A Survey of Current Practice in Systems Engineering Education

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Introduction

As defined by the International Council on Systems Engineering (INCOSE): "*Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs*". [1].
In simple terms, Systems Engineering is a structured approach focusing on the design and the management of complex engineering projects over their entire life cycle.
During the last decade, the complexity of systems has increased to an unprecedented level, due to multi-disciplinary stakeholders with various resources and considerations to be taken into account from the first system concept until the retirement stage. Much

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effort has been made to address these challenges, especially by standard organizations which published a number of handbooks and guidelines for Systems Engineering in order to develop a harmonized view of all involved processes that are required throughout a system's life cycle to transform customer needs into a system solution [2]. Several standards have been defined, from the early US Military Standard MIL-STD-499 dating back to 1969, to the last revision of the ISO/IEC/IEEE 15288 published on May 15th, 2015 [3]. Thanks to the creation of such standards, the engineering industry may better cope with the complexity problems that occur within the stages of a system life cycle. However, this requires well-trained human resources who master the fundamental and domain-specific Systems Engineering principles and their corresponding standard processes.

In order to be effective as Systems Engineer, engineering students need practical and real world experience in addition to the necessary knowledge in their traditional engineering discipline [4]. The difficulty of teaching the Systems Engineering approach for academic institutions is amplified by the fact that today's complex systems often involve the use of emerging technologies such as physical environments, visualization, virtualization, or Internet Of Thing (IoT), which are also considered as the heart of any efficient Factory of the Future [5]. In this context, the Placis[1] project has been initiated by three french engineering schools, together with industrial partners, in order to create a collaborative educational platform for Systems Engineering.

The work in this paper has been conducted in the scope of the Placis project. On the one hand, it surveys the pedagogical goals and specificities in Systems Engineering Education. We investigate the requirements for a powerful solution, present the most relevant up-to-date practices and discuss their advantages and their limits. In particular, we study the Project-Based Learning approach which is the preferred pedagogical model by most educators and researchers in this field. On the other hand, we outline some important open questions and suggest possible starting points for further research. The paper concludes by summarizing its most significant results, and provides perspectives for our future work.

1 Objectives of Systems Engineering Education

According to Muller [6], Systems Engineering Education differs from traditional monodisciplinary engineering courses, since the training needs to focus more on skills and less on transferable facts. The author gives a set of recommendations to consider for a good Systems Engineering Education program, including interaction with students, soft skill development, media use and student feedback. Dym [7] believes that "*a good Engineering Education is about process, about learning how to think like an engineer; its much more than a prescription of content*".

Asbjornsen and Hamann [8] provide an overview of Systems theory and Systems Engineering methodology in order to design a pedagogical concept for both Engineering Education in general and Systems Engineering Education in particular. They argue that the initiative to take up Systems Engineering at a university level has come from industry and not from academia. By examining the industrial motivations, the authors identify a list of learning targets for high-quality Systems Engineering Education, such as:

[1] Placis Project: Collaborative Platform for Systems Engineering, driven by SupMECA. And funded by the French Ministry of Higher Education and Research under the future investments program with the reference ANR-11-IDFI-0029

- *Broad-Based Qualitative Knowledge*
- *Deep Quantitative Knowledge*
- *Systems Engineering Ability and Insight*
- *Learning Ability*
- *Human Factors*
- *Loyalty and Individual Responsibility*
- *Global and Environmental Concerns*

For Sage [9], a major goal of Systems Engineering Education should be to acquire the abilities relative to each of the 19 focus areas for Systems Engineering identified by the Systems Engineering Capability Model (SECM) [10]. The author presents Systems Engineering Knowledge as a composition of three aspects:

- **Knowledge Perspective** which allows forecasting the need for innovation, including innovation principles to identify the appropriate systems planning and marketing directions.
- **Knowledge Principles** as formal problem solving approaches, which are usually linked to fundamental knowledge needed for research and development.
- **Knowledge Practices** representing the accumulated experience that has led to standard operating policies for well-structured problem solving.

The American Society for Engineering Education suggests consideration of: [11]:

- *Team skills, and collaborative, active learning.*
- *Communication skills.*
- *A systems perspective.*
- *An understanding and appreciation of diversity.*
- *Appreciation of different cultures and business practices, and understanding that engineering practice is now global.*
- *Integration of knowledge throughout the curriculum a multidisciplinary perspective.*
- *Commitment to quality, timeliness, continuous improvement.*
- *Undergraduate research and engineering work experience.*
- *Understanding of social, economic, and environmental impact of engineering decisions.*
- *Ethics.*

Dym et al. [12] recommend the following three activities for a powerful learning environment for Systems Engineering and similar disciplines:

- *Instrumenting the learning process to obtain quantitative and qualitative data that support metrics consistent with quality control.*
- *Teaching Design Engineering and other disciplines such as Systems Engineering across geographically dispersed, culturally diverse, international networks*
- *Engage design coaches to help manage the contextualization of engineering design theory and practice.*

Finally, in a broader context, Herrington and Kervin [13] specify nine main characteristics that any learning environment, technology-based or not, should feature:

- *Provide authentic context that reflect the way the knowledge will be used in real life*
- *Provide authentic activities*
- *Provide access to expert performances and the modeling of processes*
- *Provide multiple roles and perspectives*
- *Support collaborative construction of knowledge*
- *Promote reflection to enable abstractions to be formed*
- *Promote articulation to enable tacit knowledge to be made explicit*
- *Provide coaching by the teacher at critical times, and scaffolding and fading of teacher support*
- *Provide for authentic, integrated assessment of learning within the tasks*

At this stage, the need for an appropriate pedagogical model for Systems Engineering Education becomes apparent, a model that meets most of the previously cited goals and considerations while ensuring efficient learning outcomes and correct student assessment. This topic will be treated in the third Section. Prior to that, the next section presents some significant use cases.

2 Advances in Systems Engineering Education

This section presents some important currently proposed solutions for Systems Engineering Education around the world. Interestingly, no common pedagogical model can be identified. Each institution has its own teaching format varying from one-weak crash courses to multiple-year programs. Systems Engineering Education is often regarded as an extension to regular Engineering Education, typically taught to graduate students along with interdisciplinary studies, and sometimes included in undergraduate university programs [4]. INCOSE has formulated a policy statement that emphasizes the importance of Systems Engineering and its impact on regular engineering disciplines: "*INCOSE believes strongly that a systems perspective and the fundamental principles of systems engineering have an important role in the education of all engineers regardless of their specialty. This will strengthen the general recognition that most of today's engineering tasks are performed in multidisciplinary teams, and degree granting programs in systems engineering must be encouraged and supported*" [14].

Engineering schools do not always offer independent Systems Engineering courses or programs. Systems Engineering may be taught in the scope of a single module, under the label of product development, product design, design engineering or design thinking. Dym et al. [12] state that *”Design Thinking reflects the complex processes of inquiry and learning that designers perform in a systems context, making decisions as they proceed, often working collaboratively on teams in a social process, and “speaking” several languages with each other (and to themselves)”*. Other schools have created dedicated programs and curriculums for Systems Design, Systems Engineering and closely related areas [15]. We can therefore distinguish two approaches of Systems Engineering Education: Systems-centric and Domain-centric. *”Systems-centric programs treat systems engineering as a separate discipline and most of the courses are taught focusing on systems engineering principles and practice. While, Domain-centric programs offer systems engineering as an option that can be exercised with another major field in engineering*” [6].

2.1 Master Programs with Academia-Industry Partnerships

To meet the needs of modern engineers, and to address the innovation crisis in the U.S, Craig and Voglewede from Marquette University, Milwaukee, presented in 2010 a Master program of Engineering in Mechatronics [16]. Their approach focuses on finding a balance between academic rigor and best practice. The program includes 12 one-credit key modules covering fundamental engineering knowledge such as mathematics, physics, mechanics and electronics, along with Systems Engineering related knowledge such as control, analysis tools, systems modeling and design. The lessons learned in these modules are applied to four three-credit case study courses: *transportation system, home and office system, energy system, and automation system*. During these courses students get comfortable with the most important practices in Systems Engineering, including user and problem understanding, design, implementation, integration, trade-offs and optimization. Finally, a six-credit on-site experience allows the students to put it all together in a genuine industrial context.

Another significant example is the Master program created by the Johns Hopkins University (JHU) Whiting School of Engineering. In 2011, it was considered as the largest Systems Engineering program of the United States in terms of enrollment [17]. The program balances theory and practice, and offers different learning methods combining in-person classes, online classes and industry partnerships. It also includes a challenging capstone Systems Engineering Project. According to the authors, many students who followed the JHU program, pursued doctoral studies in Systems Engineering at other universities such as George Washington University, George Mason University, Stevens Institute of Technology, University of Virginia, and Old Dominion University.

2.2 Few-months international Academia-Industry Projects

Paris Higher Institute of Mechanics (SupMECA), leader of the Placis Project, has created a Systems Engineering Education program under the same name [18]. It aims to train engineers in a new format, asking students from different engineering schools, different countries and different disciplines, to work collaboratively on an international and multidisciplinary project. The students use the most recent engineering tools and technologies, including Catia V6, SysML, Abaqus, WebEx and Sharepoint.

Depending on the configuration of the program, it teaches to both Master and Bachelor students. In the case of Masters students, the projects are generally carried out during one semester with the following course of events:

- A multidisciplinary project is proposed or re-conducted by a company.
- The project is approved by the Industrial and Academic partners.
- Multidisciplinary student teams from different universities are formed (6-10 students per group).
- A kick-off meeting with all involved persons is organized (in-person or video conference).
- The students work on the project by distant collaboration. They are followed by teachers and industrial tutors.
- Teachers and tutors assess the students' results and performance (reports, models, behavior, final presentation, etc.)

2.3 Student challenges

AFIS, the French chapter of INCOSE, organize since 2006 a yearly student competition for robot design, called RobAFIS [19]. Around 10 student teams from french universities and engineering schools, inexperienced in Systems Engineering, participate each year in this competition.

Each team can consult a Systems Engineering teacher, and they can also question other AFIS experts. The roadmap starts about 8 months before the final stage competition, when AFIS communicates the general schedule, the regulations, specifications, and a reference development document. Three months before the final stage, the teams register and receive a LEGO Mindstorms Robotics kit in order to physically implement their solution. Fifteen days before the final stage, the teams send their development document to Systems Engineering experts for evaluation. The competition concludes by a final stage where all teams meet and operationally validate their works, along with project and configuration audits. Few weeks after the competition, the students receive a detailed debrief regarding their work.

2.4 Few-weeks Projects within regular Engineering Curriculums

In 2004, Bonnema et al. presented a solution to introduce Systems Engineering to third-year students in Industrial Design Engineering at the University of Twente [20]. The SAS project (Sensors, Actuators and Systems) applies Systems Engineering tools and techniques in a concrete situation. More specifically, the project allowed students to learn the basics and goals of Systems Engineering, and to keep an overview in a complex design project. The students worked in large groups of 12-14 persons in a project-based learning approach, without a tutor except for the possibility to discuss with some specific staff members. They were provided with lectures on a selected set of subjects on Systems Engineering, which represents 34 credit hours of the entire 140 credit hours of the SAS project, together with 53 hours for Sensors and Actuators, and 53 hours for the Assignment. The main study material was the 2.0 edition of the INCOSE handbook, the "Systems Engineering and Analysis" book [21] and the Introduction to Systems Engineering book [22].

There was no planning given to the students, except for two milestones: *Customer requirements, systems requirements, system concept, and sub systems*, that needed to be done during the first three weeks of the project, and *Sub-system design, plan for system integration and test, final system design*, scheduled for the following fours weeks. In 2004, the students were asked to design an intelligent climate-control system for houses, and in 2005 an intelligent car. They were evaluated based on poster sessions, a Sensors and Actuators exam, and a short essay on the application of Systems Engineering methods in their project.

2.5 Theoretical Courses within Industrial Engineering Curriculums

Already in 2000, Yurtseven from Dogus University in Turkey, presented two courses that dealt with Systems Engineering and Design for students in Industrial Engineering [23]. These courses were mainly theoretical. The first one addressed senior level students and provided a background on the fundamentals of Systems Engineering. After introducing the main concepts of design and engineering, the course included several topics such as: Design Options, Engineering Systems Modeling, Analysis of System Reliability, System Dynamics and State Transition Matrix Models, Modeling the Research and Development Process, Systems Life-Cycle and Optimization, and the Management of Engineering Systems Design and Operations.

The second course addressed graduate level students and introduced some unconventional methodologies in Systems Engineering. It included the following topics: Introduction to the Management of Advanced manufacturing Technology, Introduction to Sociotechnical Systems Theory, Cognitive Systems Engineering , and Soft Systems Methodology.

2.6 Few-Days Laboratories

The *Technische Universität München*, *Germany*, proposes since 2012 a laboratory on Systems Engineering in the context of product development[24]. This laboratory is held by three researchers in form of a five-day event, targeting Master and Bachelor students in Mechanical Engineering without previous knowledge in Systems Engineering. An industrial case study is used as a teaching framework, along with a subset of aspects and processes from a typical Systems Life Cycle in Systems Engineering. The selected processes are explicitly highlighted in the paper as: "*planning of activities and responsibilities for various tasks; assessment, control, and decision-making concerning organizational processes, time management, tasks, design concepts, and chosen methods; stakeholder requirements definition, requirement analysis, and architectural design of the given system; implementation, verification, and validation of the system design*". Methods related to these processes are taught by examples, after which the students (as individuals or teams) make their choice in terms of which method may be best suited for each task and apply them to the use case of the laboratory. By this means, the students do not only acquire the Systems Engineering methods, but also several important soft skills, such as moderation, presentation, and discussion.

A similar approach has been adopted at Cranfield University, UK, but as a part of a whole Masters degree program in Systems Engineering. It takes form of a one-week full-time laboratory based on a LEGO Robotics Kit [25].

2.7 LEGO-Based Programs

LEGO Robotic kits, especially LEGO Mindstorms, have been widely adopted for educational purposes. They are mainly used for two goals. The first one is to stir the interest of high school students for STEM education (Science, Technology, Engineering and Mathematics), by allowing them to discover scientific fields like electronics, mathematics, design or programming. Relevant examples are the efforts at Wichita State University [26], or the Stevens Institute of Technology BUILD IT Project, which is a university-school collaboration to increase interest and achievement in engineering, science, mathematics, and information technology [27]. It was also used by Georgia Tech School of Electrical and Computer Engineering to help students decide whether or not to major in electrical engineering or in computer engineering [28]. The second goal is using LEGO Mindstorms to teach future engineers the Systems Engineering approach. Two significant experiences are discussed in this section.

Khalaf et al. [29] propose an innovative and interdisciplinary engineering *Design-and-Build* course for the cornerstone level, to improve three aspects of Design Engineering Education: placement, content, and pedagogy. The authors use an inductive problem-based learning method of delivery through open-ended problems inspired from industry, a LEGO Mindstorms robotics kit, a C++ interface, and a 3D printer. The student teams iteratively proceed through four predefined stages, from problem formulation, to conceptual design, to preliminary and detailed design, and finally to design communication.

For student assessment, the authers created a 24 statements survey for their design course, containing eight statements for each of the three considered dimensions: problem-solving, teamwork, and communication. They evaluate the acquisition of expertise and not the skills, by making students take the survey twice, once before and once after the cornerstone design course, so that gains in favorable aptitudes and attitudes can be analyzed based on pre-/post- test scores. This solution is a good implementation of problem-based learning, especially when it comes to student and process assessment, however it is not a technology-based solution even if it deals with Robot Control, because it does not support the engineering design process using advanced technological tools. Moreover, the solution is not appropriate for student teams working from geographically distant locations, and the assessment is only based on subjective methods by asking students to fill in a survey.

In order to teach Systems Engineering fundamentals and to raise interest in STEM education in the United States, Patel et al. [30] proposed a more complete and innovative model that takes the form of a challenge, through an engineering-based product development Capstone project for US K-12 students, and also for Cornerstone undergraduate students. Unlike the previous solution, it is technology-centered and incorporates some key principles of Systems Engineering in the provided teaching model.

The authors implement their teaching model through an Integrated Design and Manufacturing Infrastructure (IDMI). It is essentially based on CATIA V6, a commercial tool from Dassault Systèmes, and employs both virtual resources such as CAD systems, and physical resources such as 3D printers. The solution includes five modules:

- *Introduction to Product Life Cycle Management: using provided video tutorials.*
- *Introduction to Systems Engineering Principles using moderately complex Electro-Mechanical Systems: LEGO Mindstorms*

- *Computer Aided Design: using Dassault Systemes CATIA V6*
- *Additive Manufacturing: using 3D printers and STL files*
- *Collaborative Tools: using SwYm (See What You Mean), Dassault Systemes online social network.*

The solution has been experimented in the Prize Challenge Summer Camp at Georgia, where students went through different stages of a product life cycle: Co-create, Design, Build and Operate, to build a LEGO Mindstorms-based product for the challenge. Compared to other Systems Engineering project-based courses and programs, this solution appears to be the most complete and the most efficient until now, especially with regard to the intergration of technological tools.

2.8 Other Programs

Many other methodologies are used to teach Systems Engineering especially in the United States. Szajnfarber et al. [31] studied some of them and classified them into *Quizzes, Lab Reports, Design Projects, Arduino Projects, Exams, Homework, Labs, Lecture and class discussion, Predominately Exams and a Design Project, Design Challenges, Research Papers, Research Projects, Case Studies.*

3 Project-Based Learning

General Engineering Education was for a long time centered around discipline-related knowledge like Mathematics, Physics or Mechanics. More recently, there has been a significant shift of focus towards softer skills, such as design thinking and systems thinking, as requested by industry [32]. This change in Engineering Education was motivated by employers who expressed their need for engineers who are not only experts in their domains, but also adept communicators, good team members and lifelong learners [12].

According to Dym et al. [12], ”*the currently most-favored pedagogical model for teaching Design is Project Based Learning*”. Despite the differences between design and systems thinking (a core aspect of the Systems Engineering discipline) [33], both Engineering Design and Systems Engineering mostly deal with processes and skills, and not with transferable and fundamental knowledge. Engineering Design is defined as *”a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints.”* [12]. Therefore, we can assume that Project-Based Learning (PBL) is actually the most-favored pedagogical model for both Engineering Design and Systems Engineering Education. According to Khalaf et al. [29], the nature of these disciplines is in inherent alignment with the PBL pedagogy, so PBL is recommended especially for developing analytical and problem-solving skills needed to address multidisciplinary and complex engineering problems.

Most of Systems Engineering Education programs that we presented previously, especially the ones that deal with LEGO or other in-practice situations, make use of PBL as their pedagogical model.

3.1 Inductive Teaching

Traditional *deductive teaching* of Engineering and Science starts with theory and progresses to their applications. The educator typically introduces a topic and explains its general principles, derives mathematical models from these principles, presents illustrative applications, makes students practice on similar applications, and finally tests their acquired knowledge in an exam [34].

In contrast to the deductive teaching approach, *inductive teaching* is about letting and helping students discover and learn theories only after the need to know them. This process is usually started by the educator presenting specific observations, case studies or problems. Some examples of inductive methods are: problem and project-based learning as two different methods, discovery learning, just-in-time teaching, etc. In the context of this paper we are interested in Project-Based Learning, as defined by Prince et al.: *"Project-based learning begins with an assignment to carry out one or more tasks that lead to the production of a final product-a design, a model, a device or a computer simulation. The culmination of the project is normally a written and/or oral report summarizing the procedure used to produce the product and presenting the outcome"* [34].

3.2 Current PBL Challenges

For many researchers and educators, PBL seems to be the most adequate model to teach general engineering, and especially for Systems Engineering. However, this does not mean that PBL is a perfect model that does not suffer from some limits, or that does not need adjustments to be more efficient. It remains some open research questions regarding PBL. Some of them have been identified by Dym et al. [12]

- *What are the best proportions of problems, projects, teamwork, technology, and reality for a given state of student development? In other words, how authentic should PBL experiences be compared to industry design experiences? Some work has begun to emerge in this area, but the answers are not yet definitive.*
- *How do the proportions change with regard to the context of different engineering disciplines and institutional missions?*
- *How should multidisciplinary design-learning teams be managed?*
- *Can a pedagogic framework developed for co-located learning teams be distributed in time and place? If so, how?*
- *How can students be authentically evaluated and graded in design courses with regard to, for example,*
  - *the quality of the design produced vs. the quality of the process demonstrated; and*
  - *individual cognitive development vs. collective team development?*

Along with the next open questions, these PBL challenges, related to Systems Engineering Education, represent the first open question that needs to be considered.

4 Open Research Questions

4.1 Technologies

Special attention to new and disruptive technologies may have a good impact on Systems Engineering Education. As stated by Martin, "*the capabilities and limitations of technology must be considered when developing a systems engineering development environment*" [35].

We have to find the appropriate way to integrate technology into Systems Engineering experiences, by idetifying the advantages of a specific technology and matching it to the specific requirements and problems to solve. Technology should not be used just for the purpose to use technology. A first technology we suggest to consider is Virtual Reality.

According to "The Treaty of Virtual Reality" [36], Virtual Reality (VR) is a technology that allows users to immerse in an artificial reality and to have interactive experiences via sensorimotor channels. In [37], the authors discussed the work of Abulrub et al. [38] who explored the benefits of VR for engineering education and training through a series of case studies at the University of Warwick. The authors showed how VR can encourage the creative learning of engineering material and environments, and concluded that some VR promises for Systems Engineering are: the development of autonomous problem solving skills, the sharing of complex information with team members, and the analysis of engineering problems under different points of view.

In the same work, the authors assumed that "*thanks to its interaction and immersion components that provide the students with a high level of realism and interactivity, VR is a well-suited tool for education and training. It offers a safe, fully controllable and cost-effective learning experience. VR teaches the students how to develop autonomous problem solving skills, and gives the instructor the ability to create realistic learning situations which are difficult, unaffordable or even impossible to set up in a classic learning context*". It has been shown that teaching and training is considerably improved by having the students apply theoretical knowledge to concrete industrial problems using VR technologies. Creativity, innovation, communication, problem solving, team work and business skills can be improved by using VR environments, which offer an unlimited experience on virtualized real-life situations [38]".

Many systems will be connected in future factories (Industry 4.0), and we also suggest to investigate the role of Internet-of-Things (IOT) in Systems Engineering Education. We believe that IoT can be of great assistance by providing, for example, the ability to immerse students in realistic situations, thanks to an IoT architecture adopted by an industrial partner. Coupled with Virtual Reality, the IoT sensor information could be projected on a virtual factory where Systems Engineering students work on virtualized copies of the industrial product.

However, an important point to be beared in mind when creating technological-based learning environments for Systems Engineering is user experience. It needs to be as plain and simple as possible, in order not to add unnecessary cognitive load to the student who is already engaged in the assimilation and application of Systems Engineering processes. Attention should be paid when creating learning processes to not make non-technological students use complex computer tools, like management students manipulating sophisticated CAD applications only for visualization or other simple tasks.

4.2 Standards

The learning methods adopted by most of the programs discussed in this paper focus rather on tools and how to use them, than on the fundamental principles of Systems Engineering. Therefore, systems engineers may perfectly use SysML editors and other related tools, while they do not really know and understand Systems Engineering processes, their goals, their execution or the links between them. The solution to this problem, especially, when the goal is to teach the fundamental concepts of Systems Engineering, may be to consider the use of Systems Engineering standards, such as the most recent 2015 edition of the ISO/IEC/15288 standard [3]. It define a set of processes and associated terminology from an engineering viewpoint. One way on how to use this standard for educational purposes might be to give related materials or lectures to students, and ask them to respect the standard while they realize their own project. However, even if we consider this solution, we still need to find responses to some questions such as: which set of processes can and should be adopted in the learning process? How much detail does the teacher give to the students on how to execute the processes, which tools to use for each process and for each activity and task? How to ensure that the students really pass through the correct processes, the right way and the right time?

4.3 Assessment

Another point that needs specific attention is the ability to efficiently evaluate student work and the acquired knowledge and skills. For that purpose, we suggest four types of assessment which any Systems Engineering Education solution should take into account:

- Result Assessment: Evaluating the quality of the outcome compared to the project requirements (expressed by the teacher or an industrial).
- Execution Assessment: Evaluating how well Systems Engineering Processes (standard or not) have been applied during the project.
- Knowledge Assessment: Evaluating the acquisition of fundamental knowledge on Systems Engineering.
- Skills Assessment: Evaluating the learned soft skills, such as collaboration, communication, team work, etc.

But the remaining question is how to deploy and efficiently apply these criteria, depending on the nature of the project?

5 Conclusion

In this paper, we investigated the main objectives of Systems Engineering Education and presented the current state-of-the-art in this field. We particularly discussed the most suited pedagogical model, which is Project-Based Learning. We also provided some open questions that need further research. This study may be a valuable starting point for educational institutions aiming to create solutions for Systems Engineering Education. It also highlights some challenges that might interest researchers from both educational and engineering sciences. It appears very clearly from this study, that specific effort needs to be dedicated to the subject of students assessment in PBL/Systems Engineering context, and also to facilitate the adoption of Systems Engineering standards and enhancing their roles in Systems Engineering Education solutions.
From our perspective, this survey helped especially in defining the specifications of our future platform for Systems Engineering Education, which is under development. In fact, in order to address the previously cited challenges, we are creating a new Collaborative Platform for Systems Engineering Education. For that, we are using some of the most recent and most disruptive technologies, such as Virtual Reality, Web 3D and Internet of Things. Our solution is a Standard-Based Solution, because the proposed learning scenario is based on Systems Engineering Standard Processes. By doing that, our goal is to make learners use the standardized processes of Systems Engineering, when engineering the requested system in a Systems Engineering learning environment. Also, we aim to be able to assess their acquired knowledge and skills, along with the processes execution quality and the obtained results.

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