ECAI 2015 - International Conference – 7th Edition
Electronics, Computers and Artificial Intelligence
25 June -27 June, 2015, Bucharest, ROMÂNIA

Teaching electric motors' starting methods in Lifelong Learning Programs

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***Abstract* – In this paper is presented a way of developing and encouraging mobilities under the Lifelong Learning European Educational Programs. The article makes a review of the actual situation for mobilities in Europe and Romania. Following this presentation, it is described a method of teaching the starting methods for an induction motor developed at the University of Pitesti. This method was developed during a Leonardo da Vinci Transfer of Innovation project in partnership with other six European partners. The methodology focuses on the starting methods of the induction machine.**

Keywords – Lifelong Learning Program, Erasmus+, learning outcome, induction machine, direct start, mobility,

I. INTRODUCTION

The internationalization affects all aspects of life: commerce, work force mobility, capital, industry, etc. Higher education makes no exception[1]. This refers to both students and teachers involved in formal and informal adult education processes.

The participants in international educational programs are better prepared to face a globalized world and its challenges [2].

The companies in the most developed countries and the society in general (USA, Canada, Australia, China, UK, Germany, etc.) give much credit to an international educational experience [1][3].

The benefits of internationalization are not age dependent or academic level[4]. Because of this, many countries encourage this phenomenon for their participants in the teaching process: both the ones that receive as the ones who give instruction. It can be seen that most of the countries have policies to encourage international cooperation in educational institutions at different levels: education, cooperation, lifelong formation, research, etc.

II. ROMANIA' SITUATION

In Romania, the number of graduates of higher education was less than 10% in 2000. Towards 2014 this percentage raised to almost 22.5% (figure 1). The graduates of higher education programs raised in Europe also from 22.5% up to 37.5%.

In Europe as well as in Romania, depending of geographical areas the number of students in tertiary education is not equally spread (figure 2). Even though Romania had an important increase in the number of students, figure 5 displays the fact that this is one of the lowest in Europe. There are countries in Europe where this number is ten times greater than in Romania.

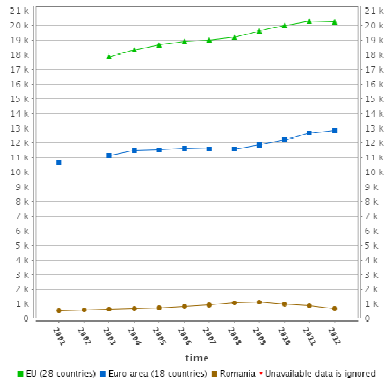

Figure 1. Tertiary educational % attainment by age group 30 – 34 years old [5]

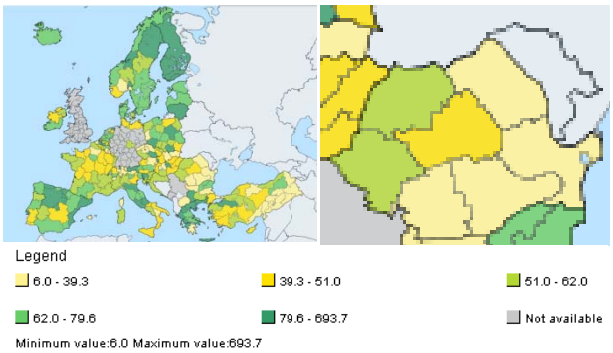

Figure 2. Students in tertiary education (ISCED 5-6) – ages 20 – 24 years old (%) [5]

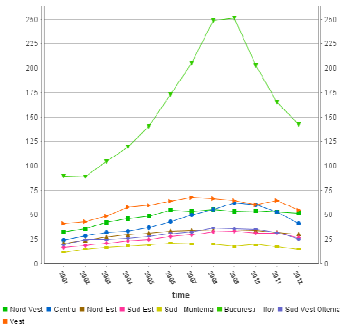

Figure 3. Students (%) of age 20 – 24 years old enrolled in tertiary education in Romania [5]

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Within Romania, there is a big variation of enrolled university students between different areas (figure 3): while in the South is around 25%, in Bucharest area overpasses 100%.

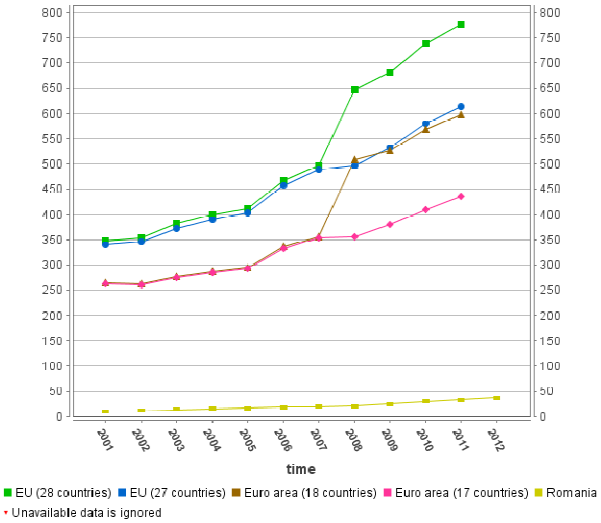

Figure 4. Mobility of students in tertiary education (ISCED 5-6) in for 1000 people in Europe and Romania [5]

During 2001 – 2013 it was a constant increase in mobilities among tertiary education students both in Romania as well as in Europe. In Europe, the mobile students almost doubled regardless of the analysed data.

Romania has a very low number of mobile students in tertiary education (figure 4). One reason is related to financial difficulties that students taking a mobility face in a different country. The scholarships awarded in Romania were very low comparing to the ones awarded by other countries. Many times, both students and teachers need to raise almost the same amount of money to be able to manage in other countries.

Another reason is due to difficulties of validation of their activity once they return in their home institution. In the Romanian Universities, there is a very rigid attitude from the teachers towards results' validation and acceptance of the abroad academic results [6][7].

Another reason for the very low percentage of mobile university students is their mentality. The education received before the university age formed them to be very dependent on their families. While in Europe, some sort of independency is acquired and granted at a lower age, in Romania it is quite frequent to encounter youth in their 18-24 years old that cannot take any decision toward their academic evolution, without having first the family approval. There are many situations when teenagers end up studying careers only to please their parents.

In Europe 5% - 11% of people of 25-64 years old has participated in a Lifelong Learning Program (figure 5). In Romania, the participation rate in this program is very low comparing to other European countries. During the past decade, the participation percentage was below 2% in Romania. The tendency in Romania is that once someone graduates a form a formal educational program, has a very little interest in continuous preparation.

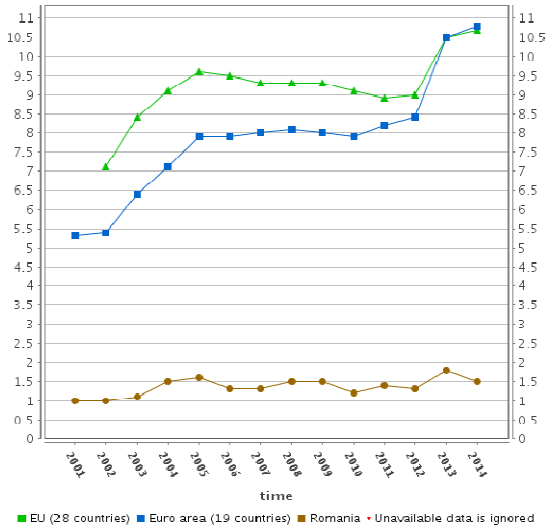

Figure 5. Lifelong learning percentage of people of 25 – 64 years old [5]

III. Methodology Development

The University of Pitesti, just as other international educational institutions [8], is aware of the very low participation of its students in mobility programs. In order to increase the number of mobilities, the University, in an European partnership, participates in a Leonardo da Vinci Transfer of Innovation project 'One Teacher and One Student working with ProjectXs'[9].

The project is developed by a consortium of seven Educational Institutions from different European areas: Spain, France, Finland, UK, Romania, Turkey and Portugal.

The main idea of the project is to develop an educational manual that allows the students to work independently of the teacher[10]. That means the teacher is only an assistant to the student while the later performs application classes.

Using the developed methodology, the student can have a concrete idea of what he/she is going to study abroad and prepare the lessons before the mobility.

One laboratory practice used for the project development by the team from the University of Pitesti is based on the induction machine starting methods. This pedagogical tool covers both the classical starting methods using contactors and relays as well as more modern tools like PLC.

When students have to perform this class, it is expected they have previous knowledge related to basic electrical CAD symbols and their meaning.

The applications are based on the electrical schematic: force and command electric circuits. In addition, it is required certain understanding of logical functions applied in Electric Drive schematics.

IV. Starting the Induction Machine

The induction machine is the widest spread machine used in industry. It can be found in general industry as well as in experimental research [11].

A. DIRECT START OF THE INDUCTION MACHINE

The direct start of the induction machine is a procedure through which the windings of the machine are connected to the grid (figure 6). Thus the nominal grid voltage is applied directly to the machines.

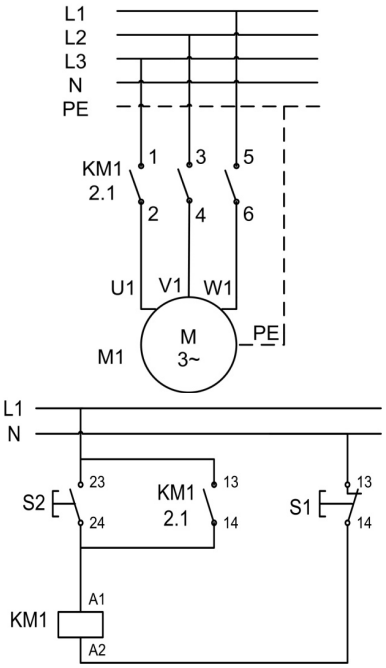

Figure 6. Direct start of the induction machine

This method is the simplest method to start an induction machine. The use of this simple application opens the way to the logical functions required to be fulfilled for induction machines' operation.

The logical function that is needed to be implemented by the KM1 coil is expressed by the equation 1:

KM1 = (S2 **AND** (**NOT** S1)) **OR** (KM1 **AND** (**NOT** S1)) (1)

For a better understanding of signals in this schematic, the equation (1) is expressed by a graphical representation in figure 7:

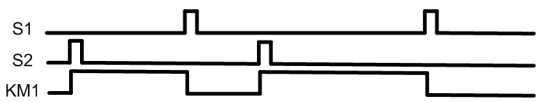

Figure 7. Graphic representation of the logic equation for direct start of the induction machine

B. STAR-TRIANGLE STARTING METHOD

Star-triangle starting of the induction machine consists in connecting the machines' windings to the grid first in star and then in triangle configuration (figure 8). This method is used to reduce the starting current pick value.

The logic equations that describe the function of the coils in the command schematic are indicated by equation (2):

KM1 = (S2 **AND** (**NOT** S1)) **OR** (KM1 **AND** (**NOT** S1))

KM2 = (**NOT** KT1+) **AND** ((KM1 **AND** (**NOT** S1)) **OR** (S2 **AND** (**NOT** S1)))

KM3 = KT1+ **AND** ((KM1 **AND** (**NOT** S1)) **OR** (S2 **AND** (**NOT** S1))) (2)

KT1 = (KM1 **AND** (**NOT** S1)) **OR** (S2 **AND** (**NOT** S1))

The graphical diagram that implements the equation (2) is displayed in figure 9.

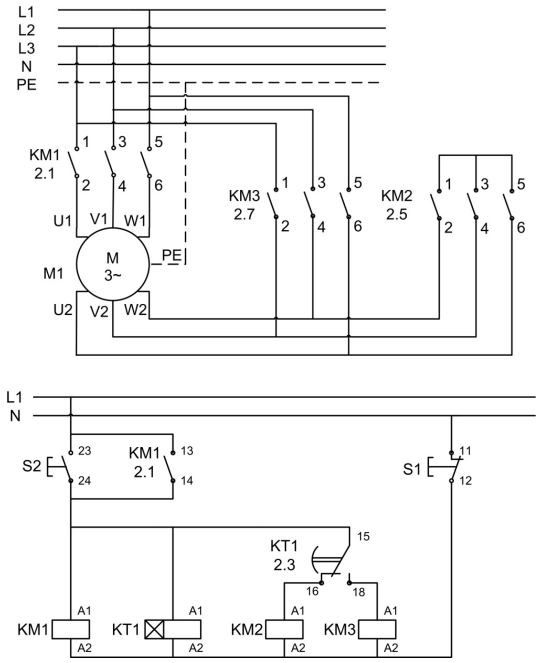

Figure 8. Star-triangle start of the induction machine

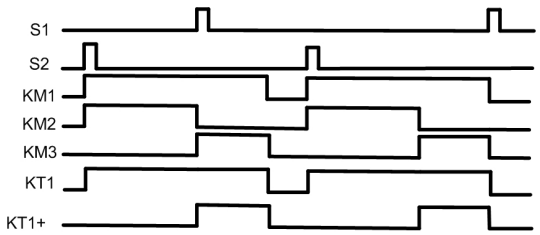

Figure 9. Graphic representation of the logic equation for indirect star-triangle start of the induction machine

C. PROJECTX

The ProjectX is the methodology developed by the projects' partners. It is focused on the Learning Outcomes. The learning outcomes are defined as: knowledge, skills and competences.

This methodology is somehow different of other teaching methodologies [12] because it gives students autonomy and independence to work on their personal rhythm.

The ProjectX that refers to the induction machines' starting methods is based on the learning outcomes indicated in *Table 1* [13]. The learning outcomes describe what a student should know, demonstrate, show, and perform once he/she studied it as indicated in [14].

Table 1. Structure of the ProjectX: Starting the induction machine. Learning Outcomes.

Learning Outcome 1: Analyze the electric schematic for starting an induction machine		
Knowledge:	**Skills:**	**Competences:**
Learning Outcome 2: Perform electrical installations and electrical maintenance for industrial premises		
Knowledge:	**Skills:**	**Competences:**
Learning Outcome 3: Install programmable automated systems		
Knowledge:	**Skills:**	**Competences:**
Learning Outcome 4: Write simple PLC program for sequential control systems		
Knowledge:	**Skills:**	**Competences:**

V. CONCLUSIONS

At present, the Romanian professionals are not involved in Lifelong Learning Programs. The participation rate in LLP programs of the students and teachers is one of the lowest in all European countries.

One reason for this is that both students and teachers have some fears about traveling for studying and teaching abroad.

The University of Pitesti is involved in a Leonardo da Vinci Transfer of Innovation together with six other European partners whose purpose is to develop an educational material to facilitate mobilities in Europe for students and teachers. The manual (final product of the project) comprises several independent units structured as ProjectX.

The novelty of this approach is that this material is prepared beforehand the mobility between all the partners. If the students and teachers have access to the material that is going to be used abroad, some of their fears could be solved before the actual mobility. By overcoming some of the fears, it is the hope of the authors that the number of Erasmus+ mobilities will increase to and from Romania.

Erasmus+ mobilities for both teachers and students bring many personal, professional and institutional benefits in many ways. By encouraging mobilities to and from abroad will bring improvement in the Romanian educational system.

Acknowledgements

The present paper is part of the project “One teacher and one student working with ProjectX”, project code 2013-1-ES1-LEO01-66485, acronym “One2one”, funded with support from the European Commission, through Leonardo da Vinci, Transfer of Innovation program.

Disclaimer

This project has been funded with support from the European Commission.

This publication reflects the views only of the author, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

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