

# **Implementing a Post-Graduate Industry 4.0 Course A Case Study during COVID-19**

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## **Abstract**

The process of planning and implementing a Post-Graduate course in a Federal Public institution such as IFSP is defined by several procedures and documents that need to be created and validated. The process requires several meetings that would not be able to happen due to the sanitary restrictions imposed by COVID-19. In addition, the courses need to be planned for a new reality of possible prolonged social distancing, full of uncertainty. This paper shows the case study of the of IFSP Sorocaba, the impacts of COVID-19 in the calendar and campus regular activities as well as the efforts of the Professors Collegiate to expedite the process of construction and implementation of a Post-Graduation Course in Industry 4.0 in the current global scenario.

## **Keywords**

Industry 4.0, Engineering Education

### **1. COVID-19 Impacts on Education in Brazil**

One of the first impacts on education in Brazil of COVID-19 was the suspension of classes due to sanitary conditions. This began in February with Law 13.979/2020 (Presidência da República, 2020) and was further officialized by the Education Ministry (MEC – *Ministério da Educação*) on March 17<sup>th</sup> (Ministério da Educação, 2020). The National Education Council (CNE – *Conselho Nacional de Educação*) followed with general instructions on March 18<sup>th</sup> (CNE, 2020) to ensure that the fundamentals of the education system (Presidência da República, 1996) are guaranteed. The situation quickly escalated as in the 20<sup>th</sup> of March our senate declared a Public Health Calamity State (Senado Federal, 2020).

The possibility and regulation for Distance Learning has been discussed and the latest official document was published by MEC in 2019 (Ministério da Educação, 2019). Several other official documents were released in the following weeks with regulations and recommendations for Distance Learning and also the applicability of such programs in Middle School (AGU, 2020), specially concerning laboratory classes and the replacement of those classes for computer simulation. In the specific topic of laboratory classes, the first document released by MEC forbid the exchange of those classes for simulations (Ministério da Educação, 2020b), but IFSP released a document allowing such exchanges (IFSP, 2020), which will enable the planning of “full-distance learning” scenarios.

One of the main impacts of the continued uncertainty that COVID-19 brought combined with the lack of scientific knowledge by the medical community was the delay in which the public teaching institutions had to wait for a more complete understanding not only of the impacts in health security and protocols, but the amount of time the pandemic would take. This also meant change and adaptations in legislation as seen above. Unfortunately, most of these questions are still open and the planning and directives are taken from previous pandemic responses, such as H1N1 (CNE, 2009), and new scientific data and research that are being published.

#### **1.1 Original Calendar for 2020 and the COVID-19 effects**

With all that scenario in place, IFSP publicized *Portaria* 2.337 (IFSP, 2020), an official document allowing the individual campus to take the necessary measures to restart the teaching activities, with the necessary healthy restrictions in place. Since the spread of IFSP campus (as seen in figure 1) are in regions with different impacts and development stages of the pandemic a single solution for the entire institution was not feasible. Another important impact factor is the type of courses that each campus offers, as they are focused on each region designed for the local

development and needs. This feature involves courses with few laboratory classes, such as Administration or Pedagogy, and courses with higher laboratory needs, such as Electronics and Mechanics.

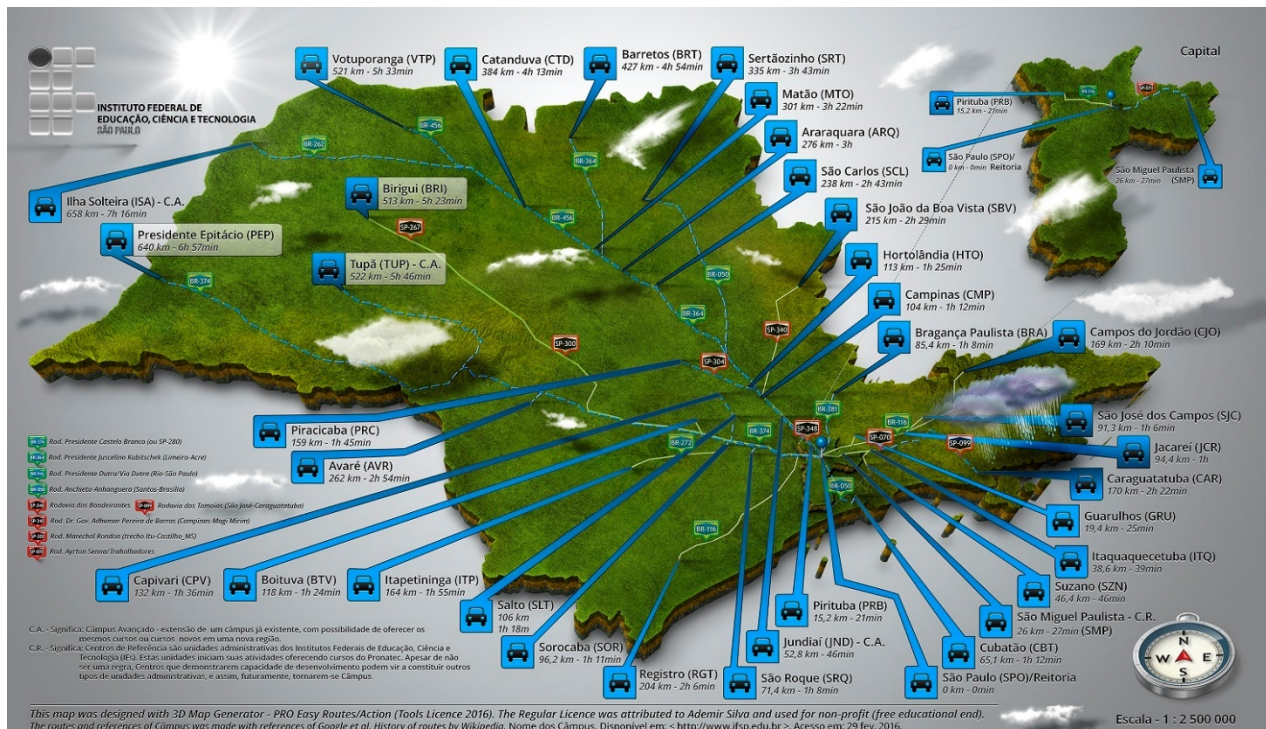


Figure 1 – IFSP Campus distribution in the São Paulo State

With the new regulations in place in June, and the liberty of each campus to adopt a strategy to return to the academic year by following local health situation as well as national recommendations, IFSP Sorocaba Campus approved a new calendar for 2020 in which the outlines are as follows:

- The recess from COVID-19 that started at March 16<sup>th</sup> will end in July 27<sup>th</sup>
- The 1<sup>st</sup> semester of 2020 will resume in July 28<sup>th</sup> 2020 and will end in October 2<sup>nd</sup> 2020
- The 2<sup>nd</sup> semester of 2020 will start in October 14<sup>th</sup> 2020 and will end in January 26<sup>th</sup> 2020.
- From there, mandatory 30 vacation will be implemented before starting the school year of 2021 in March.

This was only made possible by MP934 (Ministério da Educação, 2020c) as our Ministry of Education enabled us to change presence to distance learning and also reduce the number of days (while guaranteeing the content and hours of the courses). The new calendar presents many challenges, as most public institutions do not have the necessary structure to adopt a Distance Learning platform, as well as the students that do not possess the necessary equipment, skills and commitment for a distance learning course.

## 1.2 Original Planning for the Industry Department and the COVID-19 effects

IFSP has a four-year plan for implementing, maintaining and substituting courses. This plan is a joint effort of all the professors of the campus and is consolidated on a global document for all 36 campus of our institution. This plan is called “*Plano de Desenvolvimento Institucional*” (PDI) or Institutional Development Plan (IFSP, 2019). The period in analysis is the 2019-2023. The original planning for the Industry Department of the Sorocaba campus of IFSP, as described on the PDI, is showed below in Table 1:

On the Table, the abbreviations are as follows:

- Level – TEC = Technical; TIM = Technical Integrated with Middle School; GRA = Undergraduate; PGR = Post-Graduate
- Period – N = Night; A = Afternoon; M = Mourning
- Duration – Sem = Semesters

- Situation – R = Regular; N = New course; I = Implementation in progress

Table 1 – Industry Department Course Planning Before COVID-19

Course	Level	Period	Duration	Situation	Number of Enrolling Students				
					2019	2020	2021	2022	2023
Electronics	TEC	N	4 Sem.	R	80	80	80	80	80
Mechatronics	TEC	A	4 Sem.	R	80	40	40	40	40
Mechanics	TEC	A	4 Sem.	N	-	40	40	40	40
Electronics	TIM	M	4 Years	I	40	40	40	40	40
Renewable Energies	GRA	N	6 Sem.	N	-	-	-	40	40
Industry 4.0	PGR	N	3 Sem.	N	-	-	-	-	40

This planning accounted for several criteria, such as classroom availability (either standard or laboratories) as well as the continuous growth of the campus and the possibility of continuous study, one of the pillars of IFSP. The philosophy of continuous study is that a student that enrolls in a technical course can go as far as a Post-Graduate degree in the Sorocaba campus and also apply for Masters or Doctorate in other campuses. 3 new courses would be implemented between 2019 and 2023 – The Technical Course of Mechanics (2020), The Undergraduate course of Renewable Energies (2022) and the Post-Graduate course of Industry 4.0 (2023). The Post-Graduate course of Industry 4.0 is a specialization course, with 360 hours spread in 3 semesters.

The Electronics courses are the longest and more stable of the Industry Department, with the night course already going in for the 10<sup>th</sup> consecutive enrollment cycle in the second semester of 2020 with a semesterly enrollment of 40 students. The Electronics Technical Integrated with Middle School yearly course is now on the 2<sup>nd</sup> enrollment cycle and should become a regular course with all 4 years in 2022. Apart from them, we currently hold a semesterly enrolment of 40 students in the Mechatronics Technical course, but that was planned to be changed to a yearly enrolment of 40 students since the Technical course in Mechanics was planned for the second semester of 2020, with the campus the enrollment of 40. Mechanics and Mechatronics would alter enrollment, one in the first and the other in the second semester respectively.

The Renewable Energies Undergraduate program was proposed for 2022, and according to the structure of the internal Professors Collegiate, there are still modifications needed and new planning for the COVID-19 effects, with the possibility of an early enrollment with Distance Learning for the more theoretical subjects.

The Mechanics Technical is postponed until further notice, since it relies greatly on practical work since the first semester and the sanitary conditions of Sorocaba will not allow it. Finally, the Industry 4.0 Post-graduate program has been advanced, with work beginning just after the March class suspension. The Professors Collegiate believe the course can begin in the second semester 2021 pending the approvals mentioned before and detailed in section 2 below. There is also great uncertainty as to the real possibility of enrollment for the 2<sup>nd</sup> semester of 2020, since it will begin in October due to the Calendar changes described before. With these changes, the new plan is described in Table 2 below:

Table 2 – Industry Department Course Planning After COVID-19

Course	Level	Period	Duration	Situation	Number of Enrolling Students				
					2019	2020	2021	2022	2023
Electronics	TEC	N	4 Sem.	R	80	40	80	80	80
Mechatronics	TEC	A	4 Sem.	R	80	40	80	80	80
Mechanics	TEC	A	4 Sem.	N	-	-	-	-	-
Electronics	TIM	M	4 Years	I	40	40	40	40	40
Renewable Energies	GRA	N	6 Sem.	N	-	-	40	40	40
Industry 4.0	PGR	N	3 Sem.	N	-	-	40	40	80

## **2 Processes for Planning and approving a new Post-Graduate course in IFSP**

As a public institution, IFSP can only implement courses that are relevant and demanded by the local region. To achieve this goal IFSP holds public consultations regularly to access the need to implement new courses, maintain the existing ones or even discontinue courses that are not needed or did not have the demand for enrollment met. This public consult is one of the main drives of the PDI. Only courses that appear on the PDI are eligible to be planned and implemented.

Once a course is eligible, the process of implementing a new Post-Graduate course in IFSP was set by Normative Instruction 01/2017 (IFSP, 2017) from the Post-Graduation Department of our Research Pro-Rectorate (PRP- *Pró-reitora de Pesquisa*) which refers to the legislation that designed and implemented the Federal Technical Education Structure (Presidência da República, 2008). The process is divided in two parts: 1) Submission and 2) Validation and Approval.

The Submission is performed by sending a collection of documents to the PRP: A. the Course's Pedagogical Project; B. the impact of the new course, in terms of hours of class and professors needed as well as school's staff; C. the Professors Collegiate designation for the specific purpose of implementation of the new course; D. a Technical-Pedagogical analysis; E. approval of the Course's Pedagogical Project by the Campus Council.

Of the steps mentioned, the construction of the Course's Pedagogical Project<sup>1</sup> is by far the most important one as it is the one that supports the complete initiative, posing as the backbone that supports all remaining work. This document contains several information regarding the campus, the implementation justification and objectives of the course, the targeted graduate student, the profile of the professional that successfully concludes the course, the curriculum and individual subject objectives and content, the infrastructure needed and the profile of the professors for the subjects that are being offered.

The Validation and Approval is performed by the PRP in two phases: firstly the Research, Innovation and Post-Graduation Council (CONPIP – *Conselho de Pesquisa, Inovação e Pós-Graduação*) will issue a vote to approve the new course based on the presentation by one of the Professors Collegiate of Course's Pedagogical Project, 2 specialist reviews and the President's Council recommendation. If approved the process is then submitted to the Superior Council (CONSUP – *Conselho Superior*) for voting and approving. CONUSP is the highest council organization in our structure with representative from professors, students and outside community and is responsible for the directives of the entire institution.

## **3 Planning for Industry 4.0 Post-Graduate Course during COVID-19**

As a direct result of the calendar and planning changes due to COVID-19 described in section 1.2 and the before mentioned laws and regulations, since March 16<sup>th</sup> the professors of IFSP were unable to perform lectures and any activities related to teaching. In this time, the professors took more research and extension projects, as well as new administrative activities that were being postponed due to other calendar conflicts. Most of the activities were directed in efforts to present a new plan and new strategies for distance learning for when the semester would resume. An opportunity presented itself to begin planning and executing all the necessary steps to implement the courses in the industry department. In this effort, in March 3<sup>rd</sup> the Professors Collegiate was formed and began the work to plan a course during the COVID-19 pandemic.

With 2 weekly hours being used, the Professors Collegiate for the Industry 4.0 course began its work to define several of the topics necessary to implement the Course's Pedagogical Project. Because of the healthy regulations, local meetings were transformed into digital and thus, every 2 weeks a meeting was held to check for the status of the milestones in planning as well as the necessary group discussions.

Since IFSP is a federal public school, additional steps are necessary to implement any new course as there is a need to prove the necessity and the availability of professors in the campus with knowledge for the new course as describe in section 2. Since the PDI (IFSP, 2019) had a prevision for the course, several steps were already taken and approved

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<sup>1</sup> A complete document can be accessed at [https://prp.ifsp.edu.br/images/arquivos/PosGraduacao/Modelo\\_de\\_PPC\\_Lato\\_Sensu\\_vers%C3%A3o\\_final\\_30-01-2020.docx](https://prp.ifsp.edu.br/images/arquivos/PosGraduacao/Modelo_de_PPC_Lato_Sensu_vers%C3%A3o_final_30-01-2020.docx)



before the COVID-19 pandemic. This allowed the Professors Collegiate to begin work immediately after designated by the school's Director. A Public consult was already made to determine the need for the course in Sorocaba and the justification of the course.

### 3.1 Professors Collegiate Results

As a direct result of the work performed in these 3 months, the Collegiate was able to finalize several steps of the planning process in the construction of the Course's Pedagogical Project, reaching a status that enables the proposed enrollment of 40 students in the second semester of 2021 as it is estimated that by the end of October all the necessary steps to construct and approve in the Sorocaba Campus will be done finishing the "Submission" part of the process. Currently 14 topics have been completed on the Course's Pedagogical Project (out of the 18).

The first important decision was to establish the profile of the professional that successfully concludes the course. For this step a benchmarking strategy was utilized with both local prospecting of Industry 4.0 courses in both private and public institutions as well as international papers such as dos Santos and Lordelo (2019), Badiru (2020), Laila et al. (2020) and Ekren and Kumar (2020). At the end of the process the profile was defined as:

*The profile is described as: The Specialist in Industry 4.0 will be able to act as a manager and/or implementation of systems and technology in the areas of process, project and manufacturing as well as other areas and related technologies of Industry 4.0.*

The profile mentioned describes a more hands-on professional, and thus new challenges are presented on the COVID-19 healthy protocols as laboratory classes are more complicated to be planned and executed. With this in mind several papers were consulted to verify the possibilities of distance learning, such as Sulaiman (2019). The decision of the Collegiate is that, by allowing the course to start in the 2<sup>nd</sup> semester of 2021 we will have enough time to establish the necessary health protocols to allow classes to be resumed and allow for adaptations if necessary in this very uncertain and volatile scenario.

SUBJECTS	Code	Theory / Practical	Weekly classes per semester			Total Classes	Total Hours
			1º	2º	3º		
Introduction and Fundamentals of Industry 4.0	IFII1	T	2			40	33,3
Lean, Innovation and Design Thinking	GIDI1	T	2			40	33,3
Systems Programming and Integration	PISI1	P	4			80	66,7
<b>SubTotal :</b>			8			160	133,3
IoT / IIOT / IoS	ICSI2	T		1		20	16,7
Production Management / Smart Factory	SGPI2	T		1		20	16,7
Additive Manufacturing and Prototyping	FMAI2	P		2		40	33,3
Robotics	ROBI2	P		4		80	66,7
<b>SubTotal :</b>				8		160	133,3
Maintenance and Reliability 4.0	CEMI3	T			2	40	33,3
Artificial Intelligence and Augmented Reality	IARI3	P			2	40	33,3
Scientific Project Writing and Practical Applications	ECPI3	P			2	40	33,3
<b>SubTotal :</b>					6	120	100,0
<b>Total :</b>			8	8	6	440	366,7

Figure 2 – Proposed Curriculum

After defining the profile, the next step was establishing the curriculum of the course. Even though the planning took place during the pandemic, the Collegiate decided for a curriculum that should not be based on the limitation of virtual classrooms, but an approach that would allow both scenarios with little adaptation. The final curriculum proposal was

presented and validated in a virtual Industry Department meeting in June as illustrated in Figure 2 above. Not only the subjects themselves but the objectives and content of each of them were presented and validated.

The Collegiate also determined the impact that the curriculum matrix and the new proposed enrollment cycle would have in the following semesters. The proposed enrollment cycle (as shown in Table 3) also allowed for a softer impact on class hours in the first 2 years displayed.

Table 3 – Enrollment Cycle active Semesters

Period	1 <sup>st</sup> Semester	2 <sup>nd</sup> Semester	3 <sup>rd</sup> Semester
2021-2	X		
2022-1		X	
2022-2	X		X
2023-1	X	X	
2023-2	X	X	X

With the enrollment cycle established, it was possible to determine the Manpower by specialty needed to properly support the subjects. The result is shown in Figure 3. Since most of the theoretical courses (IFII1, GIDI1, ICSI2, SGPI2 and CEMI3) are planned to be offered in Distance Learning, regardless of the sanitary regulations allowing classes to naturally resume, the impact on structure can be greatly diminished. Despite that, the plan does show the number or “regular classrooms” that would be needed should the lecturer opt for it, as displayed in figure 4. Considering the present capacity of manpower and structure in the campus can be achieved without the necessity of new additions to the teaching staff or laboratories.

Specialty	Cumulative Classes				
	2021-2	2022-1	2022-2	2023-1	2023-2
Standard Classrooms	4	-	4	4	6
Industrial	4	1	4	5	5
Network	-	1	-	1	1
Automation	-	6	4	6	8
Other	-	-	2	-	2
<b>Total</b>	<b>8</b>	<b>8</b>	<b>14</b>	<b>16</b>	<b>22</b>

Figure 3 – Manpower Needs

Specialty	Classes / Laboratory Hours				
	2021-2	2022-1	2022-2	2023-1	2023-2
Standard Classrooms	4	1	8	5	9
PLC Lab	4	-	4	4	4
Robotics Lab	-	6	-	6	6
Computer Lab	-	1	2	1	3
<b>Total</b>	<b>8</b>	<b>8</b>	<b>14</b>	<b>16</b>	<b>22</b>

Figure 4 – Classroom Needs

A contingency plan was also drawn in the event that by July 2021 “normal” teaching can’t be resumed. All Theoretical subjects will be taught first, in a distance learning platform (such as Moodle). This will allow for a complete semester to be taught in distance learning with the subjects of IFII1, GIDI1, ICSI2, SGPI2 and CEMI3. The contingency plan also impacts on the number of enrollments offered in 2022 of 40, allowing a bigger adjustment if necessary. For the practical subjects, the amount of Theory/Practical activities is currently under review and will allow for a partial conclusion of the subjects pending only the in-Laboratory activities as allowed by the current IFSP COVID-19 specific

regulations. Professors of those practical subjects have been oriented to devise plans that will allow more simulation and asynchronous activities.

The Professors Collegiate, with the joint effort of the Research Group in Industry 4.0, also began and implemented during the COVID-19 pandemic a series of monthly online live webinar lectures, called “Series 4.0 in 40”. The series was devised to acquire data for attendance in an online platform as well as generating awareness of the change in planning for the course. The series has had 3 presentations so far with over 100 subscribed followers from academia, students and professionals in industry.

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## Biography

**Vitor M. Caldana** began his academic career with a technician course in Electronics from Liceu de Artes e Ofícios (1999) followed by an undergraduate degree in Electronic Engineering from Universidade Presbiteriana Mackenzie in 2004. In 2016, finished his Masters (M.Sc.) course in Industrial Engineering. From 1999 until 2016, worked at Caltronic Automação Industrial, a service-based company in Brazil that represents American and European automation equipment. His last position at the company was Service and Projects Manager. Was responsible for managing not only Brazil but the whole of South America, with services performed also in USA and China. During his professional career in the Industry, took several courses in USA and Europe in Automation and dedicated equipment maintenance. In 2014 began his teaching career in FIEB as a substitute teacher for the Electronics Technical Course. In 2016 left the industry for full-time dedication to teach, moving to IFSP to implement the Electronics Technical Course in the city of Sorocaba and has been engaged with this project since, teaching a variety of subjects in electronics. In 2018 began his Research Group in Industry 4.0 and in 2019 was nominated to the Global Council of IEOM representing South America.