Global Education and Industry 4.0

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Short Abstract: This study considers the global state of the art in engineering undergraduate education and focuses on trends generated by Industry 4.0. Competition increases steadily, so innovation capacity and a short time to market become essential to attend continually changing customer expectations. So is the present industry scenario that is characterized by a high level of customization demand. Qualification for the current workforce is required to attend these production strategies. After describing some actions from education, industry, and nonprofit organizations, this study demonstrates a strong and effective relationship between industrial demand and current learning activities.

Key words: Industry 4.0, workforce qualification, learning activities, engineering education, strategic competence.

1- Qualification needs for Industry 4.0

The industry presents cycles of accumulation of techniques and innovations. These paradigms are called industrial revolutions **[BT1]**. The competitors from all over the globe seem to be nearer each other than in the past, so innovation capacity to attend progressively volatile and heterogeneous markets due to constantly changing customer expectations become essential **[HG1]**. The current globalized world needs highly interconnection of processes and companies are facing an increasing number of challenges to cope with. Based on an advanced digitalization within factories, the combination of Internet technologies and future-oriented technologies in the field of "smart" machines and products seems to result in a new fundamental paradigm shift called Industry 4.0. The vision of future production contains modular and efficient manufacturing systems and characterizes scenarios in which products control their own manufacturing process. This is supposed to realize the manufacturing of individual products in a batch size of one while maintaining the economic conditions of mass production **[LF1]**.

These emerging technologies have a huge effect suggesting the replacement of some professions and need for qualified and highly educated employees. **[BY1]** The present students need to know about the activities that await them at in these "smart factories", their essential ingredient is the connection to the production facilities, that includes machines, devices, sensors and people, especially via the Internet. With the whole process from production to consumption in communication with each other, the production is shifted to cyber-physical systems. Using of the Internet of Things, Internet of Services and the Internet of People will allow all kinds of connections between machines and humans and this amount of Big Data is analyzed to be able to predict possible failures and adapt the production in real time to the changed conditions. Production processes will have to allow effective production and at the same time, be flexible due to the changing customer demand for particular products. The timely analysis of the obtained data is important for planning and managing of the flexible production and Cybersecurity becomes crucial to prevent leaks of important classified data. The augmented reality allows workers to train in a simulated environment, operation and manutention actions and additive manufacturing are used more frequently in ideation phase.

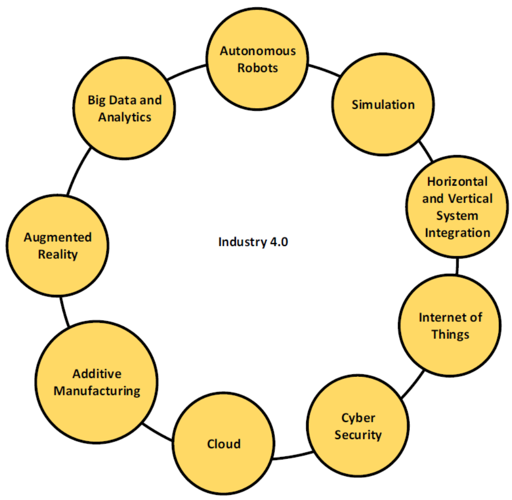

Figure 1: The industrial production process targeted in the future [BY1].

The viewpoint of the industrial production targeted in the future is presented in nine different related technological fields Fig. 1 **[BY1]**.

2- Development of human resources

The industry should collaborate with universities to achieve workforce demand **[BT1]**. A parallel can be drawn between the industry and the school environment. At the university Problem-based learning (PBL) is an essential tool to train to seek knowledge for the resolution of unknown problems, like in the case of a new industry product needed to be released. The student is instigating to investigate and search for sources of information in subjects previously studied that will be used to advance in new aspects **[Y1]**. Each new product from industry requires improvements in many areas, new design, material, structure, manufacturing process, etc., on the other hand, at school, search for knowledge can be oriented by making it essentially practical, and multidisciplinary bringing academic life closer to professional experience. There is an increase in student performance, due to both the greater retention of information available, and to the motivation and interest that is fostered by resolving real-life issues **[B2].**

3- Strategic competence development to attend Industry 4.0

Smart production systems are put in place to create the required flexibility and capacity to fulfill the actual market expectations. Some changes have to take place, simple and monotonous processes have to give rise to the automated, while other processes become more complex and intertwined **[HG1]**. At the university the freshman also has changed expectations coming from the current generation z **[SG1]**, if the industry needs implementation of the latest technologies of design and simulation tools, known as Product Lifecycle Management (PLM), the students are ready to use the same resources to do their homework, using the same software for professional use. PLM technology allows people to work on a shared database, accelerating the possibility for designers and engineers to exchange ideas and design information with no distance limitation **[H1]**. That is what some students did for some years while participating in GM-PACE program, concluded in 2018 **[P1]**, which stimulated by a global two-year competition were challenged to carry out the design and build a functional prototype of a product. In this case, more than forty universities from ten countries around the world participating with around fifteen students each formed six teams of students from different universities, using some internet communication software like *Skype* to weekly discuss issues, cloud space to share information that will be manipulated by everyone with access and many software tools to design, simulate and manufacture, all this work based on data provided by future users achieved through surveys.
All this initiative are, according to Graham **[G1]**, study, that indicates experiences found in the world's best engineering programs in the future as user-centered design, technology-driven entrepreneurship, active project-based learning, and a focus on rigorous engineering fundamentals.

4- The International Design and Engineering Education Association-IDEEA IDDEA initiative

At present, the International Design and Engineering Education Association-IDEEA took GM-PACE place with a differential, which is a course that has its classes posted on a website. In the first version of the competition, about 130 mechanical, automation and manufacturing engineering and industrial design students participate in 15 world teams from 13 universities. The students form teams to complete the project stages defined by a timetable of the instruction period and have a professor as a mentor to report and question until the meeting deadline when they have to make a presentation of their works for a jury formed by renowned professionals. During the project phases, teams formed by students from different schools located in countries of different continents must organize themselves to share tasks, make reports and prepare surveys. To make this possible they must communicate through web conferences with an appropriate schedule for everyone, that some times is difficult because of each country time zone.
This form of work is in line to efforts developed at schools such as Maua Engineering School in Brazil, where IDDEA activities worth credits as one of the workshops and projects of a new concept of lessons in the curriculum.

5- Special projects and activities - PAE (Projetos e Atividades Especiais)

After many years of working traditionally, the Maua Engineering School (located in Sao Paulo – Brazil) has made the option of introducing in its curriculum, in a more systematized way, Projects, and Special Activities. These projects and activities emerged intending to incorporate into the curriculum activities previously developed by the students in a dispersed way that were not considered in the sum of the student's work. In this way, events such as SAE MINI BAJA competition, Formula SAE, Aerodesign and now the IDEEA, among others, started to be considered as part of the student's training, and the hours of dedication to these activities became part of their curriculum.
The proposal involved a transposition of 16% of the workload of the old traditional curriculum to projects and workshops. The discipline that combines such activities receives the name of PAE - Projetos e Atividades Especiais (Special projects and activities). The PAE is several half-yearly activities in different areas of engineering and design with an active educational approach based on PBL **[CM1]**.
These activities are in line with new curriculum conceptions, which call for student-centered learning strategies, with active and collaborative participation, as in proactive learning strategies, as reported by Oliveira **[O1].**
From the first to the fourth year of the Engineering courses, students had to dedicate a four-hour workload to these Special Projects and Activities, always under the guidance of an applicator and focused on solving engineering problems. With this, the student had throughout the course, the proximity of the profession that is not guaranteed in the traditional courses of Engineering.

6- Competencies for future Engineers

As highlighted by Mattasoglio Neto **[ML1]**, several advantages in student learning were achieved with the implementation of the use of the PBL in Projects and Special Activities, as motivation, responsibility, maturity, proactivity and better preparation for professional life.
One of the objectives of the Projects and Special Activities is to develop transversal competencies in students. From the works of Lima et al. **[ML1]** and Matta et al. **[E1]**, a list of these competencies is indicated in Table 1. From the Curricular Guidelines for Engineering courses in Brazil, **[A1]**, we have the list of technical skills required in the Engineer's training. One of the Projects and Special Activities objectives is the development of students transversal competences. From Lima **[ML1]** and da Matta **[EO1]** researches, a list of competencies is presented in table 1. From the Brazilian Engineering Courses Curricular Directives **[B1]**, is presented a list of necessary technical competencies for engineers.
It is based on the competencies presented in Table 1 and Table 2 that the data from a survey were collected.

Table 1: Desirable Transversal Competences for Engineers [ML1] and da Matta [EO1].

Team work
Critical sense
Autonomy to learn
Face challenges
Proactivity
To create / to innovate
Dynamism
Leadership
Initiative
Foreign language
Interpersonal relationship
Analytical ability
Organization and planning
People management
Selection of information
Production / Interpretation of text
Capacity for argumentation
Information Technology – TI

Table 2 – Technical Competences: Brazilian Engineering Courses Curricular Directives for Engineering courses [B1]

Formulate and design desirable engineering solutions
Analyze and understand the users of these solutions and their context
Analyze and understand physical and chemical phenomena through symbolic, physical, and other models, verified and validated by experimentation
Conceive, design and analyze systems, products (goods and services), components or processes.
Deploy, supervise and control how Engineering solutions
To know and apply with legislation and normative acts in the exercise of the profession

7- Research on the application of skills

Participation in an educational engineering project, such as that promoted by IDEEA, is an excellent opportunity to develop skills that go beyond these techniques, typical of engineering training.
In order to know how the students perceived their participation in the project and which competences acquired with this participation, a research was conducted considering the main competences indicated in tables 1 and 2. For data collection, the link of a survey created on Google forms was sent using WhatsApp and WeChat the studfents. The set of questions had three different dimensions: the first sought to raise general group questions like age, gender, nationality. The second raised data developed in the project and the third, data on techniques. The survey was conducted at the end of the project after the students completed the various stages of the course and at the time of final report.
The form created was answered by the Team 14 participating in the IDEEA project, and answered by 13 participants, 8 from Brazil, 3 from China and 2 from Germany, with 11 men and 2 women. For the analysis of the perception about the development of transversal skills, a Likert scale with a score of 1 to 5 was used. Overall, considering all the respondents, the most relevant data referring to the transversal competencies taken from the research is that "Facing Challenges" and the use of "Foreign Language" are the most developed competences in the projects, both with score 4,4. On the other hand, "Dynamism" and "Analytical Ability" are the least developed, both with rating 3,8. These numbers show very close results, indicating a reasonably uniform perception for all transverse competencies. As for the perception of technical skills, the most valued by the students is "Analyze and understand the users of these solutions, and their context" with score 4,5 and the less valued is "Analyze and understand physical and chemical phenomena through symbolic, physical, and other models, verified and validated by experimentation ", with score 3,8. Something relevant is the difference of results from the responses of students from different countries, for example in the "Autonomy to learn" competence, for which a value of 4.5 is awarded to students from Brazil while a value of 3.2 is awarded for students from other countries.
These results may be related to their appreciation by different groups of students. For example, Brazilian students assign an average grade of 1.3 higher than foreign students, for the competences "Analytical ability" and "Autonomy to learn". On the other hand, the skills of "People management" and "IT" had practically the same score, both for foreign students and for Brazilians. This is something that deserves to be better studied in future research, especially with an increase in the number of respondents.

8- Conclusion

Qualification strategies are important to prepare the industry 4,0 worker, modern methods and techniques in education should be applied to develop specific skills. The sooner the future professional has contact with these practices the better they will be prepared for the job. That include relationships among people, communication skills, advanced technical knowledge, etc.
An approach aligned with the trend of education towards the future was presented. The application of these current

techniques allows us to carry out global activities for education that must be exploited to their full potential to overcome geographical and cultural barriers. The activities presented in this study are of great relevance for individual development for the future professional.
One of the factors that may have affected the results is that it was not clearly stated at the beginning of the project which competencies were desired to e achieve. This is something that should be clear to both team mentors and students. That is, the development of skills should be indicated from the outset as one of the project objectives.
As a suggestion, follow-up of development of competencies, in all participating teams, as a goal to be measured in future editions of the project.

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