Learning to Love Engineering: Developing Innovation and Industrial Related Skills

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Abstract

The authors aim to explore the role for one out-of-school hands-on program, F1 in Schools (F1S), as one of the pillars for the development of a positive vision of industry, engineering skills, employment opportunities and technical careers towards industry and future engineering career development. This work rests on the belief that the promotion of engineering skills is an important tool for education in consideration for sustainable development. Richer, fairer and sustainable societies can only be achieved by means of a qualified workforce. The lack of qualified engineers and technicians, and consequently the lack of a qualified workforce have been on the agendas of governments and countries worldwide. Mainly nowadays that it's recognized that industry and re-industrialization is the ground base for the evolution, fairness and economic prosperity. The "new" industry must compete by adding value to the processes and products, and not by reducing costs. These assets are made possible by innovative engineering and countries with innovation inputs related to human resources (engineering education) are more competitive.

Keywords: Education; F1inschools; Engineering; industry

1. Introduction

The idea that young students and parents have of industry, technology and related careers and study areas tent to visualize the "Modern Days" movie from Charlie Chaplin. According to this global setting, especially in countries where industry is the main economic income (e.g. ROSE study), up to here, were not socially valued and were unattractive to young people searching for a future professional/life direction (Sjøberg & Schreiner, 2010). . It is recognized that the industrial sector is unable to inspire and motivate sufficient young people to enter engineering programs or technical training paths related to industry, and future predictions show a significant fall in meeting business and industrial needs (RAEng, 2007, Halstead et. al, 2009; Kupfer, 2011). According to previous studies youngsters tent to choose "easier" paths and careers with another public image and recognition (Fernandes & Rocha, 2010). Various researchers have studied students' attitudes towards "industry", "science" and "technology". Researches shown that youngsters often have stereotypical images and that those images affect their attitudes toward science, industry and technology (Berdslee and O'Dowd, 1961; Brush, 1979; Chambers, 1983; Fernandes and Rocha, 2007; Finson et al., 1995; Flick, 1990; Mason et al., 1991; Mead and Metraux, 1957; Palmer, 1997). It appears that if a youngster can see himself/herself in a career, then, the likelihood of that person persuiting an educational program to prepare him/her to that career increases (Smith and Erb, 1986). These documented diminished interest in engineering, industry and industrial related careers has been long associated with several factors such as: perceptions and images of industry, lack of knowledge, lack of understanding the contribution of engineering for everyday life, teaching methods, curricula, mismatch between values and the way technical subjects are approached, career guidance, youngsters lack of understanding and appreciation for their potential future role in society (Berner, 2010; Cavallo & Laubach, 2001; Fernandes & Rocha, 2010; Moor et al., 2006; Osborne & Collins, 2001; Simon et al, 2006; Wynarczyk & Hale, 2008). "Young people need to see the point of it all. They especially want practical application (not just practical work). This might be learning about a job, developing personal skills, experiencing team work or having a subject explained to them in terms of its contemporary context" (Lord, 2006, p. 2). Youngsters need these divergent approaches to learning versus the majority of schools curriculum approaches. It's unquestionable that lifelong learning and development, with all the associated (individual/collective) strategies are central issues for the development of a capable workforce and a productive, fair and healthy country.

2. Motivation

F1 in Schools Ltd is a not-for-profit company established with committed partners with the vision "to provide an exciting yet challenging educational experience magnetic appeal of Formula One" (F1inschools foundation).The

Portuguese representatives for F1inschools are the Portuguese Technological Centres Network (RECET), the Technological Centre for the Metal Working Industry (CATIM) and other Technological Centres from the network. CATIM encompassed F1S activity in a wider project Think Industry Technology (TITP) that has the global aim to develop a positive vision of industry, of employment opportunities and technical careers in the industrial sector towards an active citizenship. The motivation for this project and related activities are 3 global and worldwide problems: (i) industry image; (ii) withdraw between youngsters in school ages and industrial activities and careers; (iii) training choices and market integration heavily influenced by commerce and services. For each one of these 3 dimensions there are specific targets to be achieved by the activities that youngsters are evolved in.

The main objectives of F1S are: a) to develop a positive vision of industry; b) to link industry with positive values and attractive careers; c) to make youngsters and industry closer; d) to make youngsters aware of industrial careers in short term; e) to motivate youngsters to carry on their studies on technological areas (mainly engineering); f) to raise awareness of the individual influence on the creation of value.

Table 1: TITP problem dimensions and specific targets

Main Problem Dimensions	Specific Targets	
Traditional image for the industry	• Develop a positive vision of the industry • To link industry with positive values and attractive careers	To develop a positive vision of industry, employment opportunities and technical careers in the industrial sector towards an active citizenship
Withdraw between youngsters in school ages and industrial activities and careers	• To make youngsters and industry closer (and vice-versa) • Evolve youngsters and industry in mutual approximation processes	
Training choices and market integration heavily influenced by commerce and services	• Make youngsters aware of industrial careers in short term • Motivate youngsters to carry on their studies on technological areas	

2.1 Methodology

The case study approach methodology was used to systematize and bring into light some key concepts of the F1S approach. It was collected data from the 2009/2010 edition, with more than 250 youngsters with an age range from 13 to 18 years old in Portugal.

The schools or the participants enrol voluntary in the program, although it's an out-of-school work, for the great majority of teams they have school support. After team's constitution, one group from the technological centre goes in place (e.g. schools) and starts to introduce F1S and the tools (e.g. Learning Management System (LMS), software, hardware, etc). The available tools can be acceded at distance (tutorials, on-line support, examples from previous editions) and locally in the technological centre (e.g. milling machines, CNC machines). From this point on the works goes according to the time and resources of each team. All the work is evaluated in 3 levels, and only the best works from each level pass to the next one: regional competition, national competition and word competition.

3. The Challenge

F1 in Schools is a global multidisciplinary challenge for students (aged 9–19) and more than 350.000 youngsters enrolled, in which groups of 3 - 6 students have to design and manufacture a miniature "car" out of balsa wood using CAD/CAM/CAE tools. The cars are powered by CO2 cartridges and they are attached to a track by a nylon wire. They are timed from the moment they are launched to when they pass the finish line by a computer. The international main purpose is the same: getting more future engineering students. Some key-elements on the project completion are: business plan, design, analyses, doing and testing, evaluating, innovation and racing. The teams are evaluated by different juries:

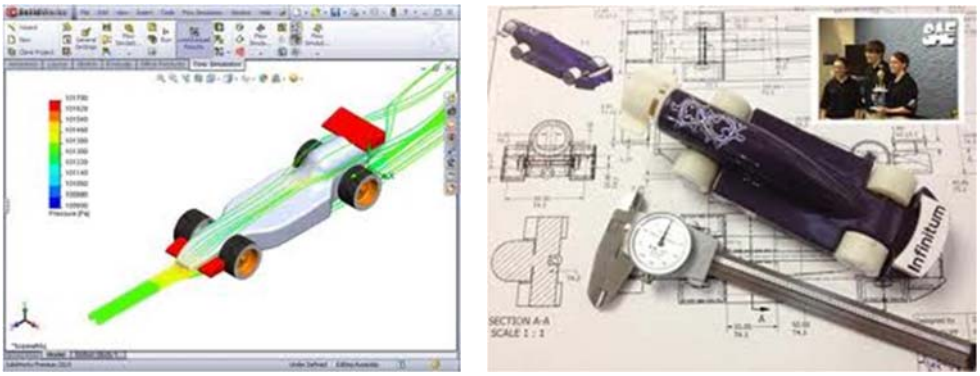

Figure 1: Flow simulation and verification of the car specifications

- Specification judging**:** a detailed inspection process where the race car is assessed for compliance with the F1 in Schools Technical Regulations.
- Engineering Judging: The scheduled engineering judging interview session will focus on the application of CAD CAM, analysis, CAD data organisation, orthographic drawing, 3D render and use of CNC machining. This is an informal interview where judges will ask the team to demonstrate their CAD / CAM work and query teams on what they have done.
- Portfolio and Pit Display Judging: Each team is required to produce a 20 page design portfolio as well as a pit display. The design portfolio is A3 size and should contain information about the team, their car design and manufacturing process, marketing techniques, project management, team work and team identity. Teams will be given an area to set up a pit display which will be judged alongside their design portfolio by a panel of judges.
- Verbal Presentation Judging: Teams will prepare in advance of the competition a timed verbal presentation to present to a panel of judges, outlining their project. Teams will usually use a PowerPoint presentation as a visual aid when presenting to the judges. The length of the verbal presentation will vary depending on the level of the competition.
- Racing: Teams will race their cars against each other on the official 20 metre F1 in Schools competition track.

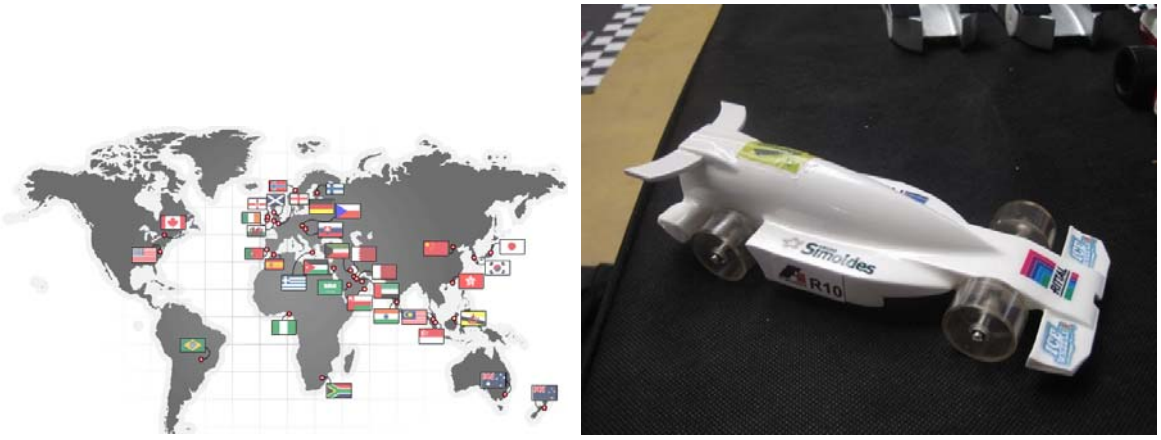

Figure 2: World challenge participation distribution and one example car

3.1 Activities

The teams have access to several support resources, such as e-learning platform and on-line support, 3D engineering software, Computer Numerical Control machines (CNC), smoke/wind tunnels, 3D printing machines. There are well defined rules for the competitions (Regional, National or International) that the teams must comply if they want to

attain with the purposed objective. The teams must take in account several items when designing, developing and materializing their projects:

- Each team must contain a minimum of 3 to a maximum of 6 students, each one with defined roles (e.g. Team manager, production engineer, marketing manager).
- Use CAD (Computer Aided Design) software to produce their ideas and model it in three dimensions (3D).
- Teams must use a CNC machine to produce their own miniature F1 car.
- To manufacture the car body each team must choose either to use technology available at the school/college or at a designated manufacturing centre/partner inside of F1inschools network.
- Follow the specifications concerning car painting. Each car body must be completed with a high quality painted finish. Only a limited amount of hand finishing to the body is allowed.
- Produce a design folder including initial ideas; design development and evidence of testing maximum 20 pages (A3 size).
- Develop partnerships. F1 teams are encouraged to develop partnerships and seek assistance from academic, businesses and industry throughout this engineering process. However, all aspects of this engineering and industry partnership should be represented in the team's portfolio. This includes CAD designs, painting of the cars, and the creation/production of the portfolio, which should remain the responsibility of the students in the team.
- Supply (in the design folder) a dimensioned 3rd angle orthographic projection and a graphic rendering of their final design, both produced using a 3D CAD package.
- Prepare and deliver a 10 minute verbal presentation on their work with or without visual aids.
- For the youngsters' teams these are complex projects, for so, they are reminded about some considerations such as:
- Resources: CAD/CAM/CAE packages help them to draw and to develop their ideas in 3D. As with most drawing packages, it takes time to learn how to use the software. CNC and 3D printing machines allow youngsters to see the project take "body" but the technology use must be studied and applied with caution. Wind/smoke tunnels allow youngsters to see the scientific aerodynamic principles and test them.
- E-learning: the resources used are complex, and so are the results to be achieved, and the ways to support self-learning. The e-learning use allows youngsters to manage their time and learning in more efficient ways. They can share doubts, help each other, have access to privileged material, and see real case studies, alongside with the technological centre on-line support.
- Research: Teams are asked to investigate existing F1 car designs to find out the latest developments occurring in the world of F1 design. Concentrate research on areas that could help teams, for example, aerodynamics, car body design, and try to apply the principles to the team ideas and in-hands projects.
- Testing: teams may want to consider testing a variety of car designs, or car parts, in a wind and/or smoke tunnel to evaluate their aerodynamic performance. Teams may also test those compounds with the 3D printing machine.

4. Manufacturing considerations: To all teams it is given a F1 Car Kit which is constituted by a balsa wood block, a set of 4 wheels, 2 axles and some glass paper, which is the minimum needed for entering the challenge, but teams are free to develop their own high tech wheels, axels and air folios.

5. Mapping best practices

The project approach allows the authors the point some of the practices that can lead to close the gap between industry and university by addressing the identified problem dimensions (see table 1). Youngsters learn to love engineering and engineering principles by experiencing it and making the link to everyday life activities.

Figure 3: 3D printing of wheels/air folios and CNC machining of the car

- Coordination team and Monitors' competency. The F1S' coordination team must have a specific profile that allows youngsters to experience the activities, to unroll their potential and to foster motivation. Some of the identified competence are: subject matter/content knowledge, nature of engineering principles, multidisciplinary, knowledge of contemporary science and engineering, variety of instructional strategies, plasticity an flexibility (dealing with different learning styles), lifelong learning, self-reflection, using divergent approaches to the learning process (e.g. laboratory, real life, experimenting), common sense knowledge and learning difficulties, use of ICT ebbed on the activities, use of knowledge/planning and curricular materials, making the link with everyday life activities.

- Building interest in engineering principles. The resources, methodologies and approaches allow youngsters to experience the application of these principles to an engaging and exciting activity (known to everyone – Formula 1). The offered resources – technology, software, access to knowledge, network makes then aware of their own abilities and in many cases potentiate it.

- Collaborative project-based learning (CPBL) All the activities were designed with the goal to promote CPBL, due to the fact that there are no solo projects, youngsters can only enter the competition when on a team. Teams have access to several support resources, namely, e-learning platform and on-line support, 3D and simulation engineering software, computer numerical control machines (CNC), smoke/wind tunnels, 3D printing machines.

- Building informed citizens of the value of engineering for a fair and prosper society. Industrialization or re-industrialization is only possible with a qualified workforce. Learning by doing opens the youngsters and stakeholders minds making it more probable in a near future.

- Design methodology and approach. The design methodology and approach adopted allow the development of multiple goals such as understanding and discussing engineering principles; developing scientific capabilities concerned with gathering and using evidences; to develop a scientific attitude towards everyday life; engaging and motivating youngsters to learn and develop soft skills. TITP and F1S activities allow youngsters to experience the engineering and scientific principles on the back stage of the Formula 1 Setting.

- Understanding concepts and applying it in simulated environments. Youngsters have the opportunity to "role-play" the all cycle. From the use of advanced prototyping software to test their theoretical approach and afterwards to learn by trial and error (hands-on approach) about engineering principles related for example to physics, material resistance or aerodynamics. Youngsters learn an experience new materials and technologies and get to work on "why products/solutions work".

- Making links to everyday life. F1S allows students to make the link between their classroom teaching and curricula with a real life application for Formula 1 (simulated environment). Alongside with the preparation of young people to future professional roles or careers, e.g. designer, product engineer.

- Making links to future paths in life. When the attractiveness of a career can be experienced, it is more likely that a similar path is followed. It appears that if a youngster can see himself/herself in a career, then, the likelihood of that person pursuing an educational program to prepare him/her to that career increases (Smith and Erb, 1986).

- Engineering process: Understanding engineering as a process and not as stable fact. Using the stat of the art technology/information/resources to attain a certain goal. The youngster's research, question, manufacture, test and ultimately compete with F1 cars (at their own scale). Understanding the scientific and engineering principles behind the all process (racing) is crucial and it's made through hand-on. Hands-on approach allows youngsters to experiment, analyse, discuss, interpret, evaluate and redefine according to the real results.

- Cooperation with several stakeholders: the project is worldwide disseminated and allows youngsters to get in touch with several stakeholders, such as employers, unions, universities, technological centres. This allows them to have a clear insight of the market and the value given to engineering.

- Applying this approach allows youngsters to realize the value of engineering and industries for creating value either individually or collectively. Experiencing hands-on and being able to exchange points of view directly with industry makes the teaching system and industry closer and anchored on real problems.

6. Innovation vector

The investment in education, research, technology and innovation is seen as a key driver of growth. Innovative ideas can be converted into new marketable products and services that help to generate growth and quality jobs.
Enterprises engage in innovation processes as a way to conquer competitive advantages, which allow them to cooperate in networks and/or compete for quality in niche markets.
In European Union (EU) exist a deficit of graduates in the fields of engineering, according EU education and training systems between 2000 and 2009, "the growth in MST (maths, science or engineering) graduates between 2000 and 2009 was relatively low, both at EU level and in most countries, compared with other fields of study such as services, health and social sciences, business and law, where growth rates in the same period ranged from over 65% to close to 100% at EU level. At more than 50%, the average percentage change for all fields of study from 2000 to 2009 was substantially higher than the MST growth rate." (EUROSTAT).
The Council of 12 May 2009 on a strategic framework for European cooperation in education and training", establish as the forth strategic objective that is important increase the creativity and innovation, at all levels of education and training fields (ET 2020).

It´s our believe that more quantity and quality engineering courses can provide certified human resources (engineers) with knowledge that will help companies to grow by innovating in several fields and get return on in investment for them and for the society .

7. Conclusions

The images that youngsters have of relevant workplaces in the industry and engineering, also changed prior and post F1S participation, at first they were superficial, unreal and even incorrect. Industry, namely manufacturing has huge potential for generating wealth, jobs and better life-quality. The "new" industry must compete by adding value to the processes and products, and not by reducing costs. These assets are made possible by innovative engineering and countries with innovation inputs related to human resources (engineering education) are more competitive.
Closing the gap between Industry and University/formal teaching system (and vice versa) is potentiated if we start the intervention in young ages. Starting sensitization projects early in life can help globally and individually, both on mentality shift and on promoting the attractiveness of future careers related to engineering and industry.

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