

Edu World 2016
7th International Conference

**ON THE EDUCATION OF THE AUTOMOTIVE ENGINEER
THROUGH PROJECT-BASED APPROACH**

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Abstract

Today, perhaps more than in the past, we think that the question for the trinomial “academia-industry-state” is:

are the graduate engineers “fit for purpose” and capable of operating in an industry that needs multi- and inter-disciplinary skills? In other words, is there a gap between industry needs for multi-skilled engineers and the current supply of graduate engineers? If so, then what should be done for reducing this gap?

This being the context, the paper discusses the current stakes for the educational institutions and presents an approach which is currently implemented at University of Pitesti in a Master programme developed with Renault Romania. Thus, our combined effort was to design an academic curriculum “fit for this purpose”, i.e., frequently employing the teamwork in multi- and inter-disciplinary project-based learning. A full semester was dedicated to transversal disciplines, which should help students to be up to the industrial task. Another semester (the last one) was entirely dedicated to practical periods or internships held in industry or research labs. Equally, involving as often as possible direct interaction between the students and local and international industry specialists was another goal of our common enterprise.

All this will be thoroughly presented and discussed in our paper, the final goal being to exchange information on this topic which we think should be currently regarded as one of paramount importance. It’s our belief that universities are challenged. It is about the challenge to produce useful graduates for industry, featuring short periods to reach the autonomy target.

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Keywords: Automotive engineering; fit for purpose; project-based learning; closed-loop system.



1. Introduction

Over the years, the automotive community accomplished many remarkable technical achievements. Certainly, all this was possible thanks to a very qualified human resource.

Nowadays, the rhythm of technical changes happening in the industry appears to exceed the possibilities of many educational institutions to cope/keep up with. One obvious conclusion would be that the gap between industry needs for multi-skilled engineers and the current supply of graduate engineers is widening. Moreover, as argued by (Slavnich, 2015), as current engineers grow older, fresh and young minds are not coming through the system fast enough.

Therefore, on the one hand, the universities are challenged to produce useful graduates for the industry, featuring short periods to reach the autonomy target. On the other hand, the whole society is challenged, as well, because in many countries what is usually known as STEM (Science, Technology, Engineering and Mathematics) went out of fashion in the favor of more accessible degrees such as for instance economical and juridical sciences, media and photography etc. Perhaps, as indicated by (Fieldhouse, 2012), currently, STEM is publicly perceived as being too hard and not that financially rewarding over the whole lifetime. Thus, something has to be done at the level of the society in order to increase the interest of young pupils for STEM (e.g. promoting the social value of engineering).

Concerning the first issue, let's analyze the involved characters and try to establish a clear way of working so that the target to produce useful graduates for the industry can be achieved. Figure 1 presents what we think should be the goal of every system: a dynamic system, featuring closed loop control.

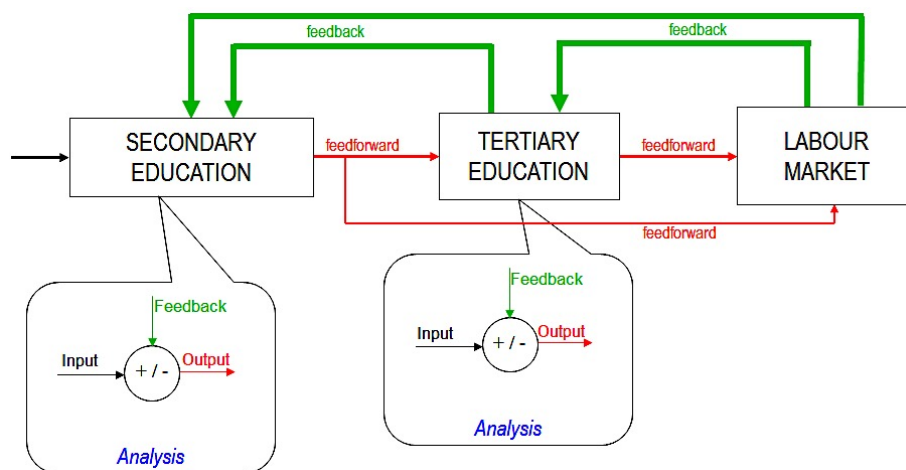


Fig. 1. Education system organized as an integrated system working in closed loop

The knowledge based society should be truly organized as an integrated system working in closed loop control. In other words, *feedback* should be the keyword. Easy to say, easy to understand but, we think not that easy to make it really working at the level of human society. What is ironic is that we are able to make complex mechanical & electrical & intelligent systems working as explained before, so that the setpoint/target to be truly achieved and sometimes, we are failing when it comes to apply the same principle to us, humans.

Moreover, what makes really difficult the optimization of the educational system's operation is the fact that every modification in the system can only be analyzed after one full cycle of study. In other

words, if we simplify the analysis by refereeing only to the bachelor degree from the higher or tertiary education, the assessment of the added value of the implemented modification can only be performed after the completion of the studies, which is usually done in 3 or 4 years. Then, another modification can be issued according to the result of the analysis, and so on.

Taking into account this particular aspect, one should understand that when there is a desire of change in the educational system, *caution* should be the keyword. If the modification which is desired is not the results of a thorough analysis of the whole integrated system (education + labor market = whole society) then time would be lost without achieving the goal and the inherent negative effects will be really hard to diminish in time and space.

In order to go even deeper with our analysis, this integrated system we are talking about should be organized to follow the operation logic of *supplier – client chain* (fig. 2), whose main feature is the *client's satisfaction*.

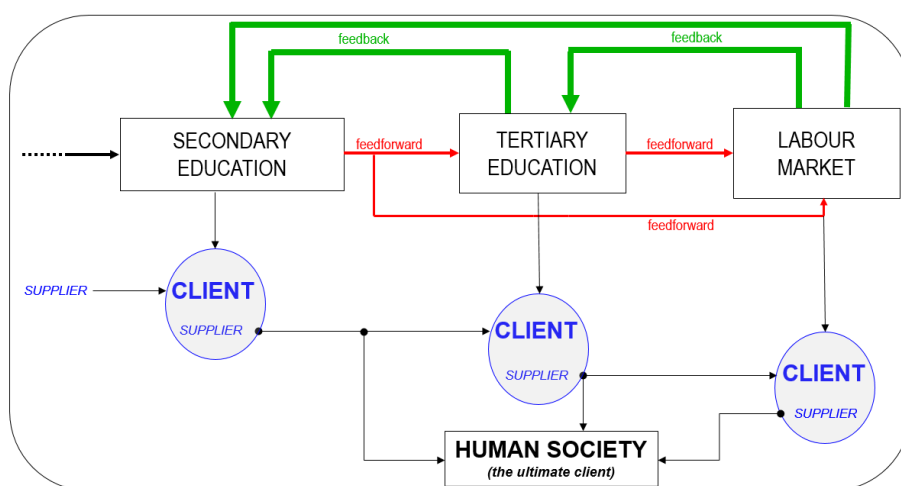


Fig. 2. The supplier-client logic

As seen from figure 2, every part of the integrated system presented before is simultaneously client and supplier. Therefore, one chance to positively resolve this system is to intensify the need for satisfaction from each client, which certainly cannot be achieved without continuous feedback throughout the whole system. In the end, the winner (or the loser) is the whole society.

These general considerations were introduced in order to underline that the change which is expected in the field of *engineering education* should be the result of an *efficient dialogue* between *academia, industry and government*. Currently, it might be accepted that the present educational methodology wasn't changed much or in a significant way since quite some time. Certainly, the situation may differ in each country. However, as discussed by (Omar, 2013), there is a general acceptance that the engineering education should suffer important updates, such as for instance not only focusing on acquiring facts but also on developing skills. According to (Finegold, 2016), *problem-based learning* should be the main goal as it is synonymous with engineering. Therefore, problem-solving skills, critical thinking skills, teamwork and project management skills (including international communication and collaboration skills) are the ones which should be the goal of every engineering educational system. In order to really encourage the development of such skills, some actions may be needed at the level of academic curricula. For example, creating a curriculum which includes *project-based*

learning approach that supports freedom of thinking, in other words which inspires innovation and creativity. With such an approach, the above mentioned skills could be developed efficiently. Obviously, this cannot be applied in the educational system without being first undertaken by the faculty staff. This means that first an important shift in professors thinking should occur. Then, some other measures should be put in action in order to increase faculty expertise in professional practice and here the industry and government might help. As mentioned before, if targeting the improvement of the educational system aiming to bridge the gap between the industry needs and the current supply of fresh/young engineers, there has to be a *tripartite collaboration between academia, industry and government*. Industry cannot simply wait to have the right graduates without any intervention in the educational system. Government should also be involved as it is about the development of the whole society.

2. Project-Based Learning. A Case Study from the University of Pitești

Renault Technologie Roumanie (RTR) which is a unique client of the educational institutions in Romania decided to step in and to bring its contribution to the improvement of fresh engineers' quality.

Their internal training entitled "Engineering of the Automotive Projects" developed in 2007 in collaboration with the Technological University of Compiègne, France (UTC), was transformed in 2009 into an ARACIS (Romanian Agency for Quality in Higher Education) Certified Master Programme, available in 4 Romanian universities, amongst them, University of Pitești. This Master programme is entitled "*Conception and Management of the Automotive Design (CMPA – in Romanian)*" and was meant to include the project-based learning approach. The teaching paradigm applied within the frame of this Master programme satisfies the needs of the automotive engineering education to embrace *active learning by doing* in order to answer the industry's requirements. When deciding to implement the project-based learning into this Master programme, we establish as a general rule that professors have to set-up a learning environment where open and honest discussion is encouraged. Dialogue with students should continue after the courses by using current communication techniques (email and social media).

This Master's curriculum combines *core courses* with *transversal courses* and with internship or practical training. Moreover, in order to make this Master programme more efficient, recognized specialists from the local and international industry are involved in the courses, giving focused lectures and presenting case studies from real life. Thus, students come in a direct contact with the industry with the derived advantages. In short, they interact also with the ones who actually do projects in the industry or real life and not only with the ones who speaks about how things are done in real life.

The core courses which covers *the first two semesters* (each of 16 hours/week and 30 credits) focus on engineering topics such as: automotive computer aided design, vehicle dynamics, modern automotive manufacturing and materials, regulations and standards in automotive engineering, advanced powertrains and drivelines, ergonomics and comfortability of automobiles, numerical methods. Their purpose is to provide the students with in-depth knowledge of the automotive engineering so that they can be technically able to develop their own projects in the second year of study. The teaching method is based on intellectual challenge. Encouraging the debates on specific subjects is also a key point of the teaching method. The professor's role is to provoke, guide and provide feedback so that students can find the solution/answer by themselves. Thus, the professor's role is to mentor rather than defining the problem statement and project boundaries.

The third semester is composed of transversal courses meant to address the need of the industry for developing the project management skills to the fresh post-graduates:

- Professional communication.
- Documentation and capitalization of information,
- Creation of product and innovative services,
- Value analysis,
- Industrial property,
- Quality management,
- Management and marketing of the innovation
- Project management,

Actually, during this semester, students aim to develop the following transversal skills in order to be able to work in high-potential innovation projects:

- ability to work in groups,
- innovation potential,
- cost control,
- time and performance.

The method used in order to “force” the achievement of this third semester’s goal relies on dividing the students in workgroups, each one undertaking a “Project”. The main steps of a “Project” are presented in table below.

Table 1. Project development

Week	Themes	Week	Themes
1	What is an automotive project; managing a project.	2	Clarification: translation of the demand. Formalization of the need.
	Project idea		Quality tools - brainstorming; the vote
	Human resources		Innovation - typologies - strategies
	Quality tools		
Clarification: demand analysis			
3	Introduction to methodology. Orientation of the action and search for information. Functional analysis	4	Marketing of the innovation
	Marketing		The marketing plan
5	Bases of rules; dictionaries; encyclopaedias; thesaurus; the search query; catalogues	6	Search engines
	Research, evaluation and selection of the technical solution		Organization. Characterization of tasks. Resources. Team Project.
7	The invention patent	8	The European patent
	The market. Market research. Sample survey. Benchmarking		Theses/dissertations; documentary watch / monitoring
	The American and Japanese patents		The company. The production. (Trade) marks
9	Planning. Project risk analysis	10	MQ system. ISO standards. Quality tools
	The production		The production
11	Companies and models	12	Professional communication: a necessary dimension of management. Slideshow. Behave – nonverbal, oral presentation exercises.
	Quality tools. Quality management tools.		The economic information; statistics
Process approach			
Realization: monitoring the project			
Process approach. FMEA (failure mode and effects)			

Week	Themes	Week	Themes
	progress. Management of the project team. Communication about the project changes.		analysis)
13	Financial management The economic information. Statistics; Web 2.0 Closing: animation of the end of project meeting. 5S - Kaizen philosophy	14	Financial management. Business plan Technical definition of the solution. Cost analysis Audit and environmental quality. Indicators and dashboards

In the fourth semester, students should be integrated in a full time internship either within the industry (OEM and/or OEM's suppliers) or within research labs (academic ones, included). The idea is to make things more realistic in this final semester of study. Approaching more concrete case studies than before with the associated challenges and trade-offs can only contribute positively to the final goal of creating a graduate engineer "fit for purpose" and capable of operating in an industry that needs multi- and inter-disciplinary skills. On this matter, our particular problem is that the local industry is not too developed so that to absorb the entire population of students.

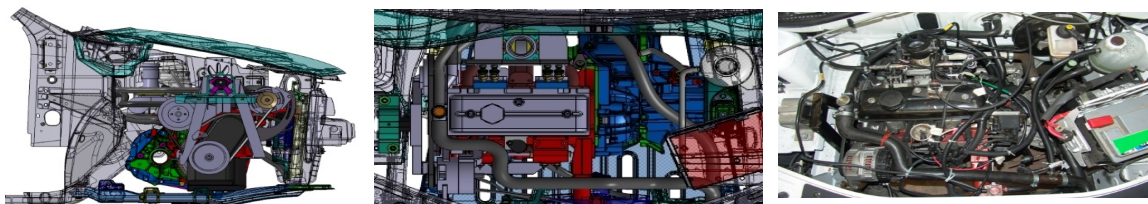
Some of the projects approached within the framework of this Master Programme are presented below:

- Dacia Duster – Mobile Office/Bureau Mobile:
 - o It is one of the most prominent projects realized in cooperation with RTR,
 - o It is the result of the involvement of 23 tutored students from all the universities working with RTR on the Master programme under discussion,
 - o These 23 trainees integrated in a 4-month internship in RTR covered all stages of developing a product, starting with numerical prototyping and ending with physical prototyping (fig. 3)



Fig. 3. Dacia Duster – Mobile Office

- Ecologic Vehicle by Intake Throttle-less Actuation (EcoVITA):
 - o It consisted in the integration into a Dacia Logan vehicle of an original spark ignition engine prototype featuring variable intake valve lift (ViVL) developed at the University of Pitești (fig. 4)

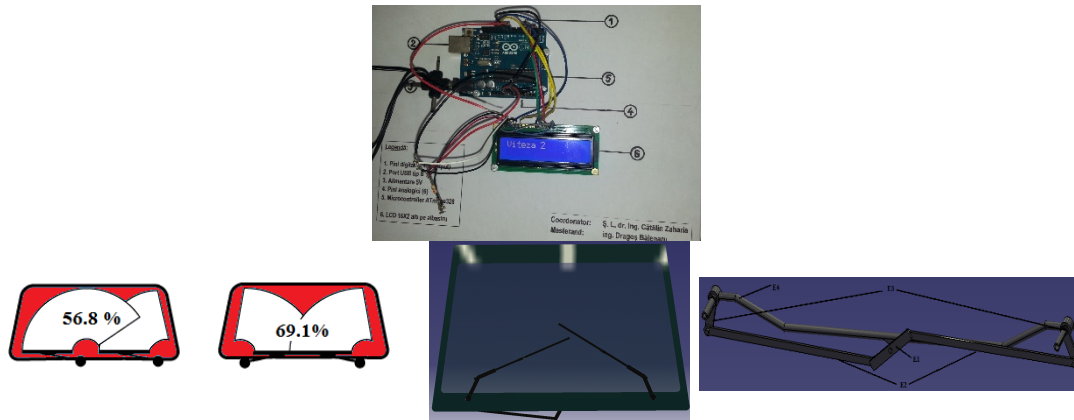


Numerical Prototype

Physical prototype

Fig. 4. EcoVITA project

- Developing an anti-phase working windshield wipers for Dacia Logan car
 - o Numerical prototype was developed and validated (fig. 5)
 - o Physical prototype is in progress



Phase working wipers vs. Anti-phase working wipers

Numerical prototype

Fig. 5. Anti-phase working windshield wipers

- EcoDriving:
 - o The goal was to develop a gear shifting indicator so that the driver can adapt the driving style in order to minimize fuel consumption (fig. 6)

Fig. 6. Gear Shift Indicator

- Transforming a Dacia Logan car passenger in a cargo vehicle:
 - o The project started from the usual Dacia Logan car, featuring 3 volumes and the goal was to obtain a hatchback type cargo vehicle (fig. 7)



Fig. 7. Logan cargo vehicle

The project-based learning approach is formally applied in our university only into this Master Programme as described before. Being convinced about the usefulness of this learning approach, for the students from license/bachelor level, we launched an optional project entitled *Challenge Kart Low Cost (KLC)*. This is the fruit of an efficient cooperation with Université de Bourgogne, Institut Supérieur de l'Automobile et des Transports (ISAT) de Nevers, France (fig. 8).



Fig. 8. Challenge KLC – a French-Romanian project: 2 electric powered karts and 5 thermal powered karts

KLC is truly a project well defined from technical, financial and duration point of view. In short, it is about developing of a go-kart over one academic year (starting from the idea and ending with an operational prototype), whose cost is not to exceed 2000 Euro (for thermal ones) or 3000 (for electric ones, excluding the batteries), aiming to participating in month of May to a motor-sport academic competition. Consequently, it is not just a simple go-karting race. Equally, it is a technological, educational and human challenge and the winner is not necessarily the fastest! By summarizing, the goal of this competition is to prepare future engineers for project management by developing the teamwork spirit, sharing responsibilities, respecting deadlines and allocated budget; finally, it aims to develop the synthesis and compromise capabilities in respect to the initial imposed constrains. This year, our competition reached its sixth edition and was organized in Romania. Next edition will be held in Nevers Magny Cours, France.

3. Conclusions

The paper discussed about the need of some important changes in the present engineering education. Particularly, the paper underlined the need of having a dynamic educational system which *rapidly* respond to industry requirements without compromising the basic needs of traditional engineering education. One of the methods to produce what in this paper is called *engineer fit for purpose* is to implement *the project-based learning approach*. On this matter, the paper presented a case study from the University of Pitești: A Master Programme developed in cooperation with Renault Technologie Roumanie, which was designed to provide to our students, hands-on experience in designing, producing and validating technical solutions for vehicles. Future efforts should be focused on continuously improving this Master programme and to extend the concept to other programmes of study.

Acknowledgements

The authors would like to express their gratitude to Renault Technologie Roumanie for their involvement in our enterprise to obtain graduate engineers “fit for purpose”. We would also like to thank Mr. Ernest Galindo from ISAT de Nevers, the author of the Challenge Kart Low Cost with whom we developed a very good connection on the education of automotive students.

Author Contributions: All the authors have equal contribution to the work presented in this article.

Conflicts of Interest: The authors declare no conflict of interest.

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