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Interview

FROM ACADEMIA TO INDUSTRY: A JOURNEY OF INNOVATION IN CHEMICAL ENGINEERING - INTERVIEW WITH PROFESSOR FERNANDO LUIZ PELLEGRINI PESSOA. ENGLISH VERSION

Dr. Fernando Luiz Pellegrini Pessoa
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SCAN ME

NOTE: Transcript and translation version 1.0.

Dear friends, the interview transcription was done by machine and later reviewed. We are aware that there are imperfections. If you would like to collaborate with improvements, please contact us at southbchem@gmail.com.

https://youtu.be/4Htl-8W8Crw?si=R81XKOu5VqG3nMJO

ABSTRACT

Background: The interview with Professor Dr. Fernando Luiz Pellegrini Pessoa covers his extensive career and contributions to chemical engineering, focusing on innovations and sustainability. **Objectives**: To explore Professor Pellegrini's experiences in various areas of chemical engineering, including teaching methods, research in supercritical extraction, biodiesel production, and process intensification. **Methods**: Semi-structured interview addressing topics such as academic and industrial career, teaching methods, ongoing research, and future perspectives for the chemical industry. **Results**: Professor Pellegrini highlighted the importance of practical application of theoretical knowledge, the development of the Water Source Diagram method, advances in supercritical extraction and biodiesel production, and the need for process intensification in the industry. **Discussion**: The interview revealed the importance of integration between academia and industry, the need for teaching methods that facilitate learning, and the challenges in implementing sustainable and efficient technologies in the chemical industry. **Conclusion**: Professor Pellegrini emphasizes the importance of process intensification and sustainability in the evolution of the chemical industry. He highlights the need for greater collaboration between academia and industry to address future challenges and implement innovative solutions.

Keywords: *Chemical Engineering, Process Intensification, Supercritical Fluids, Water Source Diagram, Industrial Sustainability.*

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Interviewer: Today, we have the honor of talking with Professor Dr. Fernando Luiz Pellegrini Pessoa. Professor, could you give us a brief presentation of your career?

Dr. Fernando Luiz Pellegrini Pessoa.

Prof. Pellegrini: I consider my career as starting 17 years ago, teaching at a college entrance exam prep course. Actually, I used to set up the courses and call first-year students. I was in my second year of scientific studies at that time, so I would call eighth-grade students to earn some money. That's when I really fell in love with academia.

I took the college entrance exam - in my time it was called vestibular - and got into Chemical Engineering at UFBA (Federal University of Bahia). I studied Chemical Engineering, took the Petrobras course, but asked to leave to avoid being tied to a job at the company. I went to do my master's at COPPE/UFRJ. After completing the credits, I joined UFBA in a large FINEP project with UFBA and, at the time, COPENE (now Braskem) for simulator development.

I stayed at UFBA for three and a half years teaching, developing research, and even became coordinator of this project for 2 years. After this period, I asked to leave this research part. I hadn't finished my master's because you get involved in many activities.

In 1986, I started a consulting and software development company. This company got two projects, but a colleague preferred to go to Rio, so we closed the company and I joined the Petrochemical Complex, where I worked for 5 and a half to 6 years. It was at what is now Braskem Vinyls, it was Camaçari Petrochemical Company, producing polyvinyl chloride (PVC). I worked a lot in the vinyl monochloride optimization area. We managed to save 2 million dollars per year by optimizing the entire process.

I did my doctorate in thermodynamics. I worked with the Danish team, the inventors of UNIFAC, Rasmussen and Fredenslund (UNIquac Functional-group Activity Coefficients). I spent 1 and a half years in Denmark. I returned to the company, resigned because I wanted to enter academic life.

I applied for three different positions: UFRJ (Federal University of Rio de Janeiro) in process engineering, UFF (Fluminense Federal University) in biotechnology, and at Rural Rio de Janeiro (UFRRJ) in transport phenomena. The UFRJ competition happened first, I passed and worked there for 28, 29 years. I left as a full professor.

Over this time, I have participated in various projects. Today I have around 160 students who have completed their master's and doctoral degrees under my supervision. This is a milestone that I consider important, as the main objective is to educate people. I hope to reach 200. Just over 40 to go. If I continue at this pace, it will take another 10-15 years. My goal is to stop at 85 years old, and then just focus on writing books.

At UFRJ, I have many articles published in journals and conferences. I don't even count conference papers anymore, there are over 600 works. In journals, there must be around 200. I'm not sure exactly, my students keep track of that. I have a student who manages this control for me, receiving a small scholarship that I pay for personally.

Then I retired. A rule came out here in Brazil where the sum of your working time, INSS (Social Security) time, with your age above 90 years, a rule that came out right at the beginning. Since I started signing my work papers early, I added it up and decided it was time for a change. I went on to apply for visiting professor positions. I was approved at both UFBA and the Federal University of Pernambuco.

Since my family is all from Salvador, Bahia, I ended up returning to Salvador. During one of these visits, I was already approved at UFBA (Federal University of Bahia), and had chosen to stay at the Federal University of Bahia, which is my homeland. Then CIMATEC came along. Someone invited me to talk with CIMATEC's board. I was enchanted by their ideas, which were quite different from the Federal University. At CIMATEC, besides doing basic research, the main objective is to direct results straight to industry. It's much more applied research, it doesn't stay on the shelf, you have to apply it. SENAI CIMATEC is made for industries.

I've been a full professor here for 7 years. We have doctoral and master's programs. Two years ago, we managed to raise our doctoral program to grade 6. It was 5, so now it's a program of excellence. We have good students and the good thing is that everything we do must be applied. What we say is that it has to reach technological maturity, or TRL (Technology Readiness Level), around 8-9. That's the objective.

Technology Readiness Level: Originally developed by NASA and is now widely used in various fields.

The scale goes from 1 to 9, where:

TRL 1: Basic principles observed and reported
TRL 2: Technology concept formulated
TRL 3: Experimental proof of concept
TRL 4: Technology validation in laboratory environment
TRL 5: Technology validation in relevant environment
TRL 6: Demonstration in relevant environment
TRL 7: Prototype demonstration in operational environment
TRL 8: Complete system qualified
TRL 9: Actual system proven in operational environment

In context, when "TRL 8-9" is mentioned, it means the goal is to reach a level where the technology is practically ready for commercial use or real implementation, with the system already tested, qualified and proven in an operational environment.

***Interviewer*:** Professor, before we begin our interview properly, I need to make some announcements:

1. Our interview will be made available under a Creative Commons license;
2. The Portuguese transcription will be published by Thcê Química Journal, and the English version in the Southern Journal of Sciences. We will also make our video available to a local television station;
3. The estimated duration of our interview is approximately 45 minutes;
4. I am not a professional reporter.

Professor, starting our questions: You have had quite a diverse career, encompassing both academic work and industry experience. How has this combination of experiences shaped your approach to engineering education and research?

Prof. Pellegrini: That made things much easier, because I have certain preferred subjects or lines of work: thermodynamics and process engineering or process systems engineering. I have this large number of students who have defended their theses because when I teach, I present cases from my industry experience. I say: "I applied thermodynamics to this. Just by using phase equilibrium, I studied and achieved savings of X thousand reais." In systems and process engineering, I show how I optimized certain processes.

I show practical cases where I applied all the theory. That's why students like to choose me as their advisor. They have that idea: "Now that I'm going to study all this theory, where will I apply it?" This helped me a lot, including focusing on industrial problems. Whenever I take material to study or review, or an article, I think: "How will I apply this industrially? How will I apply this in practice?"

This makes it easier to structure a class. I review my classes every semester. People even joke: "Professor, you've been teaching for 40 years, why do you need to review?" I answer: "I review because there are new things, new subjects." There are thermodynamic studies that I can apply, for example, to healthcare. Sometimes I give examples applying it to cataract eye drops. I keep updating myself on the practical applications of these areas.

This changes both the way of thinking and

advising. All the theses and dissertations I supervise always have a chapter on practical application. When it's basic research, we indicate: "Look, this here can lead to that." When it's applied research, I show a real industrial case.

***Interviewer*:** As a professor at SENAI CIMATEC (National Industrial Learning Service - Integrated Manufacturing and Technology Center), what innovative teaching methods have you implemented to prepare students for evolving challenges in chemical engineering?

Prof. Pellegrini: Actually, I haven't studied any of these innovative methods that have appeared. I've been doing it more or less the same way since I started. I really liked working from a specific project, a theme. For example, in the thermodynamics class at UFRJ, which has four courses in the School of Chemistry - Food Engineering, Bioprocess Engineering, Industrial Chemistry, and Chemical Engineering - I would divide the class into these four areas and start by offering a project to the groups. In healthcare, thermodynamics applied to bioprocess engineering, protein purification. The entire course was discussed based on these projects.

Today I really enjoy teaching online. For some subjects, especially when it's a lecture, it works well. For some classes, I always like to have a part that's deduction, and then I prefer the classroom and the board. I'm still old school, I like to put my derivatives and integrals on the board.

I tell students: "Every course we teach, whether master's or doctorate, has an informative part and a formative part." The formative part is fundamental. I push students to study, but I always say on the first day of class: "My concern is to give a good class and be available for you to discuss with me, but the concern to study is yours."

I give my example: my Chemical Engineering course didn't have Mass Transfer. When I went to do my master's and doctorate, as I leaned towards thermodynamics and process engineering, I only had the basic course. Today I have several Mass Transfer books because I always need to study when a project in this area comes up.

I recommend my students to study Paulo Freire, because his idea about literacy can be applied in the classroom, bringing the classroom environment and adapting the class to that environment for them to learn more. And also Augusto Boal, with the Theatre of the Oppressed, who made the audience part of the play.

***Interviewer*:** Professor, you were recognized as a level 1A researcher by CNPq. What advice would you give to young researchers who aspire to reach this level of excellence?

Note: CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) is Brazil's National Council for Scientific and Technological Development, and level 1A is the highest classification for researchers in Brazil's research productivity fellowship system.

Prof. Pellegrini: This is a question I could answer in either a beautiful or pragmatic way. The pragmatic way is to follow the rules. CNPq just released new rules this week. There won't be researcher 1A anymore, it will be researcher A, B, and C. The rules are very clear and well-defined. Each committee adapts their ideas. Being pragmatic means following that because you want to get the grant. It's about having so many publications in high impact factor journals.

I have a former student, now an excellent researcher recognized worldwide, who was pragmatic. He followed all the rules and achieved what no one had. But I never did that. I simply said: "It's a consequence." I'm very utopian indeed, I really like to dream. I said: "I'm going to publish, I'm going to do what is my obligation, which was paid for by the government."

Since I received government grants during my master's, doctorate, and post-doctorate, I have to give back to society. I didn't care much about the pragmatic aspect. I really enjoy teaching classes and giving lectures. My main function is to educate students. And my research helps me prepare my classes, because without it I can't have knowledge, be at the state of the art to be able to give a good class.

***Interviewer*:** Your work in supercritical fluid extraction has been extensive. Could you highlight a breakthrough moment in this research that particularly excited you?

Note: This is a technical question specifically about supercritical fluid extraction, which is an important separation technique in chemical engineering where substances are extracted using supercritical fluids (substances above their critical temperature and pressure).

Imagem: Laboratório para extração com fluido supercrítico.
Fonte da imagem: gerada por IA em runwayml.com.

Prof. Pellegrini: The moment was my first doctoral supervision, of who is now Professor Silvio Vieira de Melo. It was right after I joined UFRJ. When I left Salvador definitively, I was working in petrochemicals. When I arrived in Rio, there was none of that. Today there's pre-salt, but there wasn't at that time.

Since I passed the process engineering competition, after extensive research, I realized I needed to apply it to natural products. I surveyed what was available in the Rio region that I could add value to. At the time, Professor Maria Ângela Meireles from UNICAMP was who first started working with supercritical extraction in Brazil. She had the experimental part, being from food engineering. I told Silvio: "Let's work on the process engineering part focused on supercritical extraction."

Supercritical extraction is used today to purify, extract various pharmaceuticals, various biomolecules in pure form. For pharmaceuticals, you need to have 99.9999% purity, and supercritical fluid can provide that purity. Then came the oil deasphaltation part, using supercritical propane along with CO_2.

With pre-salt, where you get up to 80% CO_2 in the fields, all supercritical at 700 bar pressure and 100-120°C temperature, a corrosion problem emerged. The supercritical fluid, especially CO_2, when it reaches this condition, the dielectric constant, which is practically zero at ambient conditions, goes to 78, close to that of water. If water at this level can dissociate salts, CO_2 can too, causing corrosion.

Today I continue working with supercritical fluid. At CIMATEC, I support the food group in this area. We have a small equipment, but we can see the extraction curve and do scaling. It has a future mainly because CO_2 is a green solvent. In the future, CO_2 capture for use as a supercritical fluid will be important.

In the Amazon, for example, there are places where 3 to 4 liters of diesel are spent for people in the community to use 1 liter of diesel. If you make a well-structured biorefinery, looking at the environment, you can extract high value-added products from the Amazon rainforest and produce biofuel with the residue, adding value to that population without harming the environment..

***Interviewer*:** The Water Sources Diagram method that you developed seems crucial for water management. How do you see this tool evolving to address future water scarcity challenges?

Note: The "Diagrama de Fontes de Água" (Water Sources Diagram) is a systematic method for water and wastewater minimization in industrial processes, particularly important for sustainable water management in industries.

Imagem: Representação de uma biorrefinaria.
Fonte da imagem: gerada por IA em ideogram.ai.

Prof. Pellegrini: It was an interesting method, based on water Pinch theory. When we tried to apply it to multicontaminants, it didn't work. I talked with Professor Zempieri from UNICAMP, who did his doctorate with Linnhoff's group at UMIST. He confirmed that it really didn't work.

The method emerged when I had a student I was advising. A paper came out from Professor Henrique Matos from Instituto Superior Técnico giving an idea. My student started: "If I do it this way, it works." At the time, I was on medical leave, and I started developing the method.

We began applying it in various industries: paper, petrochemical, among others. Regarding water scarcity, industry consumes a large amount of potable water. The energy transition in Brazil has to go through an increase in energy efficiency of the Brazilian technological park. We need to optimize what we have, as the cost will be much lower with this optimization.

When we talk about water, energy is involved. When we optimize, we already contribute to decarbonization. We are trying to develop a computer program for the Water Sources Diagram. We already have two master's dissertations that developed versions in Excel VBA and C++, but we want something professional.

***Interviewer*:** How do you see the chemical industry evolving in the next decade to meet sustainability goals?

Note: This question addresses the future direction of the chemical industry in relation to environmental sustainability and climate change mitigation targets.

Prof. Pellegrini: First, industry has to believe in process intensification. The method I like is the one developed in Denmark, at the University of Lyngby. It analyzes the entire process flowchart, breaks it down into equipment, looks at the function of each one and the phenomena involved.

The goal of intensification today is to minimize environmental impact, reduce plant size while maintaining the same nominal capacity - reducing CAPEX (Capital Expenditure) and OPEX (Operational Expenditure) - and improve social impact. At CIMATEC, we're working with social metrics, because each region has its own characteristics.

One problem is that even within academia, many colleagues don't believe in intensification or don't know about it. If the academic community itself doesn't believe in it, how will this knowledge be passed on to industry? It's a relatively small community.

I had an interesting experience in a roundtable with a foreign oil company director. When I presented about thermodynamics, she said that "enthalpy and entropy were useless." I explained that these concepts are fundamental even in management. When I asked if she would apply academic knowledge in her home country without the requirement of special participation, she was honest: "I wouldn't apply it."

At SENAI CIMATEC, we have a different approach. When a project comes up, it goes through a team specialized in negotiation. Before, at the university, I used to charge very low fees. Once I charged R$ 37,000 for an energy integration project that an English company later revealed they had charged R$ 460,000 for.

***Interviewer*:** On behalf of the Second Southern Scientific Conference, I would like to express our sincere gratitude for your participation and for sharing your valuable knowledge and experiences with us. Your contribution is extremely important for the advancement of

Science and Technology in our region and in our country.

Prof. Pellegrini: Thank you. It was very good. I talked about many things that I haven't talked about in a long time. People even joke that I'm a hermit, that I just stay studying, but I do other things, I like cinema. It was a pleasure to participate.

***Interviewer*:** Thank you, Professor. Have a good day.

Prof. Pellegrini: Good day to you too.

Help with definitions:

***CAPEX** (Capital Expenditure):*

Refers to expenses that a company makes to acquire, improve, or maintain long-term physical assets, such as properties, equipment, or infrastructure.

Main characteristics:
· These are investments that generally bring benefits over time.
· Include purchases of machinery, factory construction, land acquisition, among others.
· Typically, these expenses are recorded on the balance sheet as assets and are depreciated or amortized over time.

Example:

Purchasing new machinery for a factory or constructing a new office.

***OPEX** (Operational Expenditure):*

Refers to costs related to a company's daily operations, such as salaries, rent, and utility bills.

Main characteristics:
· These are recurring expenses necessary to keep operations running.
· Include expenses such as maintenance, raw materials, energy, software licenses (SaaS), and marketing costs.
· Typically, these expenses are recorded in the income statement and directly impact profit in the period they occur.

Example:

Payment of electricity bills or maintenance of existing equipment.

DECLARAÇÕES

1. Limitações: A entrevista limita-se ao seu conteúdo.

2. Fonte de financiamento: O anfitrião financiou esta entrevista.

3. Conflitos de interesses: O anfitrião trabalha para a revista há muitos anos e isso pode ter influenciado a entrevista.

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