A Pedagogical Approach Based on Problem-Based Learning on Aeronautical Engineering Post-Graduation at InstitutoTecnológico de Aeronáutica (ITA)

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ABSTRACT

In the context of the Problem-based Learning, pedagogical interventions were introduced in the course Aerodynamic Applied to Aircraft Design (AA-234) of the post-graduation in aeronautics at Instituto Tecnológico de Aeronáutica (ITA). In this sense, the aim of this study is to describe the pedagogical process in the AA-234 course by using technical-scientific investigations in order to achieve a more efficient learning process. The characteristics of this pedagogical approach were developed in order to exercise the multiple skills and abilities related to technical, critical and teamwork capability. In addition, we intend to show that the characteristics of this pedagogical intervention is appropriate in an educational environment of aircraft design since the high technical ability, critical judgment and multidisciplinary characteristics required for this area becomes the project-based learning a tool extremely effective for aeronautical education.

KEYWORDS: *aircraft design, aerodynamics, aeronautical education, PBL, Active learning*

1 INTRODUCTION

Regarding innovative approaches for new engineering education, the Problem-Based Learning (PBL) appears as learning methodology efficient applied on American universities such as MIT (Massachusetts Institute of Technology). Project Based Learning according to [1] is a teaching and learning approach that causes transformations on education due to require more effort from students and teachers. PBL requires a critical approach when teachers develop their pedagogical activities. Teachers need to push students to an active learning process thus becoming the education more efficient. On the other hand, PBL methodology requires a student´s understanding that it has the main role on its education. This understanding will bring a deeper learning process. In this active education environment, we can say that the main characteristics of the problem-based learning can be described from the following approaches: student at the center of the learning process, development of study groups and interdisciplinary environment.
In the context of the problem-based Learning, pedagogical interventions were introduced in the discipline Aerodynamic Applied to Aircraft Design (AA-234) on the postgraduate course belong to Instituto Tecnológico de Aeronáutica (ITA). The objective of this work is to describe the pedagogical process established in the discipline AA-234 through activities of the technical-scientific investigations that are based on PBL methodology. Additionally, it is intended to show that the learning process characteristics applied on the discipline are desirable to the aeronautical design environment, since the high technical skills, the critical judgment and the multidisciplinary characteristics required by the area make the problem-based learning to be an effective tool for teaching in aeronautics. The course Applied Aerodynamics to Aircraft Design belongs to the set of disciplines offered by the post-graduation of the Instituto Tecnológico de Aeronáutica (ITA). The course aims to bring for graduate students an understanding of aerodynamic phenomena related to aircraft design as well as the practice of solving aerodynamic problems in a real environment of design. In addition, the discipline also pursues to clarify the relationship among aerodynamics and other disciplines such as structures,

loads and flight dynamics facing with several requirements in an multidisciplinary environment of the aeronautical design.
The student profile is established by characteristics that involve the aeronautical technological park in São José dos Campos, Brazil (figure 1). Thus, master and doctoral full-time students in aeronautics attend the discipline. Also, there are students who conduct postgraduate activities at same time with their work activities in aeronautical companies. Most of these students are engineers of the EMBRAER. There are still students who attend the discipline in order to qualify for their activities in the aeronautical industry.

Figure 1: Engineers of the aeronautical industry (EMBRAER) and full-time postgraduate students at ITA.

2 TECHNICAL-SCIENTIFIC INVESTIGATIONS

The pedagogical activities are based on technical-scientific investigations related to the aeronautical design that are of interest of the industry or university. The educational intent is to motivate students through challenging technological problems presenting practical aspects, since they are related to the needs of the industry and the academy. In addition, an approach based on multidisciplinary view and teamwork activities brings to the student a real perception of the aeronautical design. The development of the activities followed two steps:

2.1 Choice of the study subject

The criterion of choice of the subjects for studies was based on current needs of the aeronautical industry and academic research topics in areas of the forefront of the knowledge (figure 2). Thus, the choice of the subjects is a key strategic to motivate students. In addition, some topics developed were related to master and doctoral subjects of students who attended the discipline. Summarizing, the criterion of choice of topics followed three characteristics:

- Research related to forefront of the knowledge
- Research of technological interest for the aeronautical industry.
- Investigations related to master and doctoral subjects of the students.

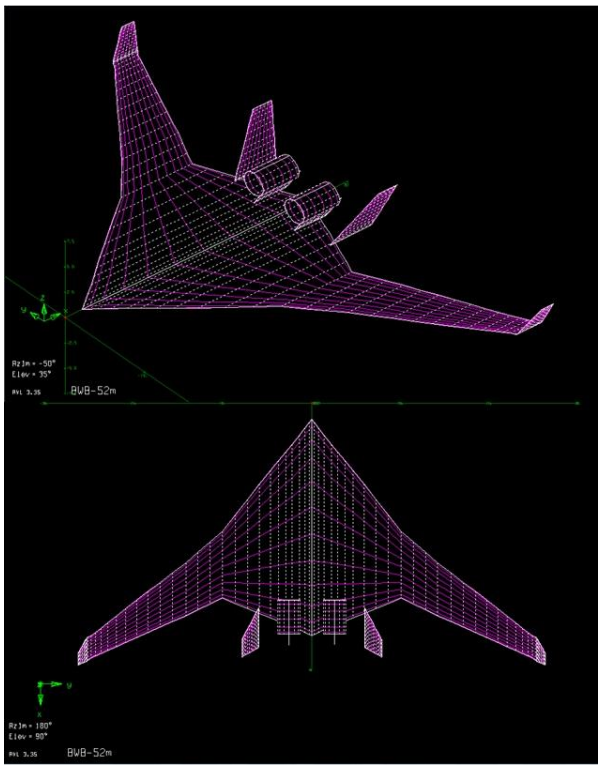

Figure 2: Aerodynamic numerical evaluation of a new concept in aircraft design (flying wing configuration).

Based on criteria previously mentioned, the following subject were established:

- Fuselage layout optimization
- Aerodynamic prediction tool for take-off and landing performance
- Aerodynamic evaluation for box-wing configuration
- Optimization tool for take-off and landing performance
- influence of the wing stiffness on drag and aerodynamic efficiency
- Multidisciplinary evaluation of the technological level of an airfoil
- A tool for excrescence prediction
- A review of innovative aircraft configurations
- Aeroelastic effects on wing aspect ratio

2.2 Pedagogical process

Students were arranged in groups of 4 or 5 members according to a personal affinity related to subjects. Researchers from ITA or engineers from EMBRAER conducted technical support of the studies. The tutors conducted the primarily orientations related to the specific aspects of the tasks, mathematical tools and bibliographic review. The work was divided into two parts: *Development of a*

Scientific-Technical Research and a Scientific Article. After students conduct scientific-technical investigations and discussions of the results, a scientific paper was prepared by each student group in the format of the articles presented in the main Aeronautical Conference performed by The American Institute of Aeronautics and Astronautics (AIAA). After analyzing the articles, the tutors selected work that can potentially be pointed out for the AIAA conference. This indication guaranteed an award score on the final grade as a way to establish an environment of motivation and meritocracy. Figure 3 outlines the arrangement of the pedagogical activities carried out during the scientific-technical research for each student group.

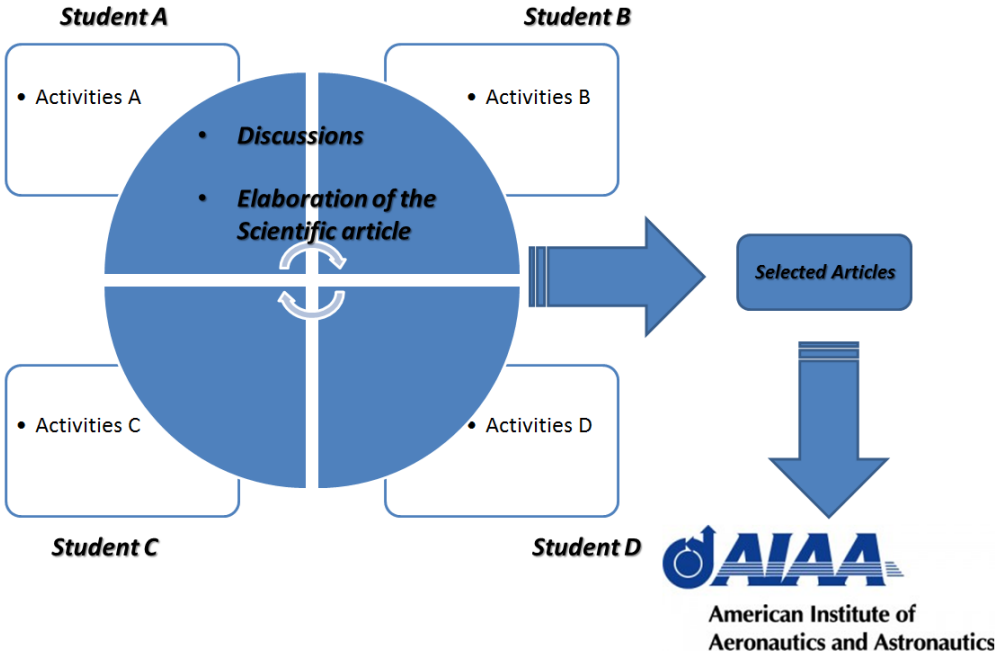

Figure 3: The pedagogical process during activities of the technical-scientific investigations

3 RESULTS

The student groups presented different result levels. Two work related optimization tool for take-off (figure 4) and landing performance and multidisciplinary evaluation of the technological level of an airfoil (figure 5) were chosen to be submitted to AIAA conference where the first one was accepted for presentation on 2017 Aviation AIAA conference . In addition, two more work, fuselage layout optimization and influence of the wing stiffness on drag and aerodynamic efficiency (figure 6 and 7), were accepted for 2017 EUCASS (European Conference for Aeronautics and for Space Science). In addition, the work regarding wing stiffness effect on drag and aerodynamic efficiency was selected during the conference to be a EUCASS journal.

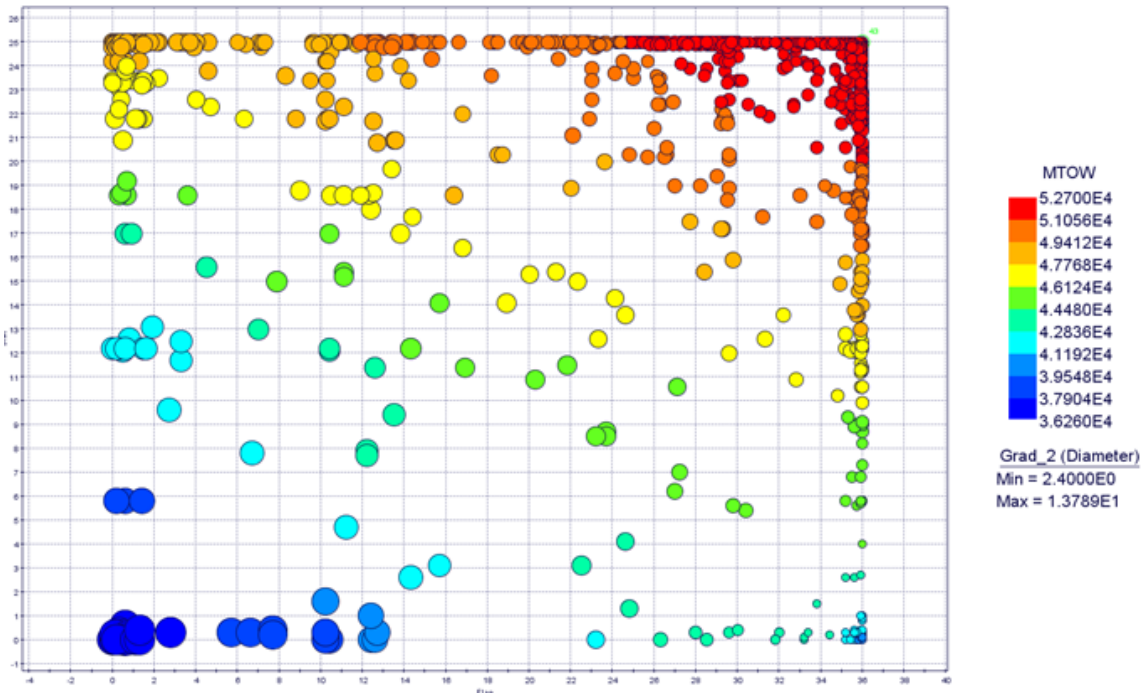

Figure 4: Optimization of the flap and slat position for take-off requirements.

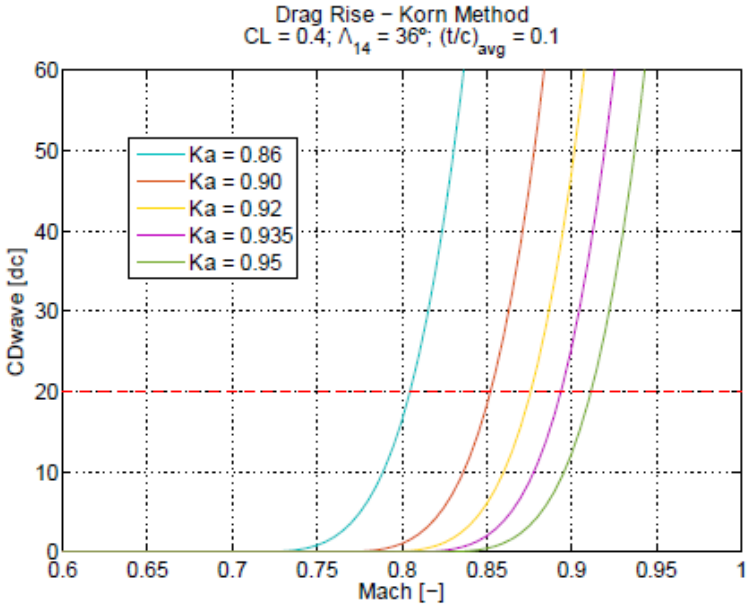

Figure 5: Airfoil technology factor effect on wing drag rise.

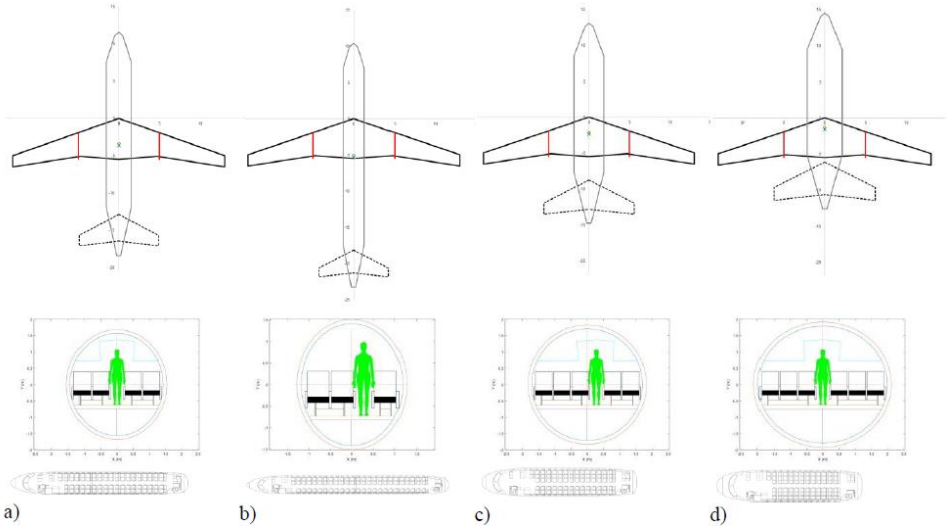

Figure 5: Fuselage layout optimization for EMBRAER 170

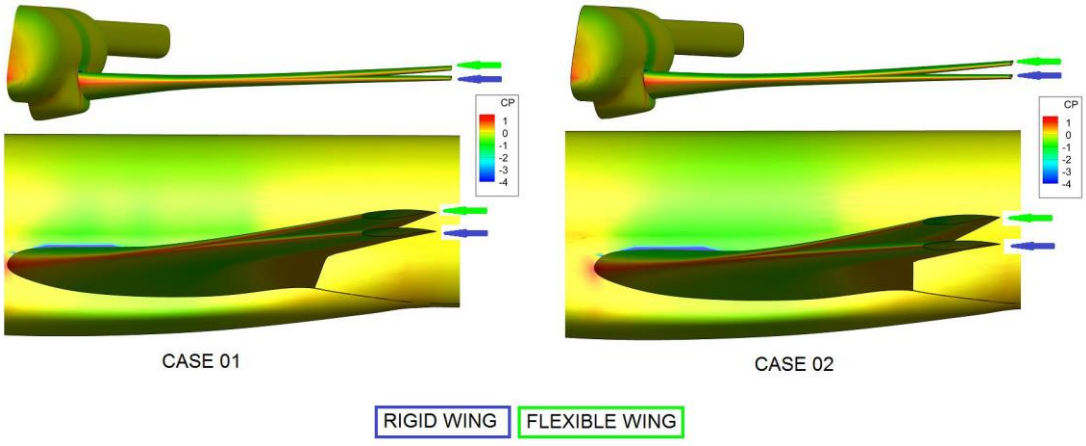

Figure 6: Wing stiffness effect on drag and aerodynamic efficiency.

Independently of the work level, all groups showed strong motivation and interest during the development of the whole task process. The students fill some formularies regarding the evaluation of the pedagogical process that they were submitted. In additional, in some informal talks, they made some comments related to learning process. Thus, follow some remarkable aspects that the students noticed as important learning process:

- Work in group: organization, planning, understanding of the member group skills.

- Academic work rigor: understanding of the several steps of the academic work
- Industrial interest: students working together with engineer from industry realized the specific interest of the industry in technologic problems
- Engineering tools: opportunity to detail with tools of the aeronautical industry environment (CFD software, semi-empirical methodologies, wind tunnel data)
- Active learning: students felt free to develop active learning regarding aerodynamic knowledge, and also they realize the importance of constructing this knowledge by themselves.

4 CONCLUSIONS

The course aerodynamics applied to aircraft design carried out in the post-graduate context of the Instituto Tecnológico de Aeronáutica presents objectives that bring great pedagogical challenges related to the multidisciplinary characteristics of the design, complex concepts of aerodynamics and practical experimentation. In this sense, the PBL methodology applied as pedagogical approaches on discipline AA-234 contributed to the success of the objectives of the discipline. The pedagogical process brought an additional motivation for the students due to develop activities related to the real aircraft design or to advanced research for future technological development. The possibility of developing subject of interest of industry considering issues of multidisciplinary kept a high level of motivation during the activities of the course. Thus, as consequence, a great number of extra-class hours spent for the activities were noticed. In addition, the students also spend many hours with the help of the tutors. The developed knowledge based on a scientific article exercised some aspects of the academic knowledge that must be considered in a postgraduate environment. Finally, some results of the activities in international conferences (AIAA and EUCASS) motivated students to keep their goal in the academic life, and also these results showed the desirable characteristics that scholars need to have to achieve good performance.

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