RESEARCH AND TEACHING STATEMENT

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1 A RESEARCH VISION ON SUSTAINABILITY AND COMPLEX ADAPTIVE SYSTEMS

The vast majority of countries are still struggling to achieve the United Nation's sustainable development goals (SDGs). One major consequence is that circularity of resources remains critically low, and millions of tons of waste and pollution continue to drive climate change, decreasing social-ecological resilience. The transition from current linear into a Circular Economy has the potential to improve resource's circularity, addressing SDGs like Clean Energy, Decent Work and Economic Growth, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action and Life on Land.

One of the key principles to build social-ecological resilience is to foster complex adaptive systems thinking. Circular Economy (CE) systems can be approached as Socio-Technical Systems (STS), adding maximum sustainable value if they eliminate waste and pollution, keep products and materials in use, and regenerate **socio-ecological systems** (SES). CE's principles are primarily based in industrial ecology and environmental sustainability, leaving a conceptual gap on sociological foundation. This gap can be addressed by changing slow variables like behaviours, legal and value systems, and traditions. Developing governance for this transition process will result in the achievement of other SDG goals in the long term.

Throughout my academic career, I've been shaping and refining my research topic: to model the emergence of behavioural change and social interactions capable of accelerating the transition to a more sustainable society. In this direction, I have given a relevant contribution to the scientific literature of sustainable operations management, supply chain/network design, multi-paradigm modelling, quantifying Resilience, and Regenerative Design. Earlier this year, I submitted a paper with an upgrade of the last chapter of my thesis, where I developed an Agent-Based model to forecast waste generation and collection for the period between 2020 and 2038, evaluating the impact of the implementation of a state policy in the regional-level. Currently, I am revising the waste network proposed in my thesis, and I aim to create a new optimisation model in R, through an extension of the Agent-based model mentioned previously. I intend to continue in this trajectory, contributing to the development of a theory of Socio-Ecological-Technological Systems, through:

a) modelling mechanisms to overcome transition inertia and accelerate the transition towards circular economy systems, and social-ecological resilience is assured;

b) simulating the conditions in which regenerative socio-technical systems emerge and self-organise;

c) monitoring ecological, social, economic and resilience performance using simple, comprehensive metrics;

d) ensuring a dynamic, optimal sustainable performance, in all four dimensions mentioned in c).

Systems achieve better sustainable performance than expected when they self-organise around behavioural change and user experience, rather than through normative design. I intend to use multi-paradigm modelling to understand how behavioural change is influenced by awareness, attitudes and environments in multiple, nested abstraction levels. Besides, I see transdisciplinarity as a means to bring "everybody on board", as stressed in the European Green New Deal. Finally, I would like to

describe multiple dimensions of different Resilience types, combining already existing models of e.g. redundancy and adaptability.

2 TEACHING–LEARNING PHILOSOPHY

I learned a while ago that *apprendre* - "to learn" in French - means both learning and teaching. I've been adopting this philosophy in my courses from two years now, providing students with more teaching activities. My behaviour in the classroom has is changing as I learn with them. In this direction, I have been gradually freeing myself and the students from the pressure of not committing mistakes, achieving much better results approaching errors as "degrees for success". As students bring their errors to the core of the learning experience, they pay full attention when they are taught through what led them to commit a mistake and how to properly solve the problem.

Since last year, I've been increasingly adopting active, problem-based learning, through a complex systems approach. For beginner students - for whom I teach Dynamics of Rigid Bodies -, I have focused on motion types and on how machines work. Gamification, supervised problem-solving, breakout rooms and quizzes have been quite effective. For more advanced students, project-based activities are more effective in consolidating their learning through the entire course, since they have an opportunity to practice all that knowledge in a realistic setting. Also here, the design of machine elements is approached from the whole mechanical system perspective and function, for example, a drivetrain, that transfers power and rotation from a power unit to the wheels of a vehicle. Ultimately, student's performance also improves due to having a more pleasant classroom experience, improving my experience in the process.

Even before COVID-19 pandemic disrupted the educational system worldwide, the emphasis was already switching from technical to soft skills; I have re-balanced content and workload to develop both skill types. For example, initiative and critical thinking are stimulated through problems where data they need is missing. In this way, students are compelled to browse the internet after the missing information, while I support them in criticising the information they found. To stimulate punctuality - one major cultural problem we face in Brazil -, they are rewarded when they connect on time for the courses. To develop teamwork skills like organisation, communication and checking, I've been promoting group problem-solving sessions with breakout rooms. Feedback is constantly provided: another assignment requires that students perform a double-blind peer review, analysing one colleague's solution for an exercise. A discussion over the solution approach is promoted with the entire class, stimulating communication, giving and receiving feedback. The evaluation process had to be adjusted accordingly while using objective criteria to ensure a transparent assessment. Other dimensions were added in the evaluation process, besides technical knowledge: participation, analysis, communication, and organisation.

I'm also engaged in supervising students and being an opponent for their bachelor's thesis defences. I normally take an active part in the development of their projects. I think it's essential that students experience science this early in their professional career. In the short term, I plan to design and teach courses related to my research field, integrating research and teaching domains for a better cascading of knowledge acquired through research. I would like to design a course where students evaluate and propose improvements for small businesses. Personally, the future of teaching resides in supervised learning by practice: students are given assignments with increasing complexity as they progress through their bachelor's. Universities may be transformed into enterprise laboratories: professors supervise and give support to veteran students and peers on their assignments, which in turn help younger students on their assignments.vFinally, to keep an updated perspective and approach on solving sustainable development problems, I plan to keep learning/teaching courses in different areas, like engineering, management, philosophy, modelling and statistics.