Aspects of a Modern Electrical Engineering Course

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Abstract *This paper presents some aspects of a project aiming at designing a new curriculum for the course of electrical engineering at the Federal University of Minas Gerais, based on a systematic planning approach t. The curriculum aims and goals were established. Subsequently a pedagogical approach based on Learning Outcomes was chosen as a better way to deliver the expected results and, for the sake of flexibility, a modular course structure was proposed. The units were to be designed with the help of the so-called "module designing cycle", comprising the Learning Outcomes, the methods of assessment and the learning strategies. A curriculum model was proposed where students progress through the different levels of competencies. Finally, some specific aspects of the curriculum model are discussed.*

Introduction

The last quarter of this century has been shaped by unprecedented changes in the political and social as well as in the economic arena. The meaning of the globalization process in economic terms is understood by huge movements of money from country to country, from one continent to another every day. The same trend can also be observed in the cultural life. Each one of these changes is complex and has its own agenda. A common aspect of them all is the role played by the electronic communication system.

In the university where culture and science are its "razon d'etre", these changes have been receiving the attention of many scientists. By one hand some look at this process as something beneficial, after all culture, science and technology are nowadays collective enterprises profiting from the diffusion of ideas. On the other hand, some others consider them as an instrument engendered to keep in place the old political order.

One of the indisputable aspects of this process is that it was initiated and has been sustained by a number of high-tech companies that add value to their product by incorporating scientific knowledge to their process. The outcome is a general claim for quality on products as well as on services. In all the cases, one can point out the role played by the engineers present in all parts of this process as a result of their work and ideas.

The engineers are directly related to the technological development, to the actions to preserve the environment and to industry efficiency and productivity. The competition already strong in all sectors throughout this century is becoming more severe. Therefore, the major assets of industry are neither the machines nor the properties. Instead, the knowledge is what matter now. Microsoft, one of the largest industry of all times**,** is a factory of knowledge. This is happening not only in America and Western Europe but also in Latin America, Asia, virtually in every corner on earth. At this time of so enormous changes there are no excuses to graduate old-fashioned professionals. Yet in many countries the university started new experiences aiming at preparing a new kind of graduate.

At UFMG discussions aiming to outline the bases for a new Electrical Engineering curriculum is also a hot issue involving staff and students alike. Since the early moments, the intention was to bring substantial changes, which could sign a new approach on learning and, therefore improve the quality on student education. More recently, a working group was appointed with the task of designing a curriculum tuned with these new trends.

The work being carried by others was considered. The experience of the Alverno College [2], Syntheses-Coalition Group [3], Carnegie-Mellon University [4] in the United States and that of the group of the new British universities

[5] were examined. Furthermore, reports from other Brazilian institutions diagnosing problems and pointing out tendencies [6] were also discussed.

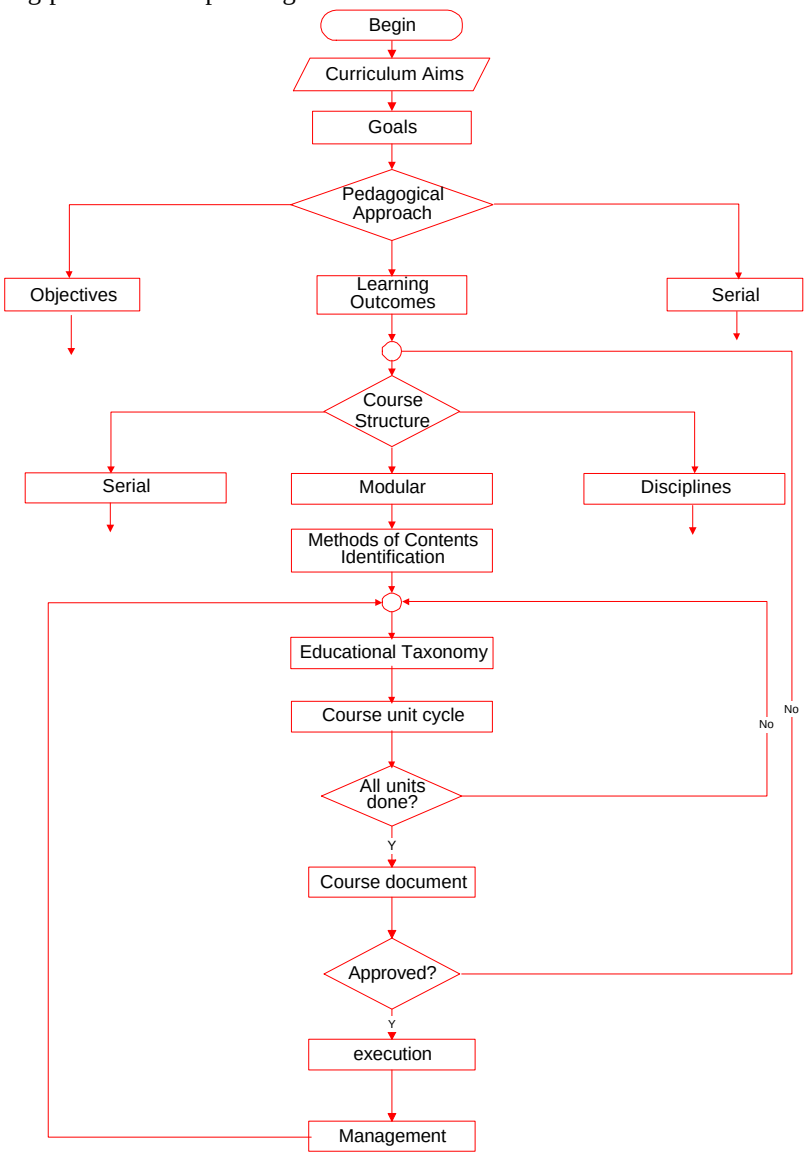

Figura-1 Curriculum flow-chart adapted from [8]

This work sets out with the purpose of designing a curriculum for the course of Electrical Engineering at UFMG in tune with the new demands brought by industry and society as a whole.

Aims and Goals – Outlining the New Curriculum

Degree courses in Brazil periodically experience what is called a "curriculum reform". Staff based on a piece-meal approach [7] set out removing old disciplines and bringing new ones, which seems to be more appropriate to fill the gap. Curricula from other universities are frequently taken to gain insight and fresh ideas into discipline contents. The courses lack overall coherence and are content's focused. They have no explicit outcomes and are always trying to catch up with the new demands. This is actually an illness plaguing courses in many other countries. Actions for conscious evaluation are very recent and plans for systematic monitoring are even more restrict. Thus, the question of (course) quality is for many more an aim then a fact. Trying to avoid these undesirable aspects, a systematic planning was adopted. A flow-chart summarising all the steps followed to design the curriculum is showed in fig.1.

The first task set under that guidance was the definition of the curriculum aims, which should be stated concisely to give to anyone a broad idea of the intended graduate's

profile. As a basic aspect of its profile, the student to be graduate under this new approach shall be fitted to the modern industrial context. Therefore, it is of paramount importance that he/she undergone a multidisciplinary learning process, prone to break-up the boundaries among the disciplines which used to being unbridgeable. The scientific method, the basis for the engineering profession, is intrinsically linked to this element. It's also an essential tool the students will have to master in order to solve the problems imposed by the new environment, without being limited by old walls.

The stated aims has as some of its goals:

- A transdisciplinary approach;
- A student oriented learning process;
- A Problem solving learning method;
- Social and environmental values;
- Emphasis on the importance of collaborative (team) working;
- Effective decision making abilities;
- Articulated interests with the pos-graduate engineering courses.

Besides, it's important to point out that there is some rationale, which underlies all the curricula, independent of their aims or goals. This is essential to bring dynamism and coherence. This curriculum rationale can be stated as [9]:

- Articulated (coherent, balanced, free of conflict and with logic development of the instructional flux);
- Realistic (based on real needs);
- Dynamic (the curriculum must be changed every time it is necessary.);
- Future Oriented (it must be designed to let room for the technological and social changes);
- Clear Outcomes (stated unequivocally such that anyone –teachers and students alike - can have a unambiguous idea about the intended outcomes);
- Student Oriented (the curriculum must be designed considering the students needs and the best ways it can help him/her);
- Systematically evaluated (the strengths and weakness must be know);
- Data Based (a good data base must be build-up such that decisions are taken in consistent way);

Although some of these points seem quite obvious, and should be present in all curriculum the experience shows that they are not always present in the undergraduate curriculum of most universities.

The Pedagogical Approach and Course Structure

Until very recently, almost all the newly appointed lecturers in many engineering courses in the Brazilian universities had no formal previous training. In fact, their teaching abilities are checked when they are being selected. Yet, in the engineering schools this process is almost a formality. Therefore, most new lecturers know virtually nothing about teaching/learning methods.

Theoretically, in most courses the adopted teaching method is the one that "objectives" are written. It isn't uncommon to seeing teachers delivering a document at the beginning of each semester, which among other information notify the students about the objectives of that particular course unit. These objectives are hardly explained let alone followed along the course. Each teacher rooted on his/her own experience and in a textbook builds up the course contents program. Furthermore, the lack of a method of assessment tuned with these objectives makes virtually impossible to pursue a coherent learning outcome. Therefore, the curriculum as a whole without a general articulation gives no grounds to achieve a specific aim. Based on the these points one can say that the *actual* teaching method in most engineering courses are in fact based on the course contents. Trying to avoid these negative characteristics in the new curriculum, other pedagogical approaches were examined.

In this project the pedagogical approach adopted is that based on the Learning Outcomes [4][10]. Here it's important to note that after all, L.O. are objectives, which have to be demonstrated by the student. Therefore, one may argue about the reasons that led to the preferences of a new pedagogical approach. The reason is threefold.

The L.O. idea seems of a practical point of view to be more consistent. It's not only a simple objective – a description of learning input. Instead, it allows a more effective measuring of what has been achieved. It's done through the description of the outcomes. – the knowledge, abilities and attitudes the student is supposed to demonstrate after the learning process to get pass in a particular course unit. This definition has an implicit (and unbreakable) connection between the outcomes and the assessment.

Another important reason is related to the course documentation. The LO's are written when designing the curriculum. Therefore, they will be an intrinsic part of it, which some moment later will be made public and anybody (teachers, students and employers) will be allowed to look at. This is a very important aspect, for it gives room for criticism and collaboration, which can improve the document. The teacher has its autonomy secured when he/she has all the freedom to prepare the course program, which is the vehicle to teach/learn the LO and the assessment components.

Last but not least, the reason related with the teacher involvement in writing the learning outcomes and the associated assessment methods for a particular course unit. This creates a commitment in relation to the LO. When delivering the course unit, the teacher tries harder to do the right things, concerned to the assessment as well as to teaching, then he used to.

Because the LO has been adopt and considering the set of goals established, it was considered that the most suitable course structure for the project is the modular one. It seemed more convenient because the course would be more flexible, giving the student more choice when to demonstrating those set of LO essential for their course option. Modules with different programs can be designed comprising the same subset of LO. In case a student fail once to demonstrate the required LO, he/she could try again without being bored with repetition. An additional point, which seemed particularly useful, was that of being another element of breaking up with the past. It became clear during this project that staff always try to find out a point with their actual disciplines.

Identification of the Outcomes

The description of the LO was considered the most difficult task by every-one participating in the project. Because people were not used to such approach, the project advanced very slowly at this point. After became aware of the meaning and other aspects of the LO, a staff pointed-out that besides the curriculum, the teachers should be reprogrammed too.

Strategies to Identify the Learning Outcomes

The strategy adopted to identify the LO started by consulting individually a group of engineers. Students views were also taken into account through arranged meetings. The UFMG staff contributed by an introspection technique.

The first group gave mixed contributions. At first letters were sent to some well-known senior engineers. The number of answers was discouraging. So, due to the lack of resources, it was decided to select a small and representative group, including senior engineers, members of industry boards and personnel staff. A more close approach with interviews was carried-out. A few interesting ideas were picked out. Some of them insisted in giving suggestions about disciplines that they believe should be part of the curriculum. Others argued for an urgent effort from the university in order to graduate engineers with more practical competencies. Most suggested generic outcomes what has confirmed one of the project's assumptions.

The students took a more pragmatic approach. They contributed by complaining about the burden they were compelled in the actual curriculum and claimed for more flexibility. They learnt about the LO approach but were not very enthusiastic. This was mainly because they also knew that the bulk of the change if it comes would affect only the new students.

The staff became involved in a different way. In the early phase of the project, the working group had sought the official staff approval for the idea of implementing the LO approach. At that time several became enthusiastic, a few were sceptical and many adopted a sympathetic approach. However, most of them expected that the working group should do the job alone and when it's done they would be called to approve or not the project. Some actions were devised in order to get them working. Presentations followed by discussion sections were carried out. In the second phase, when the LO were to be described the staff (with some student who voluntarily joint the project) were split according the their interest in Subject Specifics groups. The curriculum-working group had learnt that being these LO more familiar to all, this strategy would easy the way for the other outcomes emerge naturally within the groups. A final joint section and the work of the working group would harmonise the findings.

A well-prepared text containing general as well as specific description of the project approach was distributed to every one involved. A seminar was even held at the beginning of the activities. Among other information it was emphasised the need to look at the course unit cycle, the next step of the curriculum design plan. This cycle, illustrated in fig.2, includes LO description, assessment methods and teaching/learning strategies.

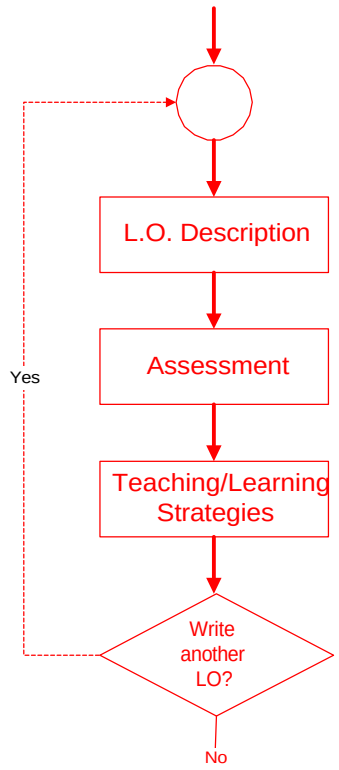

Fig.2 - Course Unit cycle

The activities related to the course unit design cycle were carried out with each group experiencing at first a brainstorm section. The participants gave many suggestions

related to the subject specific LO's. Yet, unexpected many others were also associated to the other types. This was a positive aspect, showing that the initial characterisation of specific groups has cause no damage to the process. Departing from these key words and based on the LO theory syntax (verb + subject + complement/qualifier) a number of objects were found. After a number of refinement sections and helped by an AI computer program [10] which suggests a proper verb (based on Bloom's Taxonomy) the LO started being described.

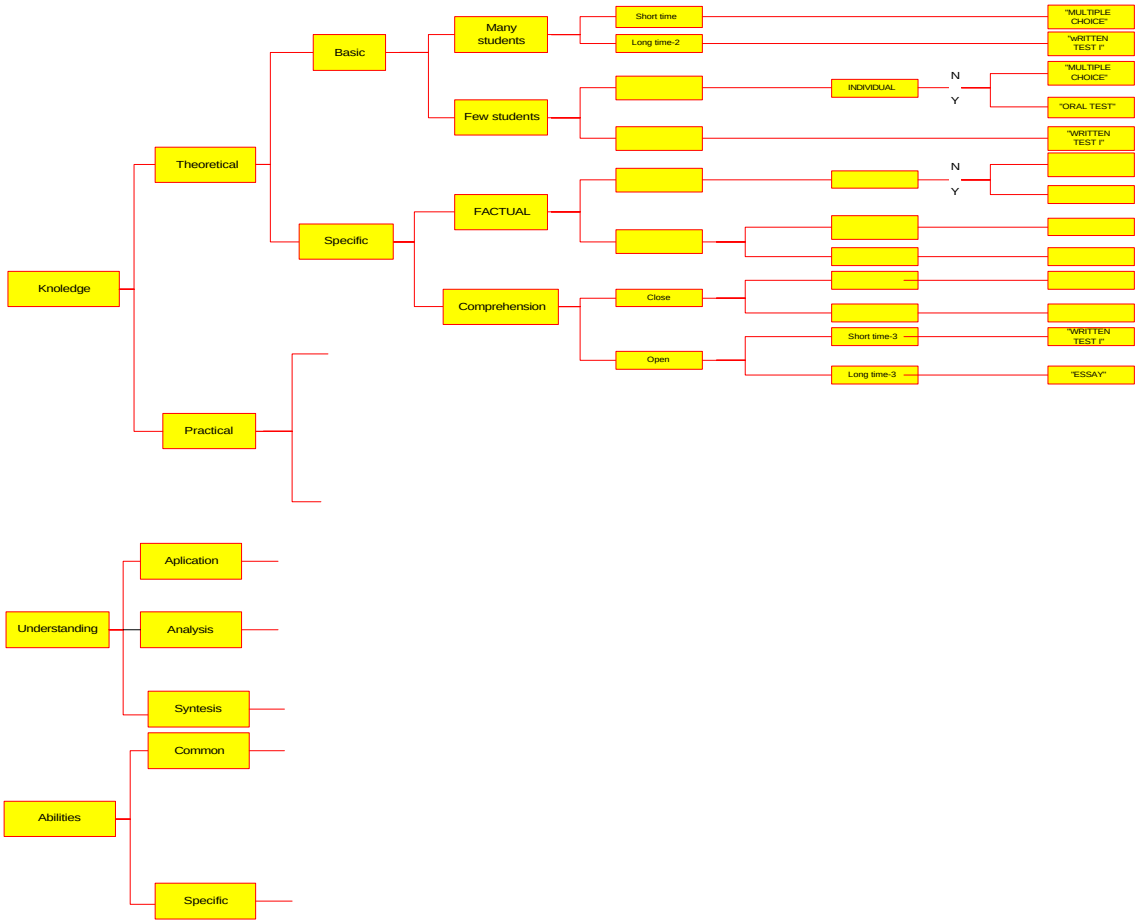

Fig.3 Choosing the components of assessment[12]

Types of Learning Outcomes

The working group decided to split the LO in four distinct types with the intention to ease their identification. This approach in some ways was also present in the actual curriculum. So, these types are:

- Common (problem solving and communication skills, social and environmental values, team working ability)
- General (optimisation, planning, testing)
- Subject Specific (Information systems, Automation systems, Energy systems)
- Interdisciplinay (fisiology, manangement, law, etc.)

It was also decided that emphasis would be put on helping students to development their entrepreneurs skills. This was an idea put forward much more to spread some managerial concepts, which is believed to be interesting to all engineers independent of their expertise. In this way they can also be considered as part of the core outcomes

Assessment Methods and Learning/Teaching Strategies

Assessment Methods

As mentioned earlier, objectives can become outcomes if they are accompanied by a proper scheme of assessment, which is understood as the whole course assessment. Therefore, it includes the group of methods that are composed by components. The methods are the way the

assessor checks that the student is able to demonstrate the LO. The components are that part of the assessment designed in order to allow the student to give evidence of the LO of a particular course unit. Examples of these are oral tests, assignments, multiple-choice tests, etc.

Each module should have its scheme of assessment designed during the curriculum design. As the working group suspected, people in engineers courses tend to keep employing a few well know components to assess wherever type of outcome they have. Thus, a special system was employed. Again the AI program was used. The way it works can be seen in fig.3. Based on the characteristics of the LO, the program indicates the components of assessment. It's interesting to point out that the method used to find some components of assessment can not be used for all types of LO. Student auto-assessment was also recommended.

Teaching and Learning Strategies

One point that came about clearly was that the weight the lecture has got in the actual curriculum was far to high and unjustified. Therefore, the designer of the new units were advised to consider other forms of teaching/learning strategies, which are more appropriate to the LO being designed. In the documents distributed by the working groups a number classic and new ways were suggested.

Among the new possibilities, the working group see at least two as very motivational. The internet and the so-called "co-operative project".

The curriculum Model

Once the LO and assessment methods are developed, modular course units will be designed considering that they will be created by a coherent and finite number of LO associated with the assessment method. Depending on the LO presents on a particular unit they can be graded as belonging to one model level or another. Also, comparing the number and complexity of LO presents in a course unit, different number of credits will be assigned. This is a new characterisation of the old credits, and not related to the notion of time.

The student will be required to get a number of credits at each level in order to graduate. The progress between levels will be possible as soon as the student manages to get, say eighty percent of the required amount at each level.

It has also been decided that the course will be characterised by four levels. It, by no means, mean that students will spent four years working toward the degree. The effort, the background and the interest of each student will be some of the factors, which will set the course duration.

Analyses and Conclusion

The project is not yet finished. So far, only a few of the course units devised have a complete set of documents. Due to a number of reasons, the progress now is much slower. When the project was initiated the working group had many good motives to adopt the LO approach. It was understood that the other staff would easily be convinced by the better characteristics of that approach. Although this really happened, some unexpected problems arose. During more than an year a hard work was done. Difficulties were overcome and solutions were found. A guide was written to help those who wanted to design modules using the LO approach.

Many of those (staff) working to describe the LO have difficulties to do the job. Thus, it was suggested that the working group should produce the course units documents. Yet, it was very clear that this was not the way out. Instead, a group of experts in each subject specific area should make a draft of the document for each unit and then the working group adequate according to the directions previously imposed.

Actually, what has been perceived is that many have not yet been made up their mind in order to change the way they teach. Time has acted in two contrasting ways. By one hand staff need more time (perhaps some external action) to understand what is the LO approach. By the other hand, the fact that the final draft was not yet presented contributed to low the moral.

Furthermore, the present curriculum has a number of problems and the pressure to change it quickly was high. Perhaps, the working group should have suggested some minor curriculum revision, in the traditional fashion at first, and only them start working with the LO approach. Several staff were expecting results in a couple of months after the appointment of the working group.

Another problematic point is that everybody became conscious of the actual curriculum approach weakness. However, there isn't a great reason to change and to justify a so high individual effort, considering that the course ranked among the best few in the country.

Presently the work group is still working and hopefully in less than six months, the whole draft may be finished.

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