br

Abstract: Over the years, teaching methods have not achieved significant changes to accompany advances in audiovisual media. Technologies could be implemented in order to create interactive platforms that would improve in quality of teaching, especially in practical disciplines offered in technical and Engineering Courses, with the purpose of enhance the learning process. In addition, many institutions do not have sufficient resources or quality technologies to meet the demand of students and teachers. This work presents a new resource for virtual learning object and virtual laboratory prototype with remote access to improve the quality of classes, in which students can get an immersive experience close to reality, and actually interact and test the knowledge acquired. The objective was to provide remote access to the control and automation laboratory and optimize practical experiments more safely. As pilot experiment, an environment consisting of a 3D model of the ARM-7220-4 arm robot was developed, presenting the majority of the robot movement functions, as well as mechanical accuracy, geometric and kinematic model of the Robot, and provided access in Moodle for the students of CEFET-MG, Campus Leopoldina. A real robot ARM-7220-4, connected to the virtual tool, responds to commands of manipulation by the environment and can also be monitored in real time through a camera installed in the physical laboratory. The teaching method is established through movement tasks in order to validate the knowledge acquired through bibliographic didactic resources, addressing theoretical aspects. Results of usage analyzes demonstrate that the new resource provides a motivation for participation, interaction and collaboration among the students who have tested the system and presents itself as a promising resource for distance learning. We would like to thank CEFET-MG, CNPq and FNDE for their support in this project.

Keywords: Virtual Learning Environment, Virtual Learning Objects, Virtual Lab, Remote Access.

32.1 Introduction

The technologies of audiovisual communication are increasingly present in our daily life, however, they are still insufficient explored in educational institutions.

Because students are already familiar with receiving interactive information across multiple platforms in their homes, these same technologies could be very useful for performing practical activities required to complement the theoretical content offered by the teacher.

The use of new educational tools such as projectors and touch-sensitive frames has brought more interactivity to classrooms, but they still do not offer an immersive experience in which the student can actually interact and test the acquired knowledge.

Many institutions, mainly Engineering courses, also lack of physical and financial resources to match to all students' needs, and many of them do not even have labs to carry out specific activities.

A virtual learning environment becomes an interesting approach to contribute to new experiences, such as to provide students with a greater involvement with practical activities, inserting virtual objects, similar to real laboratories that arouse the sensation of being physically performing practical and collaborative activities[1]. Thus, institutions that do not have sufficient resources to meet the demand of students and teachers can use more modern and interactive methods for teaching and learning with a low investment.

32.2 Purpose

This paper presents a virtual learning object for use in Engineering courses, with a proposal to create a 3D virtual laboratory in which students and teachers interact in an immersive environment.

The virtual environment is an alternative both to teaching theory and teaching in practice, with the possibility of visualizing the interaction of a real robot through the control of a virtual robot.

By accessing the virtual object, the student can develop his laboratory activities provided by the Moodle platform[2], and also control real equipment without the need of physical presence, besides making available to the institution a new technological resource to improve the practical quality in teaching of Engineering.

32.3 Design

For the development of the laboratory a virtual learning object was implemented using the Unity 3D software tool[3], consisting of a model of the robotic arm ARM-7220-4[4] and with basic functions of driving the 6 motors of the robotic joints for manipulation of the arm robot. The virtual object and a camera were embedded in the Moodle through an application server for remote access, as shown in figure 32.1.

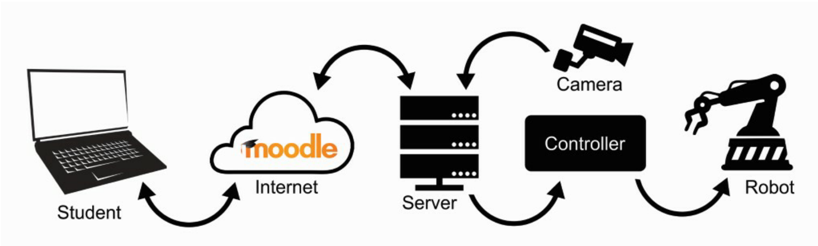


Figure 32.1 – Virtual Teaching Environment Scheme.

The learning tool was implemented with basic activities to motivate student interaction. The tasks were associated to the rotation parameters of the robotic arm motors, according to figure 32.2. For each task, the parameters were released one by one as the students succeeded in the previous tasks.

At the end of each task, the student can confirm and visualize the execution of the real robot through the camera. With this, it was possible to provide an immersive and more pleasant environment for students.

32.4 Results

For the evaluation of the laboratory, a questionnaire was applied to each student who participated in the experiment. The tasks were applied to the

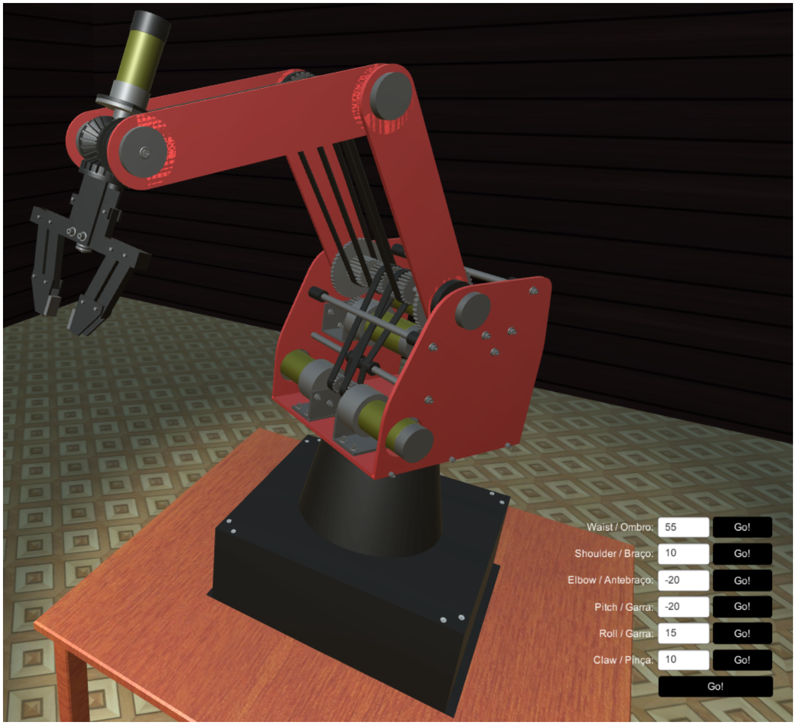


Figure 32.2 – Virtual Robotic Arm with motor rotation parameters accessed by Moodle.

students of the Control and Automation Engineering course at CEFET-MG campus Leopoldina. Only 23% of the students had participated in distance learning courses or had contact with other types of virtual learning object, but most (75%) showed great interest in the object. In relation to knowledge of robotics the level of contribution of the object in the course was evaluated. The student's level of knowledge in robotics was considered reasonable, but

93% showed great interest in learning through the virtual environment. All students approved the use of the new teaching object and confirmed that it can be essential to encourage and help learning.

32.5 Conclusions

The implementation of a virtual laboratory with remote access gives students a great immersion and interactivity with learning objects, as well as facilitate the accomplishment of practical activities in the disciplines of the Engineering course. This paper presents a proposal for a 3D virtual laboratory integrated into Moodle that can be replicated in remote simulation of laboratory experiments, making institutions that do not have such equipment can use them, requiring or not supervision for the activities, since it reduces the risk of damaging the equipment or hurting students. In addition, creating mechanisms for the interaction between virtual and real equipment.

The virtual environment was offered to control and automation Engineering students who positively evaluated the learning resource, indicating a new opportunity for the construction of increasingly interactive educational tools.

Bibliography

1. VALENTE, J. A. Blended learning e as mudanças no ensino superior: a proposta da sala de aula invertida. *Educar em Revista*, Curitiba, v. 4, p. 79-97, 2014.

2. CRAIG, J. *Introduction to robotics: mechanics and control*. Ne Jersey: Pearson Prentice Hall, 2005.

3. LIVINGSTONE, D.; JEREMY, K. Integrating web-based and 3D learning environments: Second Life meets Moodle.*CEPIS UPGRADE: European Journal for the Informatics Professional*, v. 3, p. 8-14, 2008.

4. NORTON, T. *Learning C# by Developing Games with Unity 3D*. Birmingham: Packt Publishing Ltd, 2013.

CHAPTER 33

How An Educational Program Can Improve Learning for An Engineering Student

Pedro Santos Valente[*], José Benício da Cruz Costa[♦] and Gilberto Martins Lynch[▲]

[*]Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: pedrosv2010@hotmail.com

[♦]Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: benicio@ufpa.br

▲Instituto de Tecnologia, Universidade Federal do Pará, Belém, Brazil

E-mail: gilbertolynch2020@gmail.com

Abstract: The evasion in Higher Education, especially in science courses, is a reality faced by Universities not only in Brazil, but also in several other countries around the world. The number of students who drop out of university is very expressive, resulting in academic, economic and social losses. To try to minimize this problem, the Universidade Federal do Pará (UFPA) together with the Institutto de Tecnologia (ITEC) created in 2011 the Levelling Courses Program in Basic Sciences for Engineering (LCPBSE), whose main area of action is to teach basic Mathematics, Physics and Chemistry for the newly enrolled students in Engineering Courses. These classes happen before the students have contact with the first subjects of the basic cycle, especially the discipline of Calculus 1, common to all Engineering Courses. Recent statistical studies have demonstrated that LCPBSE has a relevant role to reduce educational gaps in conceptual and operational fields in the basic sciences to Engineering, in addition to working essential topics to the basic courses of undergraduate. Recognizing the importance of LCPBSE as fundamental tool against evasion rate, the research is aiming to better understand its functionality and how it was able to increase the approval ratings. Thus, this paper has as objective to explain how the LCPBSE supports students and it tries to understand what epistemological learning mechanism under the factors contributing to students academic performance increasing. The methodology was based on the bibliographical research of several authors who study the cognitive learning. Among them, we studied those who had a philosophical cognitive/constructivist stance: Piaget, Vygotsky, Kelly, Ausubel and Vergnaud. As a result of this studies, we focus on David Ausubel's work, who proposes the Meaningful Learning Theory, a thesis that may be able to explain how LCPBSE is helping students to learn more efficiently. According to Ausubel, for learning to be meaningful, it is necessary for the new information to relate to a relevant aspect already existing in the learner's cognitive structure. These relevant aspects are called subsumers, which serve as an anchor for the new knowledge to be acquired. Based on this, the LCPBSE classes may be serving as an organizer of the students' subsumers, so that they can attend the Calculus classes already with the necessary prior knowledge. Finally, we concluded that the organization of subsumers can be a critical strategy used to improve learning and to decrease the evasion rates. Such strategy can be applied not only in the LCPBSE, but also in other programs of other Universities.

Keywords: Meaningful Learning, David Ausubel, Engineering, Evasion, Subsumers.

33.1 Background

According to estimates made by INEP (National Institute of Educational Studies and Research AnísioTeixeira), the average annual dropout rate in brazilian higher education in the period between 2001 and 2005 was 22%[1]. Analyzing this percentage, and considering that the number of enrollments made in 2008 was 5.080.056 students[2], it is possible to verify that 22% of 5.080.056 equals 1.117.612. That is, it is possible that more than 1 million academics have given up on pursuing higher education in the year 2008.

In order to try to minimize this problem, the Institute of Technology (ITEC) of the Federal University of Pará (UFPA) created in 2011 the Levelling Courses Program in Basic Sciences for Engineering (LCPBSE), whose work consists in alleviating the basic difficulties of a newcomer in higher education. Among the various factors that influence evasion, the Program works on that related to the poor quality of basic education.

The main action front of the program is to teach expository classes in elementary mathematics, physics and chemistry. So, the students who do not have an efficient educational base can alleviate their difficulties and level their knowledge. These classes are taught before the academics have contact with the first undergraduate subjects. They will serve as a basis for learning content from Calculus 1, for example.

33.2 Purpose/Hypothesis

Statistical studies have shown that the LCPBSE is playing an important role in assisting students' performance in the university's early disciplines. The approval percentage of those who took the leveling course is higher than those who did not. However, the success of the Program is still unknown. It is not yet known what epistemological mechanism is being used to achieve such results.

Then, recognizing the importance of LCPBSE as a fundamental tool against evasion rate, the research seeks to better understand the functionality of the program and how it was able to increase approval rates. Thus, this paper aims to explain how the LCPBSE supports students and seeks to understand the mechanism of epistemological learning under the factors that contribute to the increase of students' performance.

33.3 Design/Method

In order to find some theory that explains how the LCPBSE can help the student's performance in the subjects of Calculus, a bibliographical research was carried out between thinkers who study the teaching-learning process and human cognition. In this field of knowledge, three philosophical positions predominate: Behavioralism, Cognitivism and Humanism.

The present work does not seek to emphasize the behavioral question nor the human question, but it seeks to understand the mental processes of the students. Therefore, it was decided to study the theoreticians who have a philosophical cognitivist position, that is, it was made a bibliographical survey of the ideas of Jean Piaget, Lev Vygotsky, George Kelly, Gerard Vergnaud and David Ausubel, since these authors develop theories of the Learning with a focus on cognition. Some of these thinkers, in developing their theory, do not have learning as a central concept, as in the case of Piaget, which focuses on cognitive development. However, its principles have great implications for the understanding of the teaching-learning process.

33.4 Results

Among the theories and authors studied, it was verified that the Meaningful Learning Theory of David Ausubel has aspects that can be related to what the LCPBSE has been doing. The classes taught by the program may be developing the prior knowledge necessary to learn meaningfully the contents of Calculus. The classes could be, according to Ausubel's words, differentiating the students' subsumers.

The Meaningful Learning is the process by which the new information interacts substantively and non-arbitrarily with what the student already knows. It is the process by which ideas expressed symbolically relate to a specifically and relevant aspect of the individual's cognitive structure, that is, this process involves the interaction of new information with an already existing specific knowledge structure[3].

When it is said that the interaction is substantive, it is meant that it is non-literal. And when it is said that it is non-arbitrary means that the interaction is not with any previous idea, but with some specific and relevant knowledge that already exists in the cognitive structure. To this knowledge, David Ausubel calls subsumer, which can be a concept, a proposition, a mental model, an image or an already significant symbol, for example[4].

The subsumers serve as an anchor for the new knowledge. In this process, in addition to assigning meanings to new information, the subsumers also acquire new meanings, and end up undergoing a stage of growth and modification. In doing so, it becomes richer, more elaborate, and more stable. The concept of force, for example, can be expanded. The student who comes in contact with the new knowledge about gravitational force now understands that force can be attractive in nature and applied over long distances. Thus, the subsumer "force" became clearer, more differentiated and broader.

The classes taught by the program play the role of developing the subsumers that will be needed to learn meaningfully. Many academics enter the university without possessing the basic skills and competencies required in a college degree. Without these fundamentals, it is difficult to understand and relate new knowledge, although some pedagogical strategies are used to promote learning. So the LCPBSE has the function of differentiating the subsumers, making them more elaborate, broader, more stable, more inclusive and richer in meanings. In this way, the cognitive structure will be better able to give meaning to the new information.

The program accomplishes this objective through 3 procedures: identification of the relevant prerequisites, identification of students' previous knowledge and consolidation of the less elaborated subsumers.

Some statistical studies have shown the effectiveness of the program in students' income in Calculus 1. During the years 2013, 2014 and 2015, the percentage of students who took LCPBSE and those who did not take LCPBSE were measured. The data is separated by Engineering course and shown in the Figure 33.1.

33.5 Conclusions

The work sought to explain what epistemological learning mechanism the LCPBSE uses to improve the approval rates. Based on the Meaningful Learning Theory, it was verified that LCPBSE fulfills the function of developing the subsumers, making them more differentiated, elaborated and inclusive, so that they are able to serve as an anchorage for the new information. Without

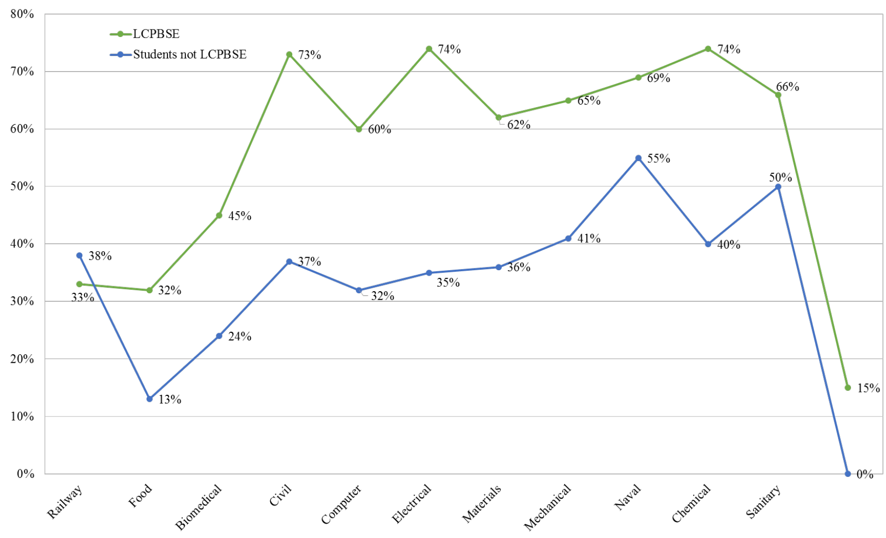


Figure 33.1 – Percentage of Engineering approval.

these stable and available subsumers in the cognitive structure, the student is not able to learn meaningfully.

In the midst of the great social losses that evasion represents, it is important to join efforts to guarantee the permanence of the academic in higher education. In this sense, it was verified that the development of the subsumers is a strategy used by the LCPBSE that is working well, and this strategy can also be applied in other programs of other universities.

Bibliography

1. SILVA FILHO, R. L. L. et al. A evasão no ensino superior brasileiro. *Cadernos de pesquisa*, São Paulo, v. 37, n. 132, p. 641-659, 2007.

2. APARECIDA, C.; BAGGI, S.; LOPES, D. A. Evasão e avaliação institucional no ensino superior: uma discussão bibliográfica. *Revista da Avaliação da Educação Superior.*, Campina, v. 16, 2011.

3. MANCINI, A. A. *Aprendizagem significativa: a teoria de David Ausubel*. São Paulo: Centauro, 2005.

4. PELIZZARI, A. et al. Teoria da aprendizagem significativa segundo Ausubel. *Revista PEC*, Porto, v. 2, n. 1, p. 37-42, 2002.

CHAPTER 34

Retrofitting of A Robot Arm Controller

Leilane Posztbiegel Santos[*]

[*]Grupo PET de Controle e Automação,
Centro Federal de Educação Tecnológica de Minas Gerais, Leopoldina, Brazil

E-mail: l.posztbiegel@gmail.com

Brenna Lopes Farace[♦], Lindolpho Oliveira de Araújo Junior[▲] and Luis Claudio Gambôa Lopes[▼]

[♦]Engenharia de Controle e Automação, Centro Federal de Educação Tecnológica de

Minas Gerais, Leopoldina, Brazil

E-mail: brennafarace@gmail.com

▲Engenharia de Controle e Automação, Centro Federal de Educação Tecnológica de

Minas Gerais, Leopoldina, Brazil

E-mail: lindolpho@leopoldina.cefetmg.br

▼Engenharia de Controle e Automação, Centro Federal de Educação Tecnológica de

Minas Gerais, Leopoldina, Brazil

E-mail: gamboa@leopoldina.cefetmg.br

Abstract: The present project deals with the development of a controller for a robot, with high processing capacity, at a low cost, using as computational platform the Raspberry Pi 3. The motivation for the development of this study was the need to find a way to coordinate a Robot Arm ED-7220-4, whose original controller suffered irreparable damage, causing its loss. This work becomes relevant since the rescue of the damaged controller is infeasible, but the electromechanical manipulator is in perfect condition. The choice of Raspberry Pi 3 was due to the versatility that this minicomputer has in relation to its computational capacity. The project consists of the use of Raspberry Pi 3, to-

gether with a drive and reading interface of the robot manipulator, to perform the control and dispense the damaged controller. For this connection to be established, a communication and motor drive interface has been developed. Through this interface were connected the motors and sensors of the arm, responsible for the movement. The programmable ports for input and output of Raspberry Pi 3 were also connected to this interface, thus closing the system control loop. The control of the robot manipulator was developed using the principle of retrofitting, allowing to discover its operation, as well as to dimension the structural components. The analysis of this structure of operation was carried out from tests of drive and readings of the sensors from the equipment itself. Therefore, the kinematic modeling of the movements was obtained analytically through the method developed by Denavit-Hartenberg. The expected impacts of this project are the use of the controller, together with the robot manipulator, in teaching-learning at technical and Engineering levels. It is also expected to use the manipulator for research related to kinematic modeling and robot dynamics, as well as technologies for remote access to laboratories. As teaching-learning methodology will be used active methods and maker culture. Finally, the formulation of the interface between the robot and the platform based on Raspberry Pi 3 was validated as well as the realization of the kinematic modeling. We would like to thank CEFET-MG and FNDE for their support in this project.

Keywords: Controller, Retrofitting, Robot Arm, Raspberry Pi 3, Engineering Education.

34.1 Background

The purpose of this paper is to develop a way to coordinate the Robot Arm ED-7220-4, whose original controller suffered irreparable damage, causing its loss. The viable solution used to replace the faulty controller was to use a C++ program, applied by Raspberry Pi 3, since the board has a greater breadth in programming.

The application of the Denavit-Hartenberg model to the prototype studied in this research will also be of paramount importance to reach a certain place in space, starting from initial references. This feature of the model, implemented in the future, will be essential for the effective control of the robotic Arm ED-7220-4.

This work becomes relevant since the rescue of the damaged controller is infeasible, but the electromechanical manipulator is in perfect condition.

34.2 Purpose

The five-joint Robot Arm ED-7220-4 used in this research is shaped like a human hand and consists of six servomotors, six encoders coupled to servomotors, and six limit switches. Each joint of the robot has its movement coordinated by a servomotor, as well as the claw located at the tip of the arm. Each movement is performed based on the pulses counted by the encoders. The servomotors, encoders and limit switches are originally connected the controller via six flat cables and the power for the robot is drawn directly from a 127-voltage source.

The Raspberry Pi board, also used in this project, is a microcomputer sized as a credit card, which is low-cost and versatile. Raspberry was created for educational purposes in such a way that students from both public schools and private schools could explore the field of computing. The use of the board entails learning about the Linux operating system, as well as the different types of programming languages that can be implemented and executed. In this case, the use of Raspberry Pi 3 is of great importance as it will serve as a base platform for the arm operation[1].

Another relevant point of this study will be the use of the method, created in 1955 by engineers Jacques Denavit and Richard Hartenberg, to define joint and segment arrays to normalize the coordinate axes for spatial (x, y, z) coordinates.

The parameters, found in the realization of the modelling, will be of paramount importance to demonstrate the kinematic analysis of position in any predefined space for robotic systems[2, 3].

To apply the principle of retrofitting, making it possible to discover the functional and structural elements of the robotic arm, a field research was carried out. Such research allowed the development of a low cost physical controller, which will replace the damaged one. This type of research was adopted because it was necessary to test the equipment's of the arm several times to understand its operation physically.

34.3 Method

As a first part of the work, the connection to allow the communication between the Raspberry Pi 3 and the six flat cables of the six Robot Arm ED-7220-4 motors (A, B, C, D, E, F) was made from an electric circuit board. As the Raspberry Pi 3 card is a microcomputer, there is the possibility of connecting a keyboard, mouse and a screen to it to obtain a viable operating interface between man and machine. From this, the Linux-derived operating system, Raspbian, was installed on the Raspberry Pi[4].

To create a program for the retrofitting of the Robot Arm ED-7220-4, describing the movement of it, and to obtain the reading of its sensors, a code was implemented in CodeLite IDE by adopting the C++ programming language. The analysis of the structure of operation was based on the reading of the sensors, as well as physical actuators tests to define the mechanical limits of the equipment and consequently the number of pulses to be applied to each motor to produce a movement.

The second part of the work developed includes the calculation of the kinematic model of Denavit-Hartenberg for the Robot Arm ED-7220-4. The parameters considered in this modeling are the angle, the eccentricity, the twist of the joints and the length of the arm. With these data, the partial matrices of homogeneous transformation were calculated, both between two consecutive joints and between the base and the claw of the robot and, finally, the total homogeneous transformation matrix[5].

34.4 Results

With this study, based on principles of robotics, mechanics and programming, it became possible to acquire relevant results for academic circles. Above all, the applicability of reverse Engineering in a robotic arm using Raspberry Pi 3 was corroborated as a substitute for a damaged controller. From this application, it was possible to understand by various practices the robot's operation, as well as its constituent parts and all the Engineering involved in the accomplishment of its movements.

Considering the architecture of the arm, composed of mechanical elements, electronics and sensors, as well as from the tests of movement realized in the equipment, it was proved the existence of a relation of dependence between some motors. This is confirmed because certain engines when triggered influence the movement of others, or even limit them. It is of great importance to point out that all the commands applied to the arm developed the same response, as expected, thus confirming a high repeatability of the movements. The effectiveness of Raspberry Pi for educational purposes has been confirmed. With the beginning of the research, it was possible to explore and learn about the use of different computer programming languages, serving as a great example the language implemented in this project. It became possible to promote robotic arm movement from an easily understood C++ code.

Finally, when using the model proposed by Denavit-Hartenberg for the studied system, it was possible to find analytically the transformation matrix that rules the movement of the arm. Moving the equipment from the interpolation of matrices, so that the equipment can reach a previously determined position in the space will be implanted in the future through computational programming.

34.5 Conclusions

The expected impacts of this project are to demonstrate the functionality of Raspberry Pi for the control of processes, to consider the use of robotics using the C ++ language, to reinforce the knowledge in basic electronics and the operating system of the studied robot, as well as to use the controller developed, together with the robot manipulator, in teaching-learning at technical and Engineering levels.

Bibliography

1. GARRETT, F. *Como funciona o Raspberry Pi? Entenda a tecnologia e sua aplicabilidade.* Available in: <http://www.techtudo.com.br/noticias/noticia/2014/11/como-funciona-o-raspberry-pi-entenda-tecnologia-e-sua-aplicabilidade.html>. Accessed in: may 2017. (This is a freeware.)

2. MONTEIRO, E. V. *Desenvolvimento de um Controlador Dinâmico para Robôs Humanoides.* Available in: <https://repositorio-aberto.up.pt/bitstream/10216/65539/1/000154194.pdf>. Accessed in: 31 may 2017. (This is a freeware).

3. SENOAJI, T.; SESULIHATIEN, W. T.; WIDODO, R. T. *Modeling Moving Object Control System for Motorized Arm Robot Using Adam Series.* Available in: <https://www.pens.ac.id/uploadta/downloadmk.php?id=1666>. Accessed in: apr. 2017. (This is a freeware).

4. GARRETT, F. *Raspbian é o sistema operacional ideal para começar com um Raspberry Pi.* Available in: <http://www.techtudo.com.br/tudo-sobre/raspbian.html>. Accessed in: may 2017. (This is a freeware).

5. KÜHNE, F. *Cinemática direta para o manipulador Stanford.* Available in: <http://www.feng.pucrs.br/~fkuhne/files/sistrob/notasdeaula/stanford.pdf>. Accessed in: may 2017. (This is a freeware.)

CHAPTER 35

The Innovative and Multidisciplinary Environments in A Brazilian University: A Case Study

Karla Rocha Liboreiro[*] and Eduardo Romeiro Filho[♦]

[*]Departamento de Engenharia Industrial, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

E-mail: karlarliboreiro@gmail.com

[♦]Departamento de Engenharia Industrial, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

E-mail: romeiro@ufmg.br

Abstract: The aim of this paper is to investigate how the innovative and multidisciplinary environments in a Brazilian public university can foster a new innovation culture. Several institutions around the world have different approaches to improve the teaching at universities to drive economic growth and to foster the entrepreneurship. Most of the Brazilian public universities do not teach entrepreneurship and innovation as part of their undergraduate general curriculum and the existing programs are disconnected and isolated initiatives. Nowadays, we can see the attempt of some universities or professors or state government to approximate the industry to the academy or trying to bring entrepreneurship to the classes at the universities. This article also highlights how the environment at universities can shape the undergraduate students' behaviors to achieve the long-term impact on the economy. The concepts of innovation, multidisciplinarity, open innovation and the role of the university are discussed on this paper. Furthermore, most of the theories of innovation suggest that multidisciplinarity is an important ingredient to promote innovation. This paper analyzes the impact of these multidisciplinary and innovative environments in students mindset, once they are exposed to the entrepreneurship ecosystem. In the view of this situation, the main aim of this study is to investigate the innovative and multidisciplinary environments in a Brazilian State

university and how they can impact the innovative student's mindset. This case study was conducted with the use of mixed methods and procedures: surveys, interviews with students and professors, local spatial observation inside the university. 55 questionnaires were applied based on the Berkeley Innovation Index (BII) and new questions about multidisciplinarity, whose instruments used to measure innovation mindset and multidisciplinarity. The survey was applied to undergraduates from different majors at university. 11 interviews were conducted with undergraduate students, professors, workers from the entrepreneurship center, incubator, accelerator, Technological Transference Office and Technologic Park. The analysis method included content analysis for the qualitative data and correlation statistics methods for the quantitative data. Finally, the correlation relationship of innovation mindset and multidisciplinarity has been fully confirmed. However, the results of the interviews showed that there is a lack of connection between different areas of knowledge inside of university that could be more effective and closer to improving the results of the innovation at university. The result shows the complexity of the process to build an innovative and multidisciplinary environment at university. There may be a need for a creative analysis and to interpret the value of this subjects and the implications for new emerging methods of teaching and connecting people inside of universities to became closer to the society needs. Beyond that, this research is intended to develop a diagnosis model for the improvement of the administration and maintenance of the innovative and multidisciplinary environments in the university.

Keywords: Berkeley Innovation Index, Innovation, Innovative environment, Multidisciplinarity, University.

35.1 Introduction

The innovation and multidisciplinarity are subjects constantly used in the educational field to show the development of new approaches of educational technologies. Undergraduate education at universities enables young people and adults to train professionals in a particular discipline to solve problems in society. Many companies and institutions around the world feel difficult the process of innovation, to increase the good ideas and follow them until become an innovator product. It is necessary to create the preconditions for innovation[1], that means create a bandwidth to maximize diversity, connection and conversation. There are three critics' preconditions for innovation: 1. create time and space in the day life of the people to reflection, ideation and experimentation, 2. maximize the diversity to complement ideas and 3. favoring the exchange ideas[1]. In this way, creating an innovation environment involves exposing people to different points of view about an idea and valuing the multidiscipline and diversity within the organization. The university is one of the main national agents responsible for converting knowledge into wealth and social development[2]. The concept of multidisciplinarity is widely disseminated in the world. In this research, it is understood that a multidisciplinarity study that aggregates different areas of knowledge around one or more themes, in which each area still preserves its methodology and independence[3].

35.2 Theory Development

35.2.1 Innovation

Innovation is driven by the ability to establish relationships, detect opportunities and take advantage of them[4]. In this way, the innovation goes beyond the horizon of the companies and is developed through a wide network of collaborators that compose an ecosystem: companies, researchers, distributors, consumers, research institutions.[5] developed a tool to measure of innovation mindset based on behaviors and core values that individuals and organizations use to demonstrate their capability to achieve the new projects. Open innovation rightly proposes working with intelligent people inside and outside the organization so that external and internal feedback is a source of improvement and sees external intellectual protection as a source of change for improvement[6] .

35.2.2 Multidisciplinarity

Multidisciplinarity is a process of attempts by people to work together among disciplines in which each one deals with common themes under their own optics, articulating, sometimes bibliography, teaching techniques and evaluation procedures[7]. The idea of multidisciplinarity is the juxtaposition of disciplines, working closely but not together[7]. The key to understand people and their relationship in the innovation environment are the interface, that means the path where the transference of knowledge and data between two or more different places or areas occurs[8]. In this way, evaluating characteristics that contribute to multidisciplinarity such as collaboration and diversity can be a way to improve interdisciplinary and multidisciplinary action in the university. Hence, the hypotheses are:H1 - The multidisciplinarity is positively related to the Innovation mindset (BII); H2 - The facet Diversity of the BII are positively related to multidisciplinarity; and H3 - The facet Collaboration of BII are positively related to multidisciplinarity.

35.3 Methodology

The methodology used was case study. For the quantitative analysis, it was performed through the online application of 55 closed questionnaires. For the qualitative analysis 11 interviews were conducted face-to-face at the interviewees' workplace or study place. The survey used the BII[9] and six questions about multidisciplinarity included. The BII was created to measure the Innovation Mindset, and were validated by University of California - Berkeley. The Innovation Mindset level is measured in a 1 to 10 scale. The following factors are components of the innovation mindset: Trust - the ability to trust others; Resilience - the ability to overcome failure; Diversity - the ability to overcome social barriers; Mental Strength - the self-confidence and belief that you can succeed; Collaboration - the ability to work with everyone including competitors when needed; Resource Awareness -the ability to balance your resources across multiple objectives and innovation zone - the ability to work in areas of uncertainty[9].

35.4 Data analysis and Results

The results of the BII showed that only the H1 that the multidisciplinarity is positively related to the Innovation mindset was confirmed (0,331). The H2 and H3 were not confirmed because the correlation multidisciplinarity and diversity and multidisciplinarity and collaboration were not significant (0,176) and (0,236).

35.5 Discussion and conclusions

The aimed evaluation of the innovative environment influence on the innovative tendencies of the student's mindset. The results of innovation mindset related to multidisciplinarity may reveal patterns of perception of value between study or working in a multidisciplinarity team to get more information about the innovative, exchange of information and knowledge sharing between the survey participants. Thereby, the results about the facets of diversity and collaboration weren't correlated to multidisciplinarity inside the organization shows how the undergraduates are interacting inside of the university. On the other hand, during the interviews the students showed their importance and worry about be in contact with different disciplines and fields to get a better formation for their future life. Future research can extend this study to other sectors or even compare public and private university. This study is also limited by the variables and the methods chosen. Finally, we recognize that this research is an initial attempt to comprehend how the characteristics of innovation developed inside the organization affect the multidisciplinarity inside of university.

Bibliography

1. SKARZYNSKI, P.; GIBSON, R. *Innovation to the core: A blueprint for transforming the way your company innovates.* Boston: Harvard Business Press, 2008.

2. CRUZ, C. H. A universidade, a empresa e a pesquisa que o país precisa. *Parcerias estratégicas*, Brasília, v. 5, n. 8, p. 05-30, 2009.

3. PHILIPPI JUNIOR, A.; SILVA NETO, A. J. *Interdisciplinaridade, tecnologia, ciência e inovação.* Barueri: Manole, p. 783-802, 2011.

4. TIDD, J.; BESSANT, J. *Gestão da inovação.* Porto Alegre: Editora Bookman, 2015.

5. SIDHU, I.; GOUBET, J.; XIA, Y. Measurement of innovation mindset. *IEEE ICE TEMS Norway*, Norway, p. 1-10, 2016.

6. CHESBROUGH, H. W. *Open innovation: The new imperative for creating and profiting from technology.* Boston: Harvard Business Press, 2006.

7. BICALHO, L. M.; OLIVEIRA, M. Aspectos conceituais da multidisciplinaridade e da interdisciplinaridade. *Encontros Bibli: revista eletrônica de biblioteconomia e ciência da informação*, Florianópolis, v. 16, n. 32, p. 1-26, 2011.

8. ARANHA, J. A. S. *Interfaces: a chave para compreender as pessoas e suas relações em um ambiente de inovação.* São Paulo: Saraiva, 2009.

9. SIDHU, I. et. al. *2016 - Berkeley Innovation Index - University of California*

Berkeley. Available in: < http://scet.berkeley.edu/wp-content/uploads/Berkeley-Innovation-Index-Concept-Paper-V9.pdf>. Acessed in: 18 april 2017.

CHAPTER 36

OPEI - Workshop of Projects, Entrepreneurship and Innovation: A Multidisciplinary Experience

Karla Rocha Liboreiro[*], Hermes Aguiar Magalhães[♦], Renata Guimarães Borges[▲], Eduardo de Campos Valadares[▼] and Eduardo Romeiro Filho[○]

[*]Departamento de Engenharia Industrial,
Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

E-mail: karlarliboreiro@gmail.com

[♦]Departamento de Engenharia Industrial, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

E-mail: hermesam@gmail.com

▲Departamento de Engenharia Industrial,

Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

E-mail: renatasg@face.ufmg.br

▼Departamento de Engenharia Industrial,

Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

E-mail: ecamposv@fisica.ufmg.br

°Departamento de Engenharia Industrial,

Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

E-mail: romeiro@ufmg.br

Abstract: The multidisciplinary teamwork is nowadays recognized as a challenge for innovation processes and also a necessary action. The University needs to include the multidisciplinary teamwork teaching approach into different levels, from undergraduate students to doctoral students, in order to improve value proposition thinking and wealth generation to society. In view of this situation, the aim of this article is to present an ongoing experience called OPEI: “Oficina de Projetos, Empreendedorismo e Inovação”, which stands for

“Workshop of Projects, Entrepreneurship and Innovation”. The OPEI class has been developed since 1st semester of 2016 at UFMG, with the participation of five professors from different areas: Industrial Engineering, Electrical Engineering, Physics, Business, and Biology. There are also active participation and academic contribution from undergraduate and graduate students, from different knowledge areas. This experience integrates not only students from different fields, but also faculties as well. Furthermore, this course connects the students with the local entrepreneurship ecosystem in the early stages of their project. This report includes each phase of class development: planning, execution and evaluation. We investigate the impact of this multidisciplinary class in student’s change of mindset, once they are exposed to innovative environment at both, the University and local entrepreneurship ecosystem. This teamwork experience also shows opportunities for student’s formation improvement in the innovation and entrepreneurship concepts. We develop the OPEI’s case study on a qualitative basis conducted with the use of a mix of methods and procedures: interviews, local observation and analysis of the student’s evaluations classes. The analytical method also includes content analysis. The results show how OPEI team is being translating multidisciplinary complexity into simplified and objective actions and content, adequate to its also multidisciplinary public, which spams students from dozens of knowledge courses and undergraduate freshmen to graduate students interacting at the same class. The results presented are intended to provide subsidies to other similar teaching experiences on the innovation and entrepreneurship subject, recognized as necessary for quality of life improvement in society.

Keywords: Multidisciplinary Teaching, Innovation, Innovative environment, University, Entrepreneurship.

36.1 Introduction

This article presents the ongoing experience at UFMG of creating a multidisciplinary discipline offered by professors from different areas of knowledge, called "Workshop of Project, Entrepreneurship and Innovation - OPEI". The OPEI class has been developed since 1st semester of 2016 at UFMG, with the participation of five professors from different areas: Industrial Engineering, Electrical Engineering, Physics, Business, and Biology. The OPEI is an elective disciplin for undergraduate students of UFMG and aims to awaken the entrepreneurial conscience of the students, promote teamwork, develop a critical eye on everyday problems and break the barrier that exists for the transformation of ideas into perceived value, in future new business. The key points will be taken into account during planning, execution and evaluation of OPEI class. We also pinpoint some actions that were required as to establish partnerships with important actors of the entrepreneurial ecosystem. This article also brings concepts and tools for ideation processes and validation of ideas, problem solution validation, product-market fit, development of new business models, agile and corporate management, people management, prototyping and communication of new ideas and products.

36.2 Theory Development

36.2.1 The multidisciplinary teamwork

High performance teams are typical formations of modern organizations[1]. Although there is a lot of information available about people management, little knowledge is disseminated on effective practices and the impact of the active sharing of experiences and knowledge that enables a superior and innovative performance of certain teams. Therefore, modern organizations must rearrange themselves internally in the search for results improvement and track the factors external to the team that can affect the business, in order to meet the diverse demands of the market and to remain competitive and innovative. In a global competitive environment, changes are rapid and teams cannot be believed to be stable[2]. The multidisciplinary teamwork involves different skills, experience and background of people working together to solve some problems or to build something new. The divergences are normal in the construction of a teamwork and play an important role to foster the diversity and different viewpoints that will contribute to innovation.

36.2.2 Teaching innovation and entrepreneurship at university

Teaching in higher education happens each day more and more with the two way transfer of knowledge between students and teachers in the classroom. In the analysis of changes from the traditional teacher-centered education for the progressive student-centered Education,[3] presents the benefits to consider the student as the focus of all the knowledge transference. The way in which a university should work in the preparation for a career is by promoting the imaginative aspects considering the various general principles underlying that career and promote the experience for the students in the academic environment[4]. Therefore, the combined interaction of the teacher, the students and the environment in which the transfer of information between them takes place is relevant for the results in the learning process[5]. Thus, this research proposes the investigation of the question: "Which are the key points for planning, execution and evaluation to build an effective multidisciplinary class capable of impacting the innovation and entrepreneurship student's mindset?" The hypothesis is: H1 - The key points chosen during OPEI class will be effective to impact students mindset and connect them to the innovative environment and to influence students behavior and their demands during the semester.

36.3 Methodology

Considering the objective of this research Case Study methodology was used.

36.4 Data analysis and Results

The data was collect during the three phases of the OPEI class development: planning, execution and evaluation. The OPEI class had 80 students enrolled in the first semester of 2016 from seventeen different undergraduate courses and 82 undergraduate students enrolled in the second semester of 2016 from nineteen different courses. The OPEI's planning phase involves some key points: definition of programmatic content, the activities and games to be applied during the classes and evaluation methodology. The challenges were the communication and the process of knowledge transfer. The evaluation of the discipline external agents were invited for examining the final presentations, the pitch. The online satisfaction survey of the discipline showed that 42 undergraduates students enrolled were satisfied (84 % positivity). In order to understand the student's perceptions about the most relevant topics in the online survey we investigate, by giving some words and asked to choose the five that they consider most relevant in the context of the topics covered by the contents during the semestre. The results confirmed the H1.

36.5 Conclusion

The focus of this paper was to present the experience of the multidisciplinary OPEI class and the main learning points. The discipline class-hours in 2017 went from 30 hours to 60 hours, due to a demand of the students for a deeper content and practice. The evaluation phase had some changes to make possible the discipline to contemplate individual activities. In addition, the leadership, decision making and autonomy of the students were areas of improvement worked and already implemented. In this way, this experience made possible an innovative environment both in a public University and in the local entrepreneurship ecosystem. This multidisciplinary teamwork experience also shows opportunities for student's formation improvement in the innovation and entrepreneurship concepts. The results presented are intended to provide subsidies to other similar teaching experiences on the innovation and entrepreneurship subject, recognized as necessary for quality of life improvement in society.

Bibliography

1. MOSCOVICI, F. *Equipes dão certo: a multiplicação do talento humano.* Rio de Janeiro: José Olympio, 2007.

2. CHESBROUGH, H. W. *Open innovation: The new imperative for creating and profiting from technology.* Boston: Harvard Business Press, 2006.

3. CHALL, J. S. *The Academic Achievement Challenge: What Really Works in the Classroom?* Ne York: Guilford Publications, 2000.

4. HINDLE, K. Teaching entrepreneurship at university: from the wrong building to the right philosophy. *Handbook of research in entrepreneurship education*, France, v. 1, p. 104-126, 2007.

5. WANKAT, P. C.; OREOVICZ, F. S. *Teaching engineering.* Indiana: Purdue University Press, 2015.

CHAPTER 37

Methods to Increase Freshmen Interest and Motivation: Combating Retention and Evasion Among Biochemical Engineering Students

Geraldo Gabriel Araújo Silva[*], Michele da Rosa Andrade Zimmermann de Souza[♦], Ana Priscila Centeno da Rosa[▲], Elisangela Martha Radmann[▼] and Thaisa Duarte Santos[○]

[*]Escola de Química e Alimentos,
Universidade Federal do Rio Grande, Rio Grande, Brazil

E-mail: geraldogasilva@gmail.com

♦Escola de Química e Alimentos,
Universidade Federal do Rio Grande, Rio Grande, Brazil

E-mail: michrandrade@gmail.com

▴Escola de Química e Alimentos,
Universidade Federal do Rio Grande, Rio Grande, Brazil

E-mail: ana.centeno@yahoo.com.br

▾Escola de Química e Alimentos,
Universidade Federal do Rio Grande, Rio Grande, Brazil

E-mail: emradmann@yahoo.com.br

°Escola de Química e Alimentos,
Universidade Federal do Rio Grande, Rio Grande, Brazil

E-mail: thaisadsantos@yahoo.com.br

Abstract: The highest levels of evasion and retention on the Biochemical Engineering major at Federal University of Rio Grande are observed during the first semesters of the undergraduate degree, in which are offered the courses that compose the basic cycle of Engineering and are the foundation for the advanced courses. Literature confirms that entering the university can be a

very stressful and life changing process, reinforcing the need of special institutional attention to the freshmen. As an alternative to fight this negative scenario and promote integration among students, a series of activities were proposed through the Program of Incentive to Academic Activities of Biochemical Engineering Students (PAIEB), supported by the Institutional Program of Student Development (PDE-FURG). During the school year of 2016, motivational speeches, and time management workshops were organized through the program, in addition of a series of testimonies of juniors and seniors about their experiences on college. To evaluate the activities, opinion surveys were conducted to all participating students. Surveys applied showed that a high number of freshmen desired to graduate on Biochemical Engineering (97.5%), felt more motivated to study (97.5%), could visualize new areas that they could work in (95%), and could visualize application for their current classes in the testimonies (92.5%). In addition, 62.5% of the freshmen considered their academic performance bellow expected. It was found that the evasion level in 2016 remained stable when compared to the 2015 level (about 17%) and decreased roughly 3% when compared to 2014, and the retention level within the freshmen year did not show significant decrease. Therefore, the answers to the surveys applied showed that the program is helping on freshman interest and motivation, and data collected from the university database implied that the program needs to be amplified and intensified to help decreasing evasion and retention on the Biochemical Engineering major.

Keywords: Exchange of Experiences, Institutional Program, Integration Among Students, Motivational Speeches, Testimonies.

37.1 Background

Entering the university is a very complex and stressful process to the students; they must learn to conciliate issues related to academic, social, family, and – sometimes – even paid employment responsibilities[1]. Reasons that lead students to evade are usually complex[2] and so are the reasons that influence on student's retention[3]. Addressing the problem to Engineering students, we find that student and institutional commitment may be key factors that influence high retention and evasion levels[4]. However, it is also found that besides the commitment, factors like gender differences, extracurricular activities, integration with classmates, financial conditions, and psychological encouragement can be extremely decisive on that matter[3].

37.2 Purpose/Hypothesis

Biochemical Engineering major is an undergraduate course that touches many fields of knowledge such as mathematics, physics, biology, chemistry and biochemistry, which can make it especially stressful to students that, at the first moment, don't identify with all the areas and struggle to adapt to the course. During the years of 2015 and 2014, for example, the retention levels on the first semesters of the Biochemical Engineering Major at FURG were roughly around 57% of all the registered students. In addition to that, the evasion levels over the years are presented on Figure 37.1.

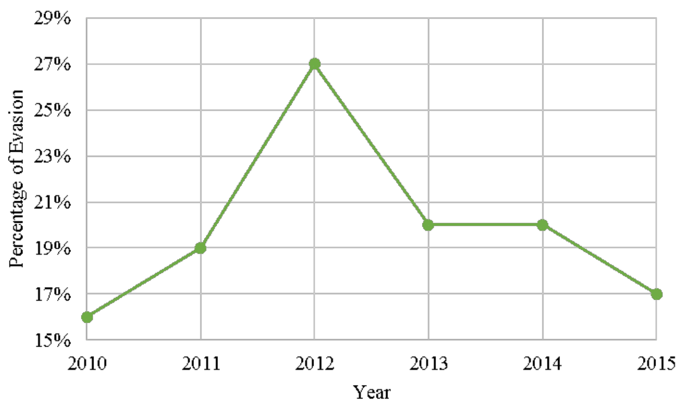


Figure 37.1 – Graph on the evasion level of the Biochemical Engineering students at FURG over the years.

The purpose of this document is to describe methods adopted at the Federal University of Rio Grande to try to increase Biochemical Engineering students interest and motivation as a way to try decreasing retention and evasion levels.

37.3 Design/Method

A series of activities were proposed through the Program of Incentive to Academic Activities of Biochemical Engineering Students (PAIEB), supported by the Institutional Program of Student Development (PDE-FURG). During the school year of 2016, the program organized a series of testimonies of Biochemical Engineering juniors and seniors about their experiences on college related activities, such as research projects, studying abroad, internship programs, and other personal experiences. Moreover, motivational speeches about college life and expectations, and time management workshops, were offered through the program to help the students conciliate college responsibilities with their other obligations and the essential leisure time, as well as to provide them a journey of self-knowledge. Both the latter were performed by appropriate professionals.

The program activities were mostly, but not exclusively, performed on the Biochemical Engineering Fundaments I course, offered on the first semester to the freshman class. Although the focus was on the freshmen, the activities were extended to all Biochemical Engineering students. To evaluate the program, opinion surveys were conducted to all participating students. All the activities, including the surveys, were constructed together with a pedagogue from the Pro-rectorate for Students Affairs of the university.

37.4 Results

According to the surveys applied, a high number of students had positive responses to the program activities, as presented on Table 37.1. In addition, 62.5% of the freshmen considered their academic performance bellow expected, reinforcing the necessity of institutional attention and programs to fight this negative scenario.

Table 37.1 – Data from the applied surveys.

Student's answers	Percentage of students
Had the desire to have their bachelor's degree on Biochemical Engineering bachelor's degree on Biochemical Engineering	97.5%
Felt more motivated to study	97.5%
Could visualize new areas that they could work in areas that they could work in	95%
Could visualize actual application for their current classes in the testimonies for their current classes in the testimonies	92.5%
Considered their academic performance bellow expected	62.5%

Data collected from the university database showed that the evasion level in 2016 was about 17%, this number remained stable when compared to the 2015 level and decreased roughly 3% when compared to 2014. Also, the retention level within the freshmen year was about 58% in 2016 and did not show significant increase when compared to the two past years.

37.5 Conclusions

According to the answers on the applied surveys, the program is indeed helping on freshman interest and motivation. Quantitative data collected from the university database show that retention and evasion levels on the Biochemical Engineering major did not increase after the described activities; therefore, the program needs to be amplified and intensified to help decreasing these levels.

Bibliography

1. CRISP, G. et al. First year student expectations: Results from a university-wide student survey. *Journal of University Teaching & Learning Practice*, Wollongong, v. 6, n. 1, p. 12-26, 2009.

2. ZEPKE, N. Being learner centered: one way to improve student retention? *Studies in Higher Education*, London, v. 31, n. 5, p. 15-64, 2006.

3. MEYER, M.; MARX, S. Engineering Dropouts: A Qualitative Examination of Why Undergraduates Leave Engineering. *Journal of Engineering Education*, New Jersey , v. 103, n. 4, p. 525-548, oct. 2014.

4. TINTO, V. Limits of theory and practice in student attrition. *Journal of Higher Education*, New York, v. 53, p. 687-700, 1982.

CHAPTER 38

Cooperative Learning Cell for Android Application Development

Antonio Márcio Albuquerque Almeida[*], Iara Barbosa de Sousa[♦], Francisco Heitor Vasconcelos[▲], Leonardo Pires de Sousa Silva[▼] and Rômulo Nunes De Carvalho Almeida[○]

[*]Departamento de Engenharia Elétrica,

Universidade Federal do Ceará, Sobral, Brazil

E-mail: marcio.albu@alu.ufc.br

[♦]Departamento de Engenharia Elétrica,

Universidade Federal do Ceará, Sobral, Brazil

E-mail: iarasousa_22@hotmail.com

▲Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: fheitorvasconcelos2@gmail.com

▼Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: leonardopires85@hotmail.com

°Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: rnunes@dee.ufc.br

Abstract: The drop-out rate in Engineering Courses represent a significant issue for higher education in Brazil. This reality is no different in electrical and computer engineer undergraduate courses at Universidade Federal do Ceará. A possible reason for this drawback may be a basic formation cycle (the first three semesters of the course) focused entirely on math and physics. Although calculus, physics and programming are fundamental to the understanding of the next subjects, they may discourage the students may discourage the students due its inherent abstraction and sometimes distant interconnection to field

Engineering tasks. In order to tackle this problem, the present paper presents a case study developed within a project called Cooperative Learning Cell for Android Development at Electrical and Computer courses of Universidade Federal do Ceará, campus Sobral. The project main objective was promote learning and knowledge sharing through self-oriented groups of Engineering students on first and second semesters. The student selection method was a questionnaire about their personal and academic interests and the only required condition was available time to attend the meetings and activities. Nine meetings happened, in the period from September to December of 2016, and a cooperative learning methodology were applied on work groups where knowledge is generated through interaction among two or more people resulting in an active participation of the education process. The meetings were divided in classes and lectures from professional and the themes discussed were basic introduction to Java and advanced content in Android development. The classes were planned with a focus on content exposition, challenges and small projects for small projects for group task solution. The lectures invited professionals which work in Engineering companies at the North region of Ceará, showing the current situation of the job market, focused on mobile applications.

Keywords: Cooperation, Engineering Teaching, Incentive, Android, Public Education.

38.1 Background

According to the Ministry of Education (MEC) of Brazil, in 2007, 105,101 people entered Engineering courses in public and private institutions. Five years later (expected time to complete the course) only 42.6% of students got a college degree. In all, 57.4% gave up halfway[1]. This evasion is a common problem for Engineering courses.

This high rate brings personal and social losses to the students who can't finish their higher education, as they may not obtain their academic training. Society also loses, since the investments destined have not been used. On this specific problem, the Universidade Federal do Ceará promotes cooperative learning programs[2]. One such program is the Cooperative Learning Cell for Android Application Development, whose main goal is to promote learning and knowledge sharing for first and second semester Engineering students at the Sobral campus.

38.2 Purpose/Hypothesis

The project is based on three parts: Learning, Cooperativity and Application Development Mobile. Learning is based on teaching a small pre-selected group[3, 4]. That is formed by students in initial periods of Electrical Engineering and Computer Engineering. Cooperativity is one of the essential conditions for the formation of team learning, where individuals share their knowledge among them[5]. For the matter in question was chosen the environment development of Android applications, due to its great popularity in the Brazilian market[6].

With the above reasoning, the lesson plan was established, which assumption the motivation of the students to join the class, with the purpose to instruct on the necessary applications to stimulate the students with issues on the subject cited before.

38.3 Design/Method

Initially made a selection of participants, through a questionnaire, where the student answered personal information. One of the essential questions was what most motivated the student to want to participate in the group. The questionnaire reviewers chose the 10 best competitors who had the best arguments, where apparently showed an interest in participation[7]. The team was open for new members to enter the class. Thereby, another 11 new members have joined totalling 21 members.

The figure 38.1 shows the first meeting, that it was explained how the project would work: schedules, books, software used (Java SE Development Kit, Netbeans, Android Studio). The most important part clarified was how the classes would work. Where would have two moments, the first was the classes through

Figure 38.1 – First meeting of the group.

social media, with content submission related to the subject of android programming or related information[8].

In second moment was the presential classes, which we started with Java programming to introduce the content. In Android programming classes we teach logical operations, arithmetic, decision structure, graphical interface etc. We show practical examples, such as creating a calculator with basic arithmetic operations. We applied exercises like to create a user application and password to be able to enter other functions of the application.

To further motivate the student was promoted classes with professionals working in Engineering companies in the Northern region of Ceará to show the current situation of the labour market on mobile applications and tips in order to avoid common mistakes in android programming.

38.4 Results

During the project, there was a desistance rate of approximately 24%. For evaluating the results for evaluating the results a quiz was developed to measure the level of interaction and learning development of participant students. The level of interest in Android programming before the course was 50%. A percentage of 45% of students indicated confidence in relation to content learning and 55% signalled reasonable confidence in learning. All of the students considered that their doubts were clarified. A percentage of 37% felt integrated with the colleagues and 50% felt reasonably integrated.

38.5 Conclusions

The Cooperative Learning Cell for Android application development has shown to be effective in bringing the student closer to the course, by learning through a group of people. Educational institutions can achieve greater participation in the student learning process through this methodology and arouse the students interest in the job market and future academic projects.

Bibliography

1. MONACO, R. *Mais da metade dos estudantes abandona cursos de engenharia 2013*. São Paulo: CNI - Confederação Nacional da Indústria, 2013.

2. MAIA, A. et al. Aprendizagem Cooperativa e a Evasão Acadêmica. *Encontros Universitários da UFC*, Ceará, v. 1, n. 1, p. 3362, 2016.

3. GARCIA, J. Avaliação e Aprendizagem na Educação Superior. *Estudos em Avaliação Educacional* , São Paulo, v. 20, n. 43, p. 201-213, 2009.

4. INOCÊNCIO, D.; CAVALCANTI, C. M. C. O Trabalho Em Grupo Como Metodologia De Ensino Em Cursos E Disciplinas On-Line. In: CONGRESSO ABED, Florianópolis, 2005. *Anais...* Florianópolis: ABED, p. 1-10, 2005.

5. TIJIBOY, A. et al. Aprendizagem cooperativa em ambientes telemáticos. *Informática na Educação: teoria & prática*, Porto Alegre, v. 1, n. 2, p. 19-28, apr. 1999.

6. Hamann, R. *Ios, Android E Windows Phone: Números Dos Gigantes Comparados [Infográfico]*. [2014?]. Avaiable in: <https://www.tecmundo.com.br/sistema-operacional/60596-ios-android-windows-phone-numeros-gigantes-comparados-infografico.htm>. Acessed in: 26 may 2017.

7. LUNELLI, A.; TREICHEL, A. *Recrutamento E Seleção: Como Fazer Uma Entrevista?*. Santa Catarina: Instituto Catarinense de Pós Graduação, 2008.

8. SOUZA, M. M. S.; SILVA, A. M. *56° CBQ - O Uso Das Redes Sociais, Face-*

book E Whatsapp, Como Ambientes Virtuais De Aprendizagem No Ensino De Química. [2016?]. Avaiable in: <http://www.abq.org.br/cbq/2016/trabalhos/6/9678-17820.html>. Acessed in: 27 May 2017.

CHAPTER 39

Electromyographic Data Acquisition

Iago Machado Carneiro Leite[*], Rômulo Nunes de Carvalho Almeida[♦], Maria Rilda Loiola de Vasconcelos[▲], Márcio André Baima Amora[▼] and Vandilberto Pereira Pinto[○]

[*]Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: iagomachado110@gmail.com

[♦]Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: rnunes@dee.ufc.br

▲Faculdade de Medicina, Centro Universitário INTA (UNINTA), Sobral, Brazil

E-mail: rilda.loiola@hotmail.com

▼Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: marcioamora@yahoo.com.br

○Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: vandilberto@yahoo.com.br

Abstract: This paper consists in the elaboration of a low-cost prototype for a electromyographic data capture. These signals come from the natural process of muscle movement, and can be captured by electrodes, which may be surface or invasive. The acquired data from the electrode are of the order of 5 mV, that are subject to all kinds of environmental interference and other unmoved muscle groups. In this way, the work in question approaches different methods of treatment of these signs, to identify them in association with movements that represent the specific muscle contraction. As a consequence of this study, it's possible to use interdisciplinary interactions within the pedagogical process of the Electrical Engineering and health courses, verifying the theoretical process associated to disciplines such as Anatomy, Physiology, Signal Processing, Microcontrollers, Electrical Circuits, among others. At Health Courses, this could be used in practical classes about muscle contraction to verify two process: the minimum stimulus capable of generating the action potential, called the threshold stimulus and the refractory period, in which the muscle is physiologically recomposed for a new contraction and the captured signal is negative. In Engineering Education, this is used at analog electronic class to evaluate the right values for resistors and capacitors for the right gain and cutoff frequency. And programming an analog/digital converter at microcontroller class. As a result of this study, we have created a functional prototype based on printed circuit that has a complete structure for laboratory application. Finally, experimental trials were carried out contemplating the movement of the biceps as a way of validating the designed experimental prototype.

Keywords: Electromyographic Signal, Filters, Interdisciplinary Interactions, Low-Cost, Prototype.

39.1 Background

Electromyography(EMG) is a technique for monitoring the electrical activity of a muscle, your value represents the sum of the electric signal from muscle contraction, controlled by the nervous. An EMG signal is the electrical activity of a muscle's motor units, and this technique could be of two types: surface EMG or intramuscular EMG. At this paper, the surface EMG will be used. In this method, superficial electrodes are used to capture the EMG signal, these devices are placed on the skin on top of the muscle[1].

Muscle contraction is based on the All-or-Nothing Law, in which a neuron can only send an impulse if the pulse intensity is above certain level, causing its membrane to be depolarized and repolarized. This minimum value that allows transmission of the action potential is known as potential threshold. Thus, for continuous propagation of the impulse to occur, the ratio of the action potential to the excitation threshold should always be greater than 1[2]. Also, involving the physiology of contraction, there is a period which the muscle can't contract, called the refractory period, in which the muscle physiologically recomposes itself to a new contraction[3].

39.2 Purpose/Hypothesis

This paper was first design to find a way to capture and analyze the electrical signal of the muscle, with the objective of studying it, both in the physiological part and in the means of obtaining it. However, there is a problem in this acquisition, which is an intrinsic characteristic of this type of signal, they are of the order of 5 milivolts. This is a major drawback because such signals can be easily influenced by noise, such as environmental interference or even from the measurement process. At this work a way for obtain this data will be developed.

39.3 Design/Method

So, in order to capture the signals, they need to go through a series of adaptation stages, such as amplifications and filtering, which are key points in this acquisition. This work can be divided into three main stages: signal improvement, analog/digital conversion(A/D) and computational analysis. For each stage the present study can be assigned to an application of Engineering teaching.

The improvement stage it's about transform the captured signal into a possible value for analysis. This is done through an analogue treatment, which consists of first rejecting the common signal. Three electrodes are positioned: two on the muscle to be analyzed(capture electrodes) and a third on another muscle(reference electrode). The signal that is common from capture electrodes and reference electrode doesn't represent a movement signal, so it's rejected and only movement signal remains, this is done by an instrumentation amplifier, which also amplifier this remain signal. Still in the analogue treatment, there are more four sub-stages: low pass, band reject, high pass filter and a voltage adder. These filters are necessary to ensure that the signal not related to the muscle is actually eliminated, the choice of the cutoff frequency of the filters coming from the spectrum of muscle contraction, which is situated in a certain range from 5 Hz to 400 Hz approximately[4]. These filters can also work as a voltage amplifier, if necessary, since they are active filters. To finalize the analogue treatment, there's a voltage adder that will impose a DC level on the final signal, this is done to make possible the A/D conversion, which will be discussed further ahead. This first part can be used in analog electronics classes, students can through signal generators impose certain frequencies on the circuit and individually analyse each filter, its cutoff frequencies and gains. In addition, they can also understand and modify the circuit, adapting it to another muscle, or for another propose. It's a great incentive for students to realize the importance of discipline.

In the second stage, the A/D conversion will be done. The signal will be converted and sent to the computer. It was chosen the Arduino UNO to do this work. The signal need to be in a range of 0 to 5 V to be received by the Arduino, so the voltage adder at the end of the circuit leaves the signal at 2.5 V so it can vary from 0 to 5 V. After converting the signal, the arduino's serial communication is also used to send this signal to the computer. This step could be done with any microcontroller that has an A/D converter and serial communication. It was chosen Arduino, but in a practice class of Microcontrollers discipline the students could adapted to another microcontroller, with greater precision and better stability, improving the students' knowledge.

And finally, has the analysis and storage of data, which is done with Matlab. This software communicates with the Arduino and receives the values, these values pass through a digital filter, are plotted on the screen and stored. A graphical interface was created in Matlab for any user to be able to start the measurement.

39.4 Results

A system-wide functional prototype was made consisting of a printed circuit board containing the entire analog circuit. The output of the board is connected to an analogue port of the Arduino, which communicates with the computer though a USB cable. In the computer, Matlab receives the data, applies a moving average filter, plots the voltage graph by time and finally stores the data if the user wishes. Samples were taken from the biceps, and qualitatively the signal seems to be as desired, it's able to capture the muscle signal that has a positive peak in the wave when contracting the muscle, and a negative peak when relaxing.

39.5 Conclusions

The first goal of the project was successfully completed. Now the second part is being implemented, which is the use of this methodology in Engineering Education and health areas. In the Engineering will be held practical classes addressing the subjects already mentioned, in classes of analog electronics, electrical circuits, microcontrollers and digital signal processing. And at health area, the prototype is being analyzed together a medical student on the feasibility of this topology to be used to verify concepts of muscle recovery time until another movement, minimum potential of action and the study of neuro-conduction. Probably it will be possible to illustrate in the qualitative way, to verify the signal and its wave form, but the quantitative on probably will not be as in the medical literature, due the technical limitations of the circuit.

Bibliography

1. MARCHETTI, P. H.,; DUARTE, M. *Instrumentação em eletromiografia.* São Paulo: Laboratório de Biofísica, Escola de Educação Física e Esporte da Univer-

sidade de São Paulo, 2006.

2. GUYTON, A. C.; HALL, J. E.; GUYTON, A. C. *Tratado de fisiologia médica.* Rio de Janeiro: Elsevier, p. 68, 2006.

3. GUYTON, A. C.; HALL, J. E.; GUYTON, A. C. *Tratado de fisiologia médica.* Rio de Janeiro: Elsevier, p. 71-72, 2006.

4. KOMI, P. V.; TESCH. P. EMG frequency spectrum, muscle structure, and fatigue during dynamic contractions in man. *European Journal of Applied Physiology and Occupational Physiology*, Heidelberg, v. 42, p. 41-50, 1979.

CHAPTER 40

Educational Robotics As A Tool to Encourage Learning

Adrielle Batista do Nascimento[*], Adriel de Oliveira Freitas[♦], Vandilberto Pereira Pinto[▲], Rômulo Nunes de Carvalho Almeida[▼] and Jermana Lopes de Moraes[○]

[*]Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: adriely-batista123@hotmail.com

[♦]Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil

E-mail: adrieloliveira_@hotmail.com

▲Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil
E-mail: vandilberto@yahoo.com.br

▼Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil
E-mail: rnunes@dee.ufc.br

○Departamento de Engenharia Elétrica,
Universidade Federal do Ceará, Sobral, Brazil
E-mail: jermanalopes@gmail.com

Abstract: The number of evasion of the students of the Engineering Courses, mainly in the first semesters, is increasing. Many studies and educational research are directed at studying the causes of this evasion. The absence of the correlation of the introductory disciplines with the practical activities of the Engineering can be considered one of the main causes. One way to connect basic science knowledge such as mathematics, physics and programming to practical and daily is to use interdisciplinarity, such as robotics that can be treated as a teaching medium and an object of learning. This encompasses from mechanics and electronics, to the elaboration of robots, to mathematical models, for the creation and execution of algorithms. In this way, an Educa-

tional Robotics project was developed with the purpose of awakening in the student the interest in the theoretical and practical parts of Engineering. This project also aims to bring students from public schools in the state of Ceará to the university environment. For this, robotics was implemented as a tool to stimulate logical reasoning and creativity. The focus of this process is that the student learn to do, and this begins when he associates the proposed problems with real situations, leading him to arrive at the most viable solution, and another fundamental part of this process is the construction of the robot, which allows it Not only understand but also know how to make the prototype. For the execution of the project, Robot prototypes were developed with low-cost, accessible and easy-to-use materials. Robot control and intelligence were developed based on the Arduino electronic prototyping platform by having its programming language standardized and being considered an open-source system. The entire Robot confection and programming logic was passed on to students through handouts, video-lessons and regular periodic training. At the end of the training, a robotics competition was held in order to verify the development of different skills, such as collaborative work, logical reasoning, creativity and the expansion of electronic knowledge. With this, it was verified that the connection between basic and Engineering knowledge facilitates the understanding of contents, helps in the organization of the reasoning and in the way the student handles and solves routine problems, generating a significant improvement in learning. This connection of knowledge also influences undergraduate students in the permanence of Engineering Courses.

Keywords: Autonomy in Learning, Educational Robotics, Engineering Education, Evasion, Interdisciplinarity.

40.1 Background

Robotics is a multidisciplinary area that draws on the knowledge of other sciences to create the robot. In this way there is inherently an interdisciplinary project where the student applies in a practical way the content and research according to his need and interest. Ideas and research provide curiosity for research, which leads to the student's intellectual development[1].

Several initiatives have been emerging, mainly by American universities, aimed at attracting students from elementary education to the areas of Engineering and Technology through the use of Robotics as a motivational tool[2].

The important thing within a dynamic work with students in a robotics class is to create conditions for discussion and to promote openness so that all students and teachers participate by presenting suggestions in solving problems. It also stresses the importance of creating problems to be solved, as the difficulties serve to explore the student's ability. We can also synthesize the main stimuli obtained through this pedagogical practice[3].

40.2 Purpose/Hypothesis

The present work aims to introduce general notions of Robotics through the 2WD Robot Kit with the objective of dynamizing the teaching-learning techniques and also motivate the high school students of the community of the Northern Region of Ceará, more particularly of the municipality of Sobral, to awaken the Interest in the Electrical Engineering and Computation courses at the Federal University of Ceará, Sobral Campus.

40.3 Design/Method

The robotics course will be taught in the initial semesters of Engineering courses with the goal of providing students with the first contact with applications in the disciplines of computation, programming and physics within Engineering.

With the robotics course students will get basic notions in Electronics, problems such as those proposed in previous editions of robotics competition will be presented to be solved using knowledge of physics, programming and calculation through the 2WD Robot. The activities will be presented to students using the application methodology in the Figure 40.1.

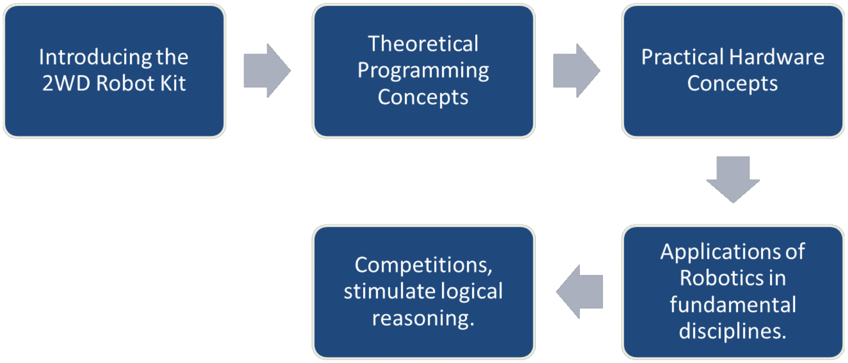


Figure 40.1 – Activity Cycles.

Figure 40.2 illustrates the 2WD Robot Kit used as an alternative tool for teaching and learning techniques in both public schools in Sobral and in the initial semesters of electrical Engineering and computing.

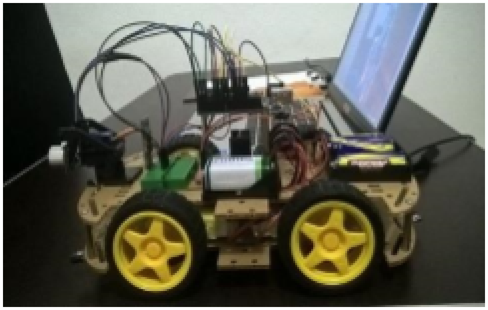


Figure 40.2 – 2WD Robot Kit.

40.4 Expected Results

It is hoped that this project will improve the learning of students in public education and help them to assimilate the contents learned in the classroom with everyday situations, stimulating them to develop skills to execute and solve problem situations, and focusing on The learning by doing, which goes beyond just learning definitions. The application of this work also aims to encourage undergraduate students to stay in the Engineering courses, since the contact with practical contents in the initial semesters motivates the student to continue the undergraduate course and to have a better view of the course approach.

40.5 Conclusions

The objective of this work is to use Educational robotics in order to motivate the high school students of the community of the northern region of Ceará, particularly in the municipality of Sobral, to arouse interest in electrical Engineering and computer Engineering courses and to motivate them. In the first semesters of graduation in order to reduce dropout. The activities presented in the present study facilitate the teaching of high school students and encourage students to attend Engineering courses, since they were very enthusiastic during and after the activities, in order to prove the motivational character of the robotics as a teaching tool.

Bibliography

1. NASCIMENTO, P. C. *Inteligência Artificial.* [2002?]. Available in: <http://www.unicamp.br/unicamp/unicamp_hoje/ju/fev2002/unihoje_ju170pag04.html>. Accessed in: 5 apr. 2017.

2. BENITTI, F. B. et al. Experimentação com Robótica Educativa no Ensino Médio: ambiente, atividades e resultados. In: WORKSHOP DE INFORMÁTICA NA ESCOLA , Porto Alegre, 2009. *Anais...* Porto Alegre: UFRGS, v. 1, n. 1, p. 1811-182, july 2009.

3. BACAROGLO, M. *Robótica Educacional: Uma metodologia educacional.* Masters dissertation. Londrina: UEL, 2005.

CHAPTER 41

The Importance of The Teaching Improvement Program in Different Kinds of Disciplines: The Contribution of The Program in Several Areas of Education

Jáder Fernando Dias Breda[*], José Carlos M. Vieira Júnior[♦] and Mário Oleskovicz[▲]

[*]Departamento de Engenharia Elétrica e de Computação, Universidade de São Paulo, São Carlos, Brazil

E-mail: jader.breda@usp.br

♦Departamento de Engenharia Elétrica e de Computação,
Universidade de São Paulo, São Carlos, Brazil

E-mail: jcarlos@sc.usp.br

▲Departamento de Engenharia Elétrica e de Computação,
Universidade de São Paulo, São Carlos, Brazil

E-mail: olesk@sc.usp.br

Abstract: The Teaching Improvement Program of Universidade de São Paulo (USP) aims to improve the academic skills (teaching, courses planning and production of teaching material) of the master and doctoral students. For reaching this purpose, the graduate students must complete a supervised internship at USP in a discipline of the undergraduate course, in which he/she can assist the teacher throughout the academic period. Taking this information into account, this work focuses in showing the importance of the students enrolled in this Teaching Improvement Program (referred here as trainees), comprising different types of disciplines of the Electrical Engineering Course, either practical, theoretical or mixed. The reports pointed out in this article are related to a trainee who has taken part of the program in four different disciplines, being responsible for supervising the undergraduate students during the experimental classes (laboratory activities), elaborating lists of exercises to be solved, and promoting weekly teaching-support meetings with tem whenever necessary. The results obtained from the inclusion of a trainee in the disciplines are quite encouraging, since it can be observed that in practical and mixed disciplines, with the aid of the trainee in the supervision and monitoring of the practical experiments, the responsible professor was able to dispense more time to explain better the theoretical part, in addition to that the monitoring became more personalized of each bench. Regarding theoretical subjects, with the lists of exercises elaborated by the trainee and made available with the material of the theoretical classes, the students were able to carry out a better follow-up of the contents throughout the academic period. In addition, due to weekly meetings with the trainee, students' questions about the content did not accumulate for the dates close to the tests, as usually occurs. Therefore, due to the experience gained in these different types of disciplines, it is suggested that a larger number of positions can be opened in the program so that more trainees can join and, consequently, more disciplines may have a trainee to assist the responsible teacher. The benefits certainly reach all the agents and institution involved: the University, the trainee himself, the responsible teacher and, finally, the undergraduate students.

Keywords: Engineering Education, Practical Disciplines, Theoretical Disci-

plines, Supervised Internship, Teaching Improvement Program.

41.1 The Teaching Improvement Program

The Teaching Improvement Program of University of São Paulo (USP), for postgraduate students enrolled in the in master's and doctoral programs, existed since 2005 and aims to improve the academic skills (teaching, courses planning and production of teaching material). For reaching this purpose, the graduate students must complete a supervised internship at USP in a discipline of the undergraduate course, in which he/she can assist the teacher throughout the academic period with a workload of six hours per week. During this period, the student may be receiving assistance from a scholarship through a selection process or even performing the internship voluntarily.

41.2 The Trainee's Internships

Taking this context into account, this work focuses in showing the importance of the students enrolled in this Teaching Improvement Program (referred here as trainees), comprising different types of disciplines of the Electrical Engineering course, either practical (in which trainees are usually more requested), theoretical (in which, usually , the trainees are less requested) or mixed. The reports pointed out in this article are related to a trainee who, during the years 2012 and 2015, taken part of the program in four different disciplines of USP's Electrical Engineering degree course: Power Quality[1], Electric Circuits I[2], Electromechanical Energy Conversion[3, 4] and Electromechanical Energy Conversion Laboratory[3, 4]. Being that twice carried out the activity voluntarily and in the others like scholarship of the program.

41.3 Developed Activities

The trainee was responsible, depending on the discipline always on the orientation and accompaniment of the teacher responsible, for the following activities:

- Power Quality: among the activities that were developed during this mixed discipline, the supervision of laboratory classes, the correction of theoretical exercises and computer simulation, and practical classes taught throughout the course by the trainee, with accompaniment of the teacher in charge, are highlighted.

- Electric Circuits I: at the beginning of the period, the trainee performed a presentation of the simulation software used during the semester. In addition, computer simulation exercises were given to the students so that the preparation and correction of these were done by the trainee. In addition, in this semester, a teaching-support meeting was offered to the students as a monitoring in order to resolve doubts about the discipline and about the exercises mentioned above.

- Electromechanical Power Conversion: because it is a theoretical discipline with in-depth content, a greater load of exercises than those presented in the classroom is necessary for a better fixation of the subject. In this way, the trainee elaborated and solved lists of exercises referring to each one of the topics of the discipline. In addition, he was still available to ask questions about these lists of exercises and the theoretical content. And, finally, in the days preceding the tests of the discipline, the trainee was available to the students in teaching-support meeting beyond the pre-established for monitoring.

- Electromechanical Power Conversion Laboratory: Due to being a practical discipline, the trainee was responsible for assisting the teacher in supervising and accompanying the undergraduate students in the assemblies of each experiment during the classes. Consequently, as the syllabus required reports from students, they often expressed doubts about the problems contained in these reports that could be exposed to the trainee during the week preceding the submission of these reports. Finally, after submitting the reports to the teacher responsible, they were sent to the trainee so that he could correct and evaluate the report of each of the groups.

41.4 Results

In relation to the disciplines considered theoretical, from the student's search for the trainee to solve the doubts of the exercises, a greater understanding of the matter given in the classroom was generated by the teacher that was necessary in the resolution. In addition, due to the possibility of being in doubt every week with the trainee, the content to be studied would not be accumulated for the next dates of the tests. In relation to the trainee, the accompaniment of the teacher's class program became necessary, as he needed to apply the correct exercises for the preparation and resolution of the lists of exercises. Since, once there is a need to provide monitoring and remedy the doubts of others, it becomes necessary to master the subject completely.

On the results obtained with practical disciplines, with the help of another person in the supervision and monitoring of the laboratory assemblies, the professor responsible for the discipline was able to give more time to explain better the theoretical part at the beginning of the class, in addition to that the follow-up became more customized from each bench, because while the teacher in charge helped a group, the trainee answered the doubts of another.

In relation to the trainee, he was able to get in touch with a laboratory discipline that uses several equipment found in practice, so the greatest gain for the trainee was obtaining the feeling of knowing how to deal with people with different styles of acting in practical situations and so far as to let each of them act without interference from the person in charge.

Finally, in relation to the mixed disciplines, because it is a combination of the other types of disciplines already commented, the results obtained were also the same ones reported previously only together.

41.5 Conclusions

The Teaching Improvement Program is a relevant program for USP, for the trainee, for the academic environment and especially for society as a whole. Because it contributes to the training of the next teachers, who will be part of the labor market in the future and will already have some didactic experience obtained during the program. In addition, due to the experience gained in these different types of disciplines as reported, it is suggested that a larger number of places may be opened in the program so that more trainees can join and consequently more disciplines may have a trainee to assist the responsible teacher, be it theoretical, practical or mixed. The benefits certainly reach all the agents and institution involved: the University, the trainee himself, through the responsible teacher and, finally, the undergraduate students.

Bibliography

1. DUGAN, R. C.; MCGRANAGHAN, M. C.; WAYNE BEATY, H. *Electrical Power Systems Quality*. New York: McGraw-Hill, 2002.

2. JOHNSON, D. E.; HILBURN, J. L.; JOHNSON, J. R. *Fundamentos de Análise de Circuitos Elétricos*. Rio de Janeiro: Editora LTC, 2000.

3. FITZGERALD, A. E.; KINGSLEY JR. C.; UMANS, S. D. *Electric Machinery*. New York: McGraw-Hill, 2003.

4. SEN, P. C. *Principles of Electric Machine and Power Electronics*. New Jersey: John Wiley & Sons, 2013.

CHAPTER 42

How to Raise and Keep Interest in Power Quality Lectures: Methodology Adopted, Positive Aspects,Challenges, and Learning Opportunities

Carlos Henrique Beuter[*], Mário Oleskovicz[♦], Fernando B. Bottura[▴] and Jáder Fernando Dias Breda[▾]

[*]Departamento de Engenharia Elétrica e de Computação, Universidade de São Paulo, São Carlos, Brazil

E-mail: cbeuter@usp.br

♦Departamento de Engenharia Elétrica e de Computação,
Universidade de São Paulo, São Carlos, Brazil

E-mail: olesk@sc.usp.br

▴Departamento de Engenharia Elétrica e de Computação,
Universidade de São Paulo, São Carlos, Brazil

E-mail: fernando.bottura@usp.br

▾Departamento de Engenharia Elétrica e de Computação,
Universidade de São Paulo, São Carlos, Brazil

E-mail: jader.breda@usp.br

Abstract: Considering the characteristics of electricity generation, transmission and distribution systems in Brazil, with or without distributed generation sources, Power Quality (PQ) is an appropriate subject, but still little inserted in the curriculum of Electrical Engineering undergraduate and post-graduate courses, especially in the courses related to the sub-area of Electrical Power Systems, and other related courses. In this context, this paper addresses the methodology adopted in the theoretical/expositive PQ lectures to undergraduate students at the Laboratory of Analysis of Power Quality Monitoring

(LAMQEE), Escola de Engenharia de São Carlos (EESC), Universidade de São Paulo (USP) between 2014 and 2016. The material will cover the positive aspects of the methodology adopted, the challenges faced and the learning opportunities envisaged. During the course, in recent years, there were lectures to complement the theoretical classes and new tools of pedagogical aid were also introduced that served as a support and development to learning. Multimedia equipment and computer simulations, presentations and individual and group discussions of technical-scientific articles, as well as arbitrary digital generator of electrical signals and a PQ analyzer applied to various components (elements) and/or electrical circuits are some of the many tools used. In order to raise and keep the interest of the enrolled students, practical exercises were included in the course, which are applied and evaluated in groups and/or individually in the classroom, with immediate feedback to students on their performance in the activities. It is worth emphasizing that the implemention of the methodology in use counts with the indispensable support of a student of the Program of Education Improvement (PAE) supported by Universidade de São Paulo (USP). In the way it is conducted, the course allows for a highly supervised involvement of the PAE scholarship holder with the teaching, greater interest and participation of undergraduate students on the activities, improvement in the quality of the teaching environment and the content lectured. The confidence of the students on the learned concepts and developed practices is evident and the number of interested students in topics related to PQ after the lectures, aiming for future works, such as end-of-course papers and at the post-graduation level, are reflecting positively. Despite some challenges and improvements that can still be implemented, the results obtained so far show that many of the tools, when properly applied, can enhance the exploration and interest of relevant topics related to PQ, stimulate and motivate the students to learn and lead them, even at the undergraduate level, to an academic research environment and at the same time very close to future professional activities.

Keywords: Laboratory Activities, Pedagogical Tools, Power Quality, Teaching Methodology, Engineering Education.

42.1 Power Quality

The generation and distribution of electricity in Brazil has very particular characteristics, which creates a unique scenario in comparison to other international environments. The subject of Power Quality (PQ) is quite appropriate and not yet widespread in the curricular basis of undergraduate and postgraduate courses in Brazil, especially those related to the subarea of Electric Power Systems. This paper addresses the methodology adopted in the compulsory subject of SEL 0409 (Power Quality), lectured to undergraduate students at the Laboratory of Analysis of Power Quality Monitoring (LAMQEE), School of Engineering of São Carlos (EESC), of the University of São Paulo (USP). It is worth mentioning that over the last few years, complementary lectures have been introduced to the theoretical classes, which are the focus of this work, and are called Expository Laboratory (EL), where new pedagogical tools have served as support and development for learning. In this paper, the positive aspects and opportunities identified in this disciplinary scenario, between 2014 and 2016, will be addressed.

42.2 PQ at USP

The SEL0409 subject was initially offered to the students who were in the fourth year of the Electrical Engineering course, with emphasis on Energy and Automation Systems, in 2006. Since its inception, it has been offered in the second semester of each year, as one of the compulsory subjects of the course. In the first years, SEL0409 was taught in three classes for about 50 students, being a theoretical subject with great informative content. Current lecture environment: Beginning in 2013, there was a reformulation in the discipline's, in which it became two classes of 50 minutes each, and with the students distributed in two different schedules. The subject continued to be offered in the second semester of each year and does not have any prerequisite. However, there is a temporal prerequisite for it.

Equipment: In LAMQEE, where all classes of SEL0409 are lectured (theoretical and lab), there are some outstanding equipment, such as a Digital Signal Arbitrary Generator (DSAG) connected to a command computer, that is also an analyzer and recorder of signal and various loads for testing and other supporting devices.

42.3 Methodology and evolution of the subject

The subject has undergone several positive changes since 2006 and has already had at least four PAE scholarships[1] over the last few years, who have supported and played an important role in the improved activities.

The EL lectures, focus of this work, with the involvement of the PAE scholarship holder, currently cover: a) the analysis and presentation in a group, but with individual evaluation, of technical-scientific articles with themes related to PQ[2]; b) a recapitulation of the main concepts of the theoretical lectures previously presented and that will be applied in the EL lectures[3]; c) trials and tests on the electric charges available in LAMQEE through DSAG; and d) application and resolution of problems in a group to fix lecture content with free method and tool, monitored by PAE scholarship holders with direct supervision of the professor responsible for the subject.

42.4 Results

Item (a) presented in section 3 allows to professionally prepare students to express themselves and defend contents and/or common ideas associated with a particular theme, as well as a reinforcement for group work. The individual evaluation creates a competitive and healthy space for those wanting to stand out, in case the group does not collaborate as a whole. Some of the groups have used the opportunity to comment more about the technical-scientific content, using the knowledge indicated in the references of the base article. Item (b) provides the student with an alternative reinforcement of the explanation of the concepts related to PQ, as well as a maturation and consolidation of the necessary knowledge. Item (c), following a flexible script that encourages interactivity with students, helps in establishing knowledge and sharpens the creativity and curiosity of those involved. Item (d) provides, besides establishing the content and feedback of performance in the classroom, the reinforcement for the students in the explanation and understanding for those less attentive. The search for problem solving also helps students to gain confidence and apply the knowledge directly. This procedure assures great visible satisfaction and contentment, regarding the students' real understanding of the problem presented.

42.5 Conclusions

SEL 0409 theoretical and laboratory expositive lectures are concurrently given in the same LAMQEE environment since 2014, providing an integrated learning environment. The lectures, combined with the computational tools available (MatLab, Maple, Mathematica and others), as well as experimental ones (DSAG, test bench and others), enhance the research related to PQ, stimulate and motivate student learning and present them to the academic environment of the research. The authors of this work believe that, in the opportunities envisaged and those that are to come, this new hybrid environment (theoretical lectures and laboratory expositions) will be an impulse in the sense that the student retains the knowledge applied and directed to PQ.

Bibliography

1. PRÓ-REITORIA de Pós Graduação da USP. *Programa de Aperfeiçoamento de Ensino* . Available in: <http://www.prpg.usp.br/index.php/pt-br/pae/o-que-pae>. Acessed in: 18 jan. 2017].

2. BOLLEN, M. H. J. et al. Trends, challenges and opportunities in power quality research. *European Transactions on Electrical Power,* Medford, v. 20, p. 3-18, jan. 2010.

3. DUGAN, R. C. Electrical Power Systems Quality, Second Edition, New York: McGraw-Hill, 2002.

CHAPTER 43

Genetic Algorithm Applied on Network Reconfiguration: Implementation of A Multi-Objective Algorithm As An Undergraduate Interdisciplinary Project

Wandry Rodrigues Faria[*], Marcelo Escobar de Oliveira[♦] and Hugo Xavier Rocha[▲]

*Engenharia Elétrica, Instituto Federal de Goiás, Itumbiara, Brazil

E-mail: wandryrodrigues@hotmail.com

♦Engenharia Elétrica, Instituto Federal de Goiás, Itumbiara, Brazil

E-mail: marcelo.oliveira@ifg.edu.br

▲Engenharia Elétrica, Instituto Federal de Goiás, Itumbiara, Brazil

E-mail: hugo.rocha@ifg.edu.br

Abstract: The electric power distribution systems are, mostly, constructed as weakly meshed networks. However, they operate as radial systems, which means that the power flows in only one way: from the substations to the consumers and there is only one electrical circuit connecting those two points. Even though the system operates as radial, there are physical links connecting points that belong the same or a different feeder or substation. Those links are mechanical switches that can be used to isolate an area in the event of an electrical failure or maintenance or to supply electrical power to an area using another source. Besides the reliability incensement, by using the switches correctly the technical power losses may decrease and the consumer's voltage magnitude might be elevated. The manipulation of the electrical distribution system aiming an optimal operation point is called network reconfiguration and is a well spread concept. Due to the several possible reconfigurations, since there are many switches in the system, the algorithms based on exact methods demands too much time and computational effort, on the other hand, by using metaheuristics the efforts are reduced and the solutions are optimized. This paper presents the development of a metaheuristic algorithm created as the result of an undergraduate interdisciplinary project combining two courses from the Electrical Engineering major of the Instituto Federal de Goiás (IFG), Campus of Itumbiara: Introduction to the Electrical Power Systems and Topics on Artificial Intelligence. The presented tool uses a multi-objective Genetic Algorithm that uses an NSGA-II routine to evaluate voltage magnitude on the loads and the system's total power loss. The tool was tested using IEEE's test systems and presented satisfying results, however, the major gain is the strengthening of the multidisciplinary activities applied to the Engineering teaching. Interdisciplinarity has been the object of study to many research groups around the world. Thus, this paper salients the relevance of projects involving two or more courses as a mean to encourage the students to evolve a critical view of problems and the search for solutions using multiple course's subjects.

Keywords: Backward-forward Power Flow, Distribution Systems, Genetic Algorithm, Multi-objective Optimization, Network Reconfiguration.

43.1 Background

Over the last few years, the scientific community has been pressed to solve huge society's issues. The electrical Engineering branch, for example, has the challenge to increase the amount of available electrical power in a sustainable and environmentally friendly way. Most of the challenges cannot be solved by a single research field, therefore it is fundamental to use interdisciplinarity[1]. However, applying various points of view and approaches to a single problem may lead to a discrepancy on the issue's cause and obstruct the converging to a solution[1]. It is proposed in[1] the introduction to interdisciplinary research as a tool to prepare the students to deal with real problems involving multiple fields of study. Another worldwide concern, presented in[2, 3], is the arduousness found by electrical Engineering students to apply theoretical concepts to researches and projects design. Both[2] and[3] present a multidisciplinary approach combined to prototypes design as a solution to the lack of contact with the practical application of subjects. Since the focus of the IFG-Itumbiara's Electrical Engineering major is Electrical Power Systems and given the great number of courses containing programming languages, the presented project, which was developed as an assignment to two disciplines, aims to ease the teaching of both Electrical Power Systems – as well as its analysis – and Programming Languages – as well as its applications to solving electrical Engineering problems.

43.2 Purpose

In order to assure the optimal operation point of a distribution system, or yet on the event of a system failure and a partial system isolation is needed, the reconfiguration network study is applied. On this evaluation, a solution with the fewer unsupplied consumers and minimum power loss, respecting the system's limitations, is sought. The distribution network electrical circuit's is changed by maneuvering mechanical switches placed on the system[4]. However, there are several switches in the distribution system which makes the evaluation of every possible configuration a very complex problem. Due to the infinity of possible reconfigurations, manual technics to evaluate the circuits cannot be applied. A common approach to solving the problem is the employment of computational tools.

In general, computational routines use exact methods to solve a problem. However, due to the huge number of possibilities when it comes to network reconfiguration, these methods are proven inefficient – they demand too much time and computational effort. The second method of problem solving used by computational routines is named metaheuristic. This method seeks optimized not-exact solutions which reduce time and computational effort[4, 5].

The software used by the concessionaires of electric energy and presented in the academic environment to solving the distribution system reconfiguration problem, in most cases, use metaheuristics methods[4-7]. Even though metaheuristic computational routines and electrical power systems are combined to solve problems in distribution systems, in college the evolutionary algorithms – which are an example of metaheuristic routine – are not studied on the Electrical Power System course, but on Topics on Artificial Intelligence. The approach of the subjects as two isolated problems inhibits the student's comprehension as to the application of evolutionary algorithms in real problems and the practical analysis of the distribution systems. The presented computational tool aims to demonstrate the evolutionary algorithm's applicability to solving real electrical Engineering problems promoting, at the same time, behavior analysis of reality-based distribution systems.

43.3 Method

An essential tool for distribution systems interpretation and analysis is the power flow. The topic is covered by the power systems field courses and one of the most used methods in distribution systems is the backward-forward sweep. This well spread computational routine is described in[4, 8] and was developed as an assignment to Introduction to Electrical Power Systems.

The requirement to Topics on Artificial Intelligence was the development of an evolutionary algorithm. Considering that the power flow's output data allow a quality evaluation of the system, once interpreted it may be used as a fitness function to an evolutionary algorithm. The power flow routine developed to Introduction to Electrical Power Systems was then attached to the genetic algorithm. It is shown in figure 43.1 some of the subjects and courses used in the development of the metaheuristic algorithm.

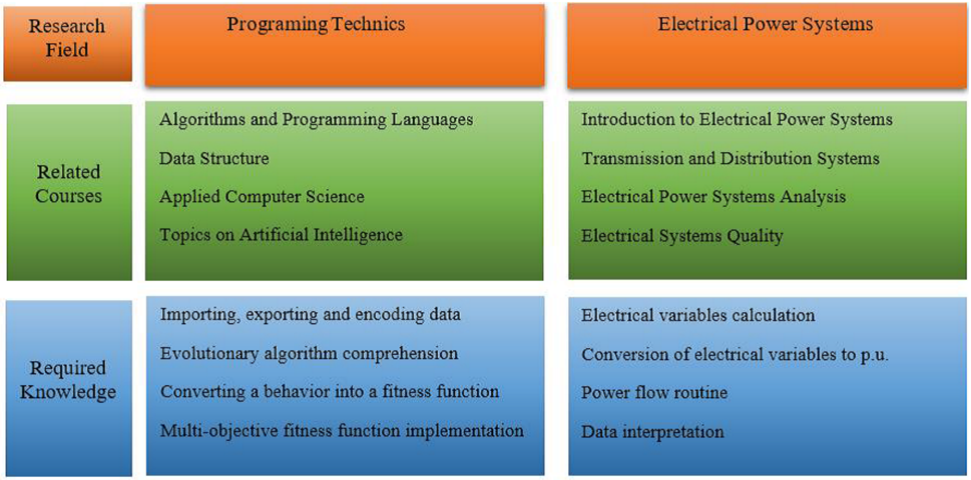


Figure 43.1 – Undergraduate Courses and Subjects Related to the Computational Tool.

The algorithm's fitness function considers the voltage magnitude in each node and the system's total active power loss. The tool relies on an evolutionary multi-objective routine named NSGA-II, described in[9, 10], to evaluate the solutions.

43.4 Results

The computational tool's functionality was tested with IEEE's test systems. The results were compared to the ones obtained by other authors and were satisfactory.

Seeing that the network reconfiguration problem solving through evolutionary algorithms is a well-spread concept, to highlight the gains brought to the student and professors involved in the development of the project is far more important than presenting the optimized systems. In the first place, the student could verify the application of many electrical Engineering courses to the development of a tool which can be used in real action planning for distribution systems.

Considering that all the subjects approached by the course can be found on the program, and particularly to show the appropriateness of evolutionary algorithms associated to electrical Engineering problems solving, the source code may be applied to the Topics on Artificial Intelligence classes.

The comprehension of electrical power systems' response to a certain load factor – approached in Introduction to Electrical Power Systems – may be enriched by practical examples using the power flow routine included in the presented program. The simulation results can also be used in Transmission and Distribution Systems as well as in Electrical Power Systems Analysis classes to demonstrate in a practical way the gains of an optimized configuration to a distribution network.

43.5 Conclusions

The paper presents a computational tool developed as an assignment to the electrical Engineering courses Topics on Artificial Intelligence and Introduction to Electrical Power Systems. Notwithstanding, the concepts used to create the routine are not limited to those two disciplines.

The project's outcome is the result of the student's critical sense growth which was magnified by the multidisciplinarity approach. The student's increase of interest when assignments combine theoretical concepts, acquired on the courses, and projects, especially with practical applications, is notorious.

Thus, the computational routine can be used to improve even more the students' comprehension and interest in correlated disciplines, in addition to it, the tool may be used as a foundation to further interdisciplinary projects.

Bibliography

1. ISHIDA, T. et al. Interdisciplinary Education for Design Innovation. *Computer*, Washington DC, v. 50, p. 44-52, 2017.

2. LEE, W.; CONKLIN. N. B. Improvement of Student Learning Experience via an Interdisciplinary Undergraduate Research Project with Top-down Design and Bottom-up Implementation. In: IEEE INTEGRATED STEM EDUCATION CONFERENCE, Princeton, 2017. *Proceedings...* Princeton: IEEE, p. 49-51, 2017.

3. MARAI, G. E.; FORBES, A. G.; Johnson, A. Interdisciplinary Immersive Analytics at the Electronic Visualization Laboratory: Lessons Learned and Upcoming Challenges. In: WORKSHOP ON IMMERSIVE ANALYTICS, Greenville, 2016. *Proceedings...* Greenville: IEEE, p.54-59, 2016.

4. MING, Z. et al. An Improved Genetic Algorithm for Distribution System Reconfiguration. In: INTERNATIONAL CONFERENCE ON POWER SYSTEM TECHNOLOGY, Kunming, 2002. *Proceedings...* Kunming: IEEE, v. 3, p. 1734-1738, 2002.

5. SARFI, R. J.; SALAMA, M. M. A.; CHIKHANI, A. Y. A Survey of the Stat of the Art in Distribution System Reconfiguration for System Loss Reduction. *Electric Power System Research*, Netherlands, v. 31, p. 61-70, 1994.

6. JIANSEHNG, L.; YOU-MAN D.; BO-MING, Z. Hybrid Flow Pattern and its

Application in Network Reconfiguration. In: PROCEEDINGS OF THE CSEE 2001 CSEE, 2001.

7. NARA, K.; SHIOSE, A.; KITAGAWA, M. Implementation of Genetic Algorithm for Distribution Systems Loss Minimum Reconfiguration. *IEEE Transactions on Power System*, Athens, v. 7, n. 3, p.1044-1051, 1992.

8. PENGXIANG, B.; JIAN,L.; WENYAN, Z. Convergence of branch current based distribution power flow method. *Journal of Xian Jiaotong University*, Shaanxi, v. 35, n. 4, p. 343-346, 2001.

9. ROCHA, H. X. et al. Statistical Decision Support for Fitness Function Formulation to Multi-Objective Evolutionary Algorithms: a Case Study on Computer Automated Exterior Lighting Design. *IEEE Latin America Transactions,* Washington DC, v. 14, p. 281-288, 2016.

10. ROCHA, H. et al. Exterior Lighting Computer-Automated Design Based on Multi-Criteria Parallel Evolutionary Algorithm: Optimized Designs for Illumination Quality and Energy Efficiency.*Expert Systems with Applications,* Tarrytown, v. 45, p. 208-222, 2016.

CHAPTER 44

The Mobilization of The Concept of Vector and Linear Transformation Concepts in Civil and Production Engineering: A Dipcing Methodology Based Analysis

Barbara Lutaif Bianchini[*] and Gabriel Loureiro de Lima[♦]

[*]Faculdade de Ciências Exatas e Tecnologia, Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: barbara@pucsp.br

♦Faculdade de Ciências Exatas e
Tecnologia, Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: gllima@pucsp.br

Eloiza Gomes▲ and Guilherme Fernandes Oliveira▼

▲Escola de Engenharia Mauá, Centro Universitário do Instituto Mauá de Tecnologia,
São Caetano do Sul, Brazil

E-mail: eloiza@maua.br

▼Escola de Engenharia Mauá, Centro Universitário do Instituto Mauá de Tecnologia,
São Caetano do Sul, Brazil

E-mail: guifoliveira3@gmail.com

Sheila Stravate Leonel°

°Pontifícia Universidade Católica de São Paulo, São Paulo, Brazil

E-mail: sheilastravate@gmail.com

Abstract: Motivated by the need of remodeling the way mathematical contents are developed in Engineering Courses in order to create bonds between these mathematical subjects, the context of the student formation area and the specificities of their future professional performance, a primary investigation has taken place, by the means of the theory “A Matemática no Contexto das Ciências (MCC)” (in Portuguese), searching for the connections between the disciplines of Linear Algebra (AL in Portuguese), Analytic Geometry (GA in Portuguese) and the non-mathematical disciplines that belong to the basic Engineering section (“Núcleo Básico” in Portuguese), such as specified in CNE/CES 1362/2001 (National Guidelines for Brazilian Engineering Courses), in the undergraduate courses in Civil Engineering and Production Engineering of two Brazilian Institutions. The research, which incorporates the use of the MCC, was based on an adaptation of the Central Step of the Dipcing Methodology (“Diseño de Programas de Estúdio de Matemáticas em Carreras de Ingeniería”), especially over the data collect period from textbooks. In this paper, were analyzed the mobilizations of the concepts of notions of vector, in the subjects “Operations Research I”, “Electricity”, “Thermal Sciences” (in the Production Engineering Course) and linear transformations, in the subjects “Transport Phenomena”, “Electromagnetism”, “Mechanic of Rigid Bodies” (in the Civil Engineering Course).

Keywords: Controller, Retrofitting, Robot Arm, Raspberry Pi 3, Engineering

Education.

44.1 Background

The Curriculum Guidelines for Brazilian Engineering Courses (Resolution CNE/CES 11/2002) Establish that each course should, on your resume, a division of the contents into three cores: basic, vocational and specific, regardless of their modality[1]. Oliveira and Gomes (2016a) emphasize that, in general, the basic core subjects are more concentrated in the initial semesters of the courses and contemplate, mainly, contents related to the areas of Physics, Chemistry and Mathematics[2]. The connections between mathematical disciplines Analytical Geometry (GA - portuguese) and Linear Algebra (AL - portuguese) and those that are not mathematical of the basic nuclei of the Civil and Production Engineering Offered by the Pontifical Catholic University of São Paulo (PUC/SP) and the Instituto Mauá de Tecnologia (IMT) are the objects of study in this article.

In the light of Theory The Mathematical in the Context of Sciences (MCC - portuguese), That the researcher Patrícia Camarena Gallardo, from the National Polytechnic Institute (IPN- spanish) of Mexico, began to develop from 1982, the present investigation in which they are considered of paramount importance the connections between the mathematical disciplines and the others that compose an Engineering course. According to Camarena (2013), MCC contemplates five interconnected phases (curricular, didactic, cognitive, epistemological and teaching), and propose, in the first instance, the discussion of the possibilities of a more contextualized teaching, especially from the exploration of the connection of Mathematics with other sciences, And adapted to the real needs of Engineering students, regarding the mobilization of concepts and mathematical tools, both in the other subjects of the course, and in their professional performance, aiming, from such reflections, to plan approaches for these disciplines that can lead the student to the effective construction of a Mathematics for life, that allows it to act in an analytical, logical and well-founded way[3]. Of the phases mentioned that make up the MCC, we remain, with some adaptations, to the curricular phase, which includes a specific methodology for exploratory analysis and data collection, the Dipcing Methodology, presented below and detailed in [4-6].

44.2 Dipcing Methodology

Camarena (2002) developed the Dipcing Methodology (Diseño de programas de estudio de matemáticas em carreras de ingeniería), around the premise that, in an Engineering course, Mathematics subjects must have objective programs, in which the teacher effectively perceives why each theme is present in it. It is intended to provide reflection on why to teach mathematics to that target audience, as well as what mathematical skills should be developed in order to contribute to an integral formation of the future professional[7].

The Dipcing is composed of three stages: central, precedent and consequent, of which the central bases this research, considering that this is to perform an analysis of the contents of GA and AL which, implicitly or explicitly, are mobilized by the non-mathematical disciplines of Civil Engineering and Production courses.The central stage, according to Camarena (2002), is carried out by means of the analysis of the most used materials as references in non-mathematical disciplines of that modality of Engineering that is being investigated[4]. Based on this, we conducted a survey with the teachers responsible for non-mathematics core subjects, and then we turn our attention only to those in which the mobilization of GA and LA concepts actually takes place.

44.3 Results

In accordance with the proposition offered by the central stage of the Dipcing Methodology, the curricular link between AL and the non-mathematical subjects belonging to the Civil Engineering course was established. In the discipline of Transport Phenomena we study the continuous deformation provaced by the shear stress when applied to a fluid, this transformation is equivalent to the linear transformation occurred in a given flat figure when subjected to a shear. This AL content is mobilized as a theoretical basis for the construction of the concept of Shear Stress in Transport Phenomena. In the discipline Electromagnetism, the rotation in R2, one of the linear transformations studied in AL, is used in the construction of the Uniform Magnetic Field concept. The mobilization of such a notion occurs as a theoretical basis for the construction of a specific concept of Electromagnetism. As for the discipline of Mechanics of Rigid Bodies, once again, Geometric transformations are now mobilized as tools, especially rotation (linear transformation).

When developing researches on Analytical Geometry (GA), it was found that there could be two kinds of applications for this subject along the whole graduation course, which are: implicit and explicit. While “Operations Research I” was discovered to make use of GA in an implicit way, Electricity and Thermal Sciences were found to operate with GA in explicit means. These findings lead the research to specify those different types of applications.

Being able to use concepts and tools developed by GA to better understand and build knowledge in any subject qualifies the GA application as implicit. In other words, implicit concepts make the subject understanding much easier, providing learning methods and shortcuts that complements a given concept. In the other hand, explicit applications of GA, which can be found in Electricity and Thermal Sciences, need GA’s tools directly, to apply new or already learned techniques. This type of application is easier to identify, once it highlights the use of the same methods and tools developed in GA's teaching program.

44.4 Conclusions

The link between the GA and AL disciplines and some of the non-mathematics of Civil and Production Engineering curricula presented in this work was established from data collected, until now, By means of two researches of Scientific Initiation, one carried out in PUC/ SP and another in IMT, In the scope of this larger study that is being developed by professors of these institutions, bringing this article, therefore, only a small part of the data that have been obtained aiming at reflection, from the MCC theory, of the processes of teaching and learning of Mathematics in Engineering courses.

In summary, this article shows that the concepts studied in GA and in AL Are really essential so that students of Civil Engineering and Production can solve problems related to their specific area of activity Or to effectively understand the theoretical development of some non-mathematical subjects present in the curricula of their undergraduate courses.

Bibliography

1. BRASIL. Resolução no. 11 do Conselho Nacional de Educação/Câmara de Educação Superior, de 11 de março de 2002. Institui Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia. Avaiable in: <http://portal.mec.gov.br/cne/arquivos/pdf/CES112002.pdf>. Accessed in: 31 May 2017.

2. OLIVEIRA, G. F.; GOMES, E. Reflexões a respeito da disciplina de Vetores e Geometria Analítica e sua vinculação com a Física I e II – utilizando Metodologia Dipcing. In: *Anais* DO CONGRESSO BRASILEIRO DE EDUCAÇÃO EM ENGENHARIA, Natal, 2016.

3. CAMARENA, G. P. A treinta años de la teoría educativa "Matemática en el Contexto de las Ciencias". *Innovación Educativa,* Ciudade de México, v. 13, p. 17-44, 2013. Avaiable in: <http://www.scielo.org.mx/pdf/ie/v13n62/v13n62a3.pdf>. Accessed in: 31 may 2017.

4. CAMARENA, G. P. Metodología curricular para las ciencias básicas en ingeniería. *Revista Innovación Educativa*, Ciudade de México, v. 2, p. 22-27 , 2002.

5. CAMARENA, P. Constructos Teóricos de la Metodología Dipcing en el Área de la Matemática. In: 3º CONGRESO INTERNACIONAL DE INGENIERÍA ELECTROMECÁNICA Y DE Sistemas, Ciudade de México, 2004. *Anais*... Ciudade de México: IPN-ESIME-SEPI, 2004.

6. LIMA, G. L.; BIANCHINI, B. L.; GOMES, E. Dicping: uma metodologia para o planejamento ou redirecionamento de programas de ensino de Matemática em cursos de Engenharia. In: *Anais* DO CONGRESSO BRASILEIRO DE EDUCAÇÃO EM ENGENHARIA, Natal, 2016.

7. OLIVEIRA, G. F.; GOMES, E. (2016b). *Reflexões a respeito da disciplina de Vetores e Geometria Analítica na graduação em Engenharia de Produção a partir da teoria A Matemática no Contexto das Ciências.* Relatório de Iniciação Científica. São Caetano do Sul: Centro Universitário do Instituto Mauá de Tecnologia, 2016. Avaiable in: <http://maua.br/files/122016/reflexoes-respeito-disciplina-vetores-geometria-analitica-graduacao-engenha ria-producao-partir-teoria-matematica-contexto-das-ciencias-270855.pdf>. Accessed in: 31 May 2017.

CHAPTER 45

Scientific Initiation Project As Curricular Internship Activity: The Relevance for Undergraduate Students in Civil Engineering

Fernando Júnior Resende Mascarenhas[*]

[*]Escola de Engenharia de São Carlos,
Universidade de São Paulo, São Carlos, Brazil

E-mail: fer.jr.resende@hotmail.com

Abstract: This paper will discuss the importance of the scientific initiation accepted as internship activity for the Civil Engineering professional. Moreover, it will be pointed out the scientific initiation project that was developed by the author of this paper during his undergraduate in Civil Engineering at PUC Minas, in Brazil. To that end, it was observed that research activities contribute to intellectual, logical reasoning, critical reading ability, improved writing skills and orally speaking skills improvement, as well as they develop certain skills and competencies of fundamental importance to the professional. Because it is an internship activity and, above all, a project of scientific initiation, there is a range of knowledge and courses involved, specifically, in this project: Reading and production of texts, Scientific and Technological Methodology, Informatics II, Analytical Geometry and Linear Algebra, Calculus I, II and III, Theory of Structures I and II and Structures of Concrete I. It is also highlighted the Advanced Structural Analysis course and the subjects related to the thematic of the teaching-learning in Civil Engineering majors. Even though they are not related to a specific course studied in the baccalaureate of Civil Engineering, they have been constantly analyzed and studied due to their significance to the project. Thus, the relevance of such research project for the formation of the student as a citizen and as a future teacher must be emphasised. Furthermore, the experiences gained through the scientific initiation project are impacting in the formation as professionals of the area. In short, if the objective of the

student is to do masters and doctorates, conducting research projects encourages and contributes significantly to the achievement of this objective. Hence, the indisputable gain in the possibility of theoretical deepening, as well as the daily living with the challenges, and the search for overcoming them, and the constant improvement of skills and competences previously explained, show how relevant scientific initiation accepted as internship activity is because it allows the conversion of practice and theory.

Keywords: Competences, Internship, Scientific Initiation Projects, Skills, Undergraduate in Civil Engineering.

45.1 Background

Practical and multidisciplinary activities that allow the convergence of theory and practice are essential for professional training. In this context, there are Supervised Curricular Internships. Brazilian Law no. 11,788, dated September 25, 2008, establishes that:

> Art. 1st Internship is a supervised school-based educational act developed in the work environment, aimed at preparing students for productive work of regular education in institutions of higher education. Paragraph 1 - The internship is part of the pedagogical

> project of the course, besides integrating the formative itinerary of the student. Paragraph 1 - The internship is aimed at learning the skills of the professional activity and the curricular contextualization, aiming at the development of the learner for the life of the citizen and for the work[1].

In this context, this paper will discuss the importance of internship activities for the Civil Engineering professionals, and it has as main focus, to discuss the research activity, used as internship, developed by the author of this paper.

45.2 Purpose/Hypothesis

In order to have civil engineers who are capable and well prepared to act in the most appropriate manner, technically and ethically, it is necessary that students have contact with the internship, either through activities in companies or in the public sector, or through extension activities and research projects. With regard specifically to research activities, they contribute to the intellectual development, logical reasoning, critical reading ability, improved writing, orally speaking ability, as well as developing certain fundamental skills and competences.

45.3 Design/Method

The research analysed in this paper is a scientific initiation project funded by the Research Incentive Fund (FIP) of the Pontifical Catholic University of Minas Gerais (PUC Minas), under the head of Professor Doctor Everaldo Bonaldo. The scientific initiation project began in February 2016 and ended in March 2017.

The title of the scientific initiation project is “Development of an educational object for structural analysis and design of reinforced concrete beams”. MATLAB programming language was used, and the project aims to develop an algorithm that makes the structural analysis: determination of the support reactions and shear stress and bending moments diagrams of beams.

Because it is an internship activity and, above all, a research project, there is a range of knowledge and courses involved in it. The course of Reading and Production of Texts was fundamental in this project, since, constantly, there is the needing to read scientific articles and books and, with a certain periodicity, it is needed to write reports and articles. Being able to express yourself through writing as well as being able to read a text critically are fundamental skills for any student and, above all, for the Civil Engineering professional who wants to stand out.

In turn, the discipline of Scientific and Technological Methodology was fundamental to adopt a cohesive position with the research activity, such as the development of data collection and analysis skills, and how and where to start a research. Araújo and Santos emphasize that courses such as this increase "the integral formation of students, stimulating their reflective formation, with more humanistic approaches, retaking the profession's broad character in favour of the new sociocultural requirements"[2].

As previously mentioned, this research is about the development of software, and MATLAB is used, which is taught in the course of Informatics II. For Bowen, the "inclusion of computer programming at the beginning of the curriculum was seen by the Faculty of Civil Engineering" of the University of North Carolina, "as a way to improve students' skills in the application of technical knowledge, and in the quantity of exercises solved"[3].

Calculus courses are important for the development and use of mathematical concepts, especially integrals. As well as the course of Analytical Geometry and Linear Algebra was essential to work with matrices. Teixeira, Pereira and Barroso emphasize "the importance of Linear Algebra in the professional life of the engineer is notorious" and "linear mathematical models have played an important role together with the development of informatics"[4].

Theory of Structures I and II courses subsidized all knowledge related to structural analysis (determination of support reactions and normal, shear and bending diagrams envelopes), as well as the various techniques used.

On the other hand, the course of Structures of Concrete I contributes to the understanding of concrete structures, according to NBR 6118 of 2014, more specifically the dimensioning of reinforced concrete beams.

45.4 Results

A research project contributes to that students have a meaningful learning. According to Braathen, "Mechanical Learning occurs with the incorporation of new knowledge in an arbitrary way, that is, the student must learn without understanding what it is about or understand the meaning of why", and Meaningful Learning "runs with the incorporation of new knowledge into the student's cognitive structure, and it can be associated with prior, related and relevant knowledge already existing in this cognitive structure".[6] Finally, the relevance of this scientific initiation project for vocational training stands out. As established in Article 5 of Resolution CNE/CES 11, "each Engineering course must have a pedagogical project that clearly demonstrates how all of the planned activities will guarantee the desired profile of its egress and the development of the expected skills and abilities"[5], and in carrying out this research, it was evident that the Civil Engineering Bachelor of PUC Minas in Barreiro encourages the development of such skills and abilities, as well as allows the interdisciplinary between the contents, with real and forceful applications, not restricted to classrooms.

45.5 Conclusions

In short, the experiences gained through this scientific initiation project are striking for every undergraduate student and as a future graduate student. The indisputable gain in the possibility of theoretical deepening, as well as daily living with the challenges, the search for overcoming them and the constant improvement of skills and competences previously explained, show how relevant the activities (like this project of scientific initiation) are because they allow the conversion of practice and theory.

Bibliography

1. BRASIL. Lei n°. 11.788, de 25 de setembro de 2008. Dispõe sobre o estágio de estudantes. *Diário Oficial da União*, Brasília, 26 de sept. 2008.

2. Araújo, E. M.; Santos,F. C. A. Proposta de inclusão da disciplina “Metodologia da Pesquisa em Engenharia de Produção” na graduação da EESC – USP. In: *Proceedings* 29TH CONGRESSO BRASILEIRO DE EDUCAÇÃO EM ENGENHARIA, Porto Alegre, p. 181-188, 2001.

3. BOWEN, J. D. Motivating Civil Engineering Students to Learn Computer Programming with a Structural Design Project. In: *Proceedings* American

Society for Engineering Education Annual Conference & Exposition, Salt Lake City, p. 9.931.1-9.931.11, 2004.

4. TEIXEIRA, K. C. B.; PERREIRA, A. C. C.; BARROSO, N. M. C. Álgebra Linear nos cursos de Engenharia: sua importância na formação do futuro Engenheiro de Teleinformática. In: *Proceedings* 41ST CONGRESSO BRASILEIRO DE EDUCAÇÃO EM ENGENHARIA, Gramado, p. 1-7, 2013.

5. BRASIL. Ministério da Educação. Conselho Nacional de Educação. Resolução CNE/CES 11, de 11 de março de 2002. Institui Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia. *Diário Oficial da União*, Brasília, 9 abr. 2002. Seção 1, p. 32.

6. BRAATHEN, P. C. Aprendizagem mecânica e aprendizagem significativa no processo de ensino-aprendizagem de Química. *Revista Eixo, Brasília*, Brasília, v. 1, n. 1, p. 63-69, 2012.

CHAPTER 46

Regression Analysis Applied to Soil Mechanics

Everaldo Bonaldo[*], Fernando Júnior Resende Mascarenhas[♦], Leopoldo Grajeda[▲] and Juliana Torres de Oliveira Bonaldo[▼]

[*]Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: bonaldo@pucminas@hotmail.com

[♦]Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: fer.jr.resende@hotmail.com

[▲]Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: leopoldo@grajeda.com.br

▼Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: jultoli@gmail.com.br

Abstract: The present dissertation aims to demonstrate the results from the scientific initiation project that proposes the use of MS-Excel to determine the coefficients of the soil shear equation: cohesion and the angle of internal friction. This project has two main objectives. First, the development of a computational analytical method with the use of computational techniques of regression analysis in MS-Excel to determine the equation of shear strength. Second, this project was attended by four students from the second term (first year) of Civil Engineering of PUC Minas, in Brazil, under the supervision of a student of the last year and three professors of PUC Minas. These four students only had previous knowledge of the basic disciplines, without knowledge about Mechanic of Materials and Soil Mechanics, which are primordial for the project's development. The interdisciplinary that has occurred between the disciplines of Soil Mechanics, Laboratory and Field Tests, Mechanic of Materials, Calculus, Analytical Geometry and Linear Algebra was detected with the accomplishment of this work. It was observed that the values obtained using MS-Excel are reliable, and using MS-Excel solved the difficulties of precision found in the determination of the cohesion and the angle of internal friction.

Hence, it is possible to conclude that the automation of the procedure behaved in a very effective way, and it can be clearly applied and used by students and professors. In addition, such computational analytical method proved to be viable and indicated option to gain time savings and optimization of works, since the program proved to be highly efficient and reliable in obtaining the shear equation, meeting the expectations and the objectives established by the project.

Keywords: Computational Tool, Equation of Shear Strength, Excel, Linear Regression, Soil Mechanics.

46.1 Background

The breakdown of soils is an important matter concerned with soil mechanics, with an emphasis on Geotechnical Engineering. The soil rupture occurs by shearing, since the soil has very low tensile strength and high compressive strength[1]. Thus, “when it refers to soil resistance, it is implicitly its shear strength”[1].

The determination of the shear boundary strength of soils has a direct impact on several real Engineering problems, such as: “the shear strength of soils is a fundamental issue in the problem involving limit equilibrium analysis such as the load bearing of foundations, stability of slopes, dams and embankments, and buoyancy of earth in containment structures”[2].

Based on this, using the knowledge of Soil Mechanics, Laboratory and Field Tests, Mechanic of Materials, Calculus, Analytical Geometry and Linear Algebra and Programming, this project aims to develop a computational analytical method with the computational implementation of regression analysis techniques in MS -Excel to determine the shear strength equation that can be used by both students and teachers. Moreover, it proposes to create interdisciplinary ties, arousing in the participating students the interest in subjects that they will still study, as well as they arouse the taste for participating in scientific initiation projects.

46.2 Purpose/Hypothesis

In classrooms, in the subjects of Laboratory and Field Tests, Soil Mechanics and Foundations, the graphical determination of shear strength of soil is made using the Mohr-Coulomb Circles, and the rupture envelopes are made using graph paper, ruler, square and compass. Such methodology used in the teaching-learning process has its limitations and problems at the time of execution. As an example, the professor, when presenting the graphic solution, finds difficulty “when there is a need to re-present some design steps for a differentiated approach for some students”[2].

In addition, students should be very precise when designing Mohr’s envelopes, since this practice in classrooms has shown that if the drawing is done in a not appropriate way, no matter how small the error, it generates large changes in the parameters extracted from it. Therefore, the use of computational resources is of great value in determining the Mohr-Coulomb envelope and the shear strength equation. According to Ventri and Neto, cited by Fakhey and Alves (2006), the Engineering student’s expectation when entering the course is “to find and utilize current and modern resources within the teaching-learning process, since these generations are accustomed to the use of Computing in all its day-to-day activities”[3].

46.3 Design/Method

In order to determine the coefficients of the soil shear equation: cohesion and the angle of internal friction using MS-Excel, the participant students were headed by three professors and by one student as teacher assistant.

In order to reduce the errors mentioned in the previous session and to allow both students and teachers to have a new tool for determination of the shear breaking equation by the Mohr-Coulomb criterion, an Excel programming was developed that fulfills such Function. Basically, the user has to type the maximum and minimum tensions of the analysed soils and click at the bottom "Iniciar", as shown in Figure 46.1, and the MS-Excel will give the searched results.

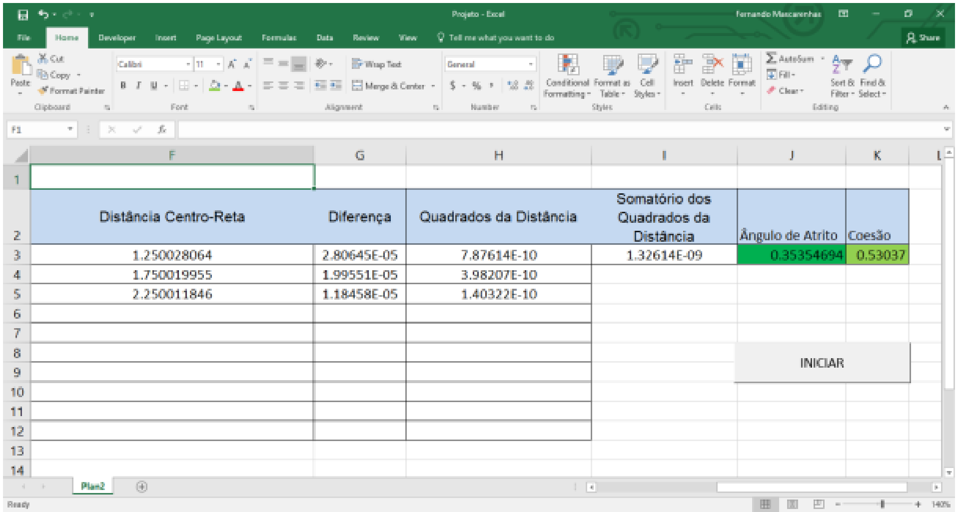


Figure 46.1 – Obtaining the searched results.

46.4 Results

Demonstrating the efficiency of the proposed computational analytical method, a huge number of tests were done using known values and comparing the Excel results with those obtained through manually process. Thus, this carried out tests confirmed that the results given by MS-Excel are very precise.

Table 46.1 demonstrates one of those tests in which the results obtained manually by four students were compared with the one obtained using MS-Excel. The coefficients of the soil shear equation: cohesion and the angle of internal friction are shown.

Table 46.1 – Comparing results obtained manually and using MS-Excel.

Method	Cohesion	Angle of internal friction
Student 01	0.52	19.80
Student 02	0.52	19.79
Student 03	0.59	10.75
Student 03	0.60	12.40
MS-Excel	0.53037	19.47
Reference Values	0.53037	19.47

46.5 Conclusions

With the accomplishment of this work, it is evident the interdisciplinary that occurred between the courses of Soil Mechanics, Laboratory and Field Tests, Mechanic of Materials, Calculus, Analytical Geometry and Linear Algebra for the participating students.

Hence, it is concluded that the automation of the procedure behaved in a very effective way, and can be clearly applied and used by students and teachers. In addition, the developed computational analytical method with the use of computational techniques of regression analysis in MS-Excel proved to be viable and indicated option to obtain time savings and optimization of works, since the program proved to be highly efficient and reliable in obtaining the shear equation, meeting the expectations and the objectives established by the project.

Bibliography

1. CAVALCANTE, E. H.; CASAGRANDE, M. D. T. *Mecânica dos Solos II.* Aracajú: Departamento de Engenharia Civil da Universidade Federal de Sergipe, 2006.

2. NALON, G. H. et al. O uso do Geogebra no Ensino de Mecânica dos Solos. In: *Proceedings* 40th CONGRESSO BRASILEIRO DE ENSINO DE ENGENHARIA, Belém, p. 1-7, 2012.

3. FAKHYE, R. J. M.; ALVES, S. M. *Tendências e Inovações no Ensino de Engenharia.* Chapecó: Universidade Comunitária Regional de Chapecó (Unichapecó), 2007.

Made in

LaTeX.

Since education is the activity of spreading knowledge with the teaching principles, Engineering Education includes all forms of related education focused on resolving a condition through the application of techniques and technologies. It is about solving problems!

Engineers and their professors can use several knowledge-teaching tools: mathematical methods and structured knowledge – the hard ones –, process-facilitating strategies and contextual knowledge – the soft ones. Above all, the inseparability of knowledge and its practical application is in fact a unique characteristic of Engineering Education itself.

This publication collects alive experiments and experiences from several professors, students and professionals that dedicated their precious time in thinking the Engineering Educations practices and tools. Therefore, here it can be found the emerged truth from the passion for knowledge-spreading of Engineering principles.

Leonardo Guerra de Rezende Guedes

ISBN 978-85-495-0151-6