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## FACILITATING SCIENTIFIC EVENTS GUIDED BY COMPLEX THINKING: A CASE STUDY OF AN ONLINE INTER/TRANSDISCIPLINARY ADVANCED TRAINING SCHOOL

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### ABSTRACT

Aim/Purpose	This paper aims to illustrate, through an exploratory ideographic case study, how a Complex Thinking framework can inform the design of scientific events and the facilitation of scientific Inter and Transdisciplinary groups towards positive emergent outcomes, both at the level of the functioning of the group and the collective complexity of their thinking. Moreover, it aims to show how the choice of facilitation strategies can contribute to positive emergent outcomes in the context of a fully online event, with its inherent constraints. Finally, this study aims to conduct an exploratory qualitative evaluation of the participants' experiences during School, with a focus on the processes and how they relate to the aims of the School and the goals of the facilitation.
Background	Science needs to embrace modes of knowing capable of generating more complex (differentiated, integrated, recursively organized, emergent), ecologically fit, and creative responses, to meet the complexity of the world's challenges. New formats and strategies are required that attend to the facilitation of Inter and Transdisciplinary scientific events and meetings, towards creative and complex outcomes. A Complex Thinking framework provides suggestions for the facilitation of Inter and Transdisciplinary meetings and events through targeting key properties which may lead to the emergence of complex and creative outcomes.
Methodology	We adopt an ideographic case study approach to illustrate how a complex systems approach, in particular a Complex Thinking framework, grounded in an

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enactive view of cognition, guided the design choices and the facilitation strategies of an online Inter and Transdisciplinary Advanced Training School (Winter School). We aim to illustrate how the facilitation strategies were selected and used to promote deep and creative interactions within the constraints of an online environment. We adopt an exploratory qualitative approach to investigate the participants' reports of their experiences of the School, in light of the principles and goals that guided its design and facilitation.

Contribution	This paper opens a new area of theoretical and applied research, under the scope of a Complex Thinking framework, focused on the facilitation of Inter and Transdisciplinarity at scientific events, meetings, and discussions towards complex and creative outcomes.
Findings	The results of the exploratory qualitative analysis of the participants' experiences regarding the event suggest a critical role of its methodology in fostering rich, deep, and constructive interactions, in leading to the emergence of a collective group experience, to the integration of ideas, and in facilitating transformative personal experiences, under the effects of the emergent group processes. It suggests that the strategies employed were successful, anticipating and overcoming the particular constraints of an online event.
Recommendations for Practitioners	This case study suggests that a Complex Thinking framework can fruitfully guide the design of facilitation strategies and activities for scientific events and meetings, activating a number of key relational processes that contribute to or boost the emergence of positive group experiences and the production and integration of novel ideas.
Recommendations for Researchers	This study calls for action-oriented and applied research focused on the developmental evaluation of innovations, regarding the facilitation of scientific creativity and integration, within the scope of a Complex Thinking approach.
Impact on Society	This paper calls for new modes of organization and formats of scientific activities, suggesting that Inter and Transdisciplinary events and meetings may benefit from intentional management and facilitation of interactions between participants to produce transformative impacts. It demonstrates the importance of the organizational principles used to plan and run events that engage multiple and various societal agents, from academics to practitioners and social activists, towards enhancing their richness and relevance to complex real-world challenges.
Future Research	This study highlights the need for process-focused systematic case study research using complex systems-informed designs to explore how and which facilitation strategies may promote which (interaction of) properties of Complex Thinking and associated processes and how, and under which conditions, these lead to more complex and creative outcomes.
Keywords	complex thinking, interdisciplinarity, transdisciplinarity, facilitation, emergent group processes

## INTRODUCTION

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The call for more complex modes of thinking in science has long been made by Edgar Morin (e.g., Morin, 1990, 2005, 2014). Morin advocated that the understanding and recognition of the complexity of the world has deep implications for the ways we organize our modes of thinking and, through

them, our human and scientific activities. Simultaneously, he called attention to the necessity to attend to our own roles, as observers, in the construction of such complexity. Morin proposed that the recognition of particular properties of complex systems points to properties that our own modes of thinking should be able to exhibit. He highlighted a set of core principles for building more complex modes of thinking (e.g., dialogical principle, recursivity, hologrammatic principle).

To tackle the complexity of the “real-world” and address key global challenges, Science needs to develop frameworks, tools, and modes of thinking that are capable of attending to known properties of complex systems (e.g., complexity thinking) and, going even further, to embrace Complexity (Boulton et al., 2015) by embedding and enacting these properties in the organization of its own thinking and modes of operation (e.g., complex thinking) (Melo 2020a; Morin, 2005, 2014).

Building on the work of Edgar Morin, a new framework was recently proposed to guide the practice of Complex Thinking (CT) (Melo, 2020a), through a pragmatic approach. In line with Morin’s (2007) distinction between a general and a restricted complexity approach, this framework aims at promoting practices that go beyond the mere recognition of complexity, towards supporting a “performance” of complexity. Identifying a set of dimensions and properties of complex systems-related, it postulates that their enactment, at the level of the thinking (i.e., the coupling with a target system of interest), would lead to more complex (differentiated, integrated, emergent) and ecosystemically fit outcomes. This complexity could be expressed, for example, through creative and abductive leaps (Darbellay et al., 2014, 2017; Magnani, 2011; Melo, 2018, 2020a) capable of organizing and guiding effective and adaptive actions, even in the face of uncertainty and partial information. The dimensions organizing more complex forms of thinking, and their respective properties include: (a) structural complexity (structural variety and dimensionality, relationality, recursivity); (b) dynamic and process complexity (temporal scales, processes and dynamics, ambiguity and uncertainty); (c) causal and explanatory complexity (modes of description and finalities, historicity, circular complexity/parts-wholes relations, emergence); (d) dialectic complexity and complementarities (dualities and complementary pairs, trinities and complementarities of processes and levels); (e) complexity of the observer (multipositioning, reflexivity, intentionalities); (f) adaptive and evolutionary complexity (adaptive value, evolutionary potential); (g) pragmatic complexity (pragmatic value, pragmatic sustainability); (h) ethical and aesthetical complexity (ethical value, aesthetic value); and (i) narrative complexity (differentiation and coherence, identities, flexibility/openness).

In this framework, which is grounded in an enactive view of cognition (Maturana & Varela, 1992; Varela et al., 2016), CT is defined as a mode or process of coupling between an observer and a target system of interest that: (i) attends to properties of complex systems (e.g., relationality, non-linearity, recursivity, multiple time scales), (ii) while enacting them in the coupling with a target system of interest. Simultaneously, CT is defined as the outcomes of such processes that are more likely to generate meaningful information and positive and sustainable outcomes and to guide practice and support a positive co-evolution between an intervenor, a target system of interest, and their environment. The framework postulates that, under certain circumstances, the enactment of the properties of CT may lead to emergence in the form of creative outcomes, i.e., novel, valuable and surprising (Boden, 2004) and of abductive hypotheses and explanations (Magnani, 2011; Shook & Paavola, 2021) that will expand an array of positive possibilities for action. Applications of this framework in the context of Inter and Transdisciplinary research have not yet been investigated.

This new CT framework was proposed with a focus on interventions targeting ‘real-world’ complex systems. If one considers scientific groups, and other human groups and teams, as complex systems (Arrow et al., 2000), the framework could then be used to guide the design and facilitation of a variety of interventions aimed at supporting positive and creative interactions in Inter and Transdisciplinary groups and events, towards the facilitation of more complex creative and abductive outcomes. Simultaneously, the framework can be used to guide a facilitation process that directly aims at promoting Collective Complex Thinking, as a distributed property of Inter and Transdisciplinary

groups, thereby increasing their potential to generate positive and meaningful outcomes; namely, when targeting “real-world” and “wicked” complex systems.

Inter and Transdisciplinarity require intentional management and facilitation (Lyall et al, 2011; von Wehrden et al., 2019). While naturally presenting more complex internal organizations, these modes of knowledge production do not happen naturally, or just as special forms of scientific collaboration (Lyall et al, 2011). “True” (Boden, 1999; Klein, 2017) Inter and Transdisciplinarity require rich and deep interactions and mutual perturbations between a variety of disciplines or critical stakeholders to lead, in non-linear ways, to the emergence of novel ideas and solutions, as well as their integration-hallmarks of their complexity (Weingart, 2000).

A Complexity-informed perspective has not been absent in debates about Inter and Transdisciplinarity and its multifaced relations to Complexity (Klein, 2001, 2004; McMurtry, 2011; Newell, 2011). Different authors have adopted Complexity-informed perspectives in the conceptualization of Inter and Transdisciplinarity (Lotrecchiano & Misra, 2018; Montuori, 2013). On the other hand, Complexity-informed perspectives have made critical contributions to debates on education and educational strategies (Davis & Sumara, 2006). However, a CT approach is insufficiently explored in these domains, both as a way to promote more complex forms of thinking in Inter and Transdisciplinary and as a framework to guide the management and facilitation of scientific interactions, not just in research teams but also in other scientific meetings, workshops, conferences, and training events.

In contrast to significant advances made in the domains of group and team facilitation, namely in the development and evaluation of tools, techniques, and strategies for their facilitation (Salas et al., 2020; Tang, 2019), both the research and the practice of facilitation in Inter and Transdisciplinarity are very much incipient and in urgent need of theoretical and pragmatic developments (von Wehrden, 2019).

Despite significant advances in the understanding of key factors and processes affecting positive outcomes in Inter and Transdisciplinarity (Hall et al., 2018, 2019) much remains to be addressed regarding their facilitation. This is applicable not just in the context of research projects but also when considering scientific activities that: (i) are not limited by the constraints and scope of (more or less) strictly-defined objectives within research projects; (ii) adopt a co-learning, collaborative stance; (iii) adopt an exploratory and discovery-oriented perspective; (iv) aim at creative and abductive outcomes (e.g., new frameworks, new explanations, new solutions); and (v) target ‘real-world’ complex systems and aim to inform interventions.

On the one hand, a Complexity frame of reference can help us conceptualize Science groups and teams as complex systems and, hence, guide our attention to critical processes underlying the emergence of higher order processes (e.g., shared identity; sense of belonging) (Arrow et al., 2000; Jonas-Simpson et al., 2015), which need to be facilitated. On the other hand, a CT framework can move a step beyond by signaling critical properties of complex systems to be enacted in the design of interventions with these groups and in choosing the strategies that will, in turn, provide support: (i) to enact those properties in the context of their own internal interactions (e.g., to promote positive emergent group properties and conditions for creativity and abduction); and (ii) in coupling with their target systems of interests, towards more complex modes of thinking leading to novel emergent and potentially effective outcomes (e.g., generating novel ideas, explanations, and modes of action).

In this paper, we adopt an exploratory ideographic (Harvey, 2009) case study approach aiming to illustrate how a complex systems approach, more specifically a CT framework (Melo, 2020a), can inform the design of scientific events and the facilitation of scientific Inter and Transdisciplinary group towards positive emergent outcomes, both at the level of the functioning of the group and the collective complexity of their thinking.

The target case is an online Inter and Transdisciplinary Advanced Training School (a ‘Winter School’ hereafter referred to as ‘School’). The School was designed as a 5-day (35 hours total) fully online event. The School’s core themes related to Complexity and Change and approached the Sustainable Development Goals (<https://sdgs.un.org/goals>) under the lenses of Complexity Studies, as well as a diversity of critical social perspectives. It aimed at exploring alternative modes of thinking and practices towards building positive and sustainable human and global change (cf. Campos et al., 2021). The processes of the School were designed to be methodologically congruent with a Complexity frame of reference and a Complex Thinking approach (Melo, 2020a). It targeted academics, activists, intervenors, and educators aiming at the co-construction of new ways of thinking and action that inform the pursuit of sustainable and desirable alternatives for the place of humanity. The School integrated a variety of creative techniques and media, to support rich interactions and dialogues amongst the participants, and the co-evolution and co-construction of new ideas. It included 13 registered participants, and 8 lecturers, plus 4 organizers/facilitators who were also lecturers. Additionally, this study aims to illustrate how a CT framework may contribute to positive emergent outcomes in the context of a fully online event and how, through the choice of facilitation strategies, it can overcome some of its inherent constraints. Finally, this study aims to conduct an exploratory qualitative evaluation of the participants’ experiences during the School with a focus on the facilitation processes. We aimed to understand to what extent the participants’ experiences related to the overall aims of the School and the goals of the facilitation.

## **GENERAL OVERVIEW OF THE SCHOOL**

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### ***CONTENT AND FOCUSES***

The School’s thematic contents covered themes related to Complexity Studies focusing on Sustainable Development, Complexity, and Change, and on building alternative practices and modes of thinking in relation to the Sustainable Development Goals. A detailed description of the contents and activities of the School (Campos et al., 2021) is available at [https://www.researchgate.net/publication/351821420\\_CES\\_Winter\\_School\\_2020\\_'Sustainable\\_development\\_complexity\\_and\\_change\\_thinking\\_and\\_practices\\_for\\_the\\_SDG\\_and\\_other\\_objectives'\\_Descriptive\\_and\\_evaluation\\_summary\\_report](https://www.researchgate.net/publication/351821420_CES_Winter_School_2020_'Sustainable_development_complexity_and_change_thinking_and_practices_for_the_SDG_and_other_objectives'_Descriptive_and_evaluation_summary_report).

### ***DURATION AND FORMAT***

The School took place fully online during a period of 5 consecutive days, with a total of 35 hours of direct contact time.

### ***AN INTER AND TRANSDISCIPLINARY GROUP: PARTICIPANTS***

The School targeted academics/researchers, students, educators, and activists. The group comprised 13 registered participants (including 4 poster presenters), 6 females, and 7 males. The School involved 8 guest lecturers (4 of whom participated in the evaluation) plus 4 organizers, also facilitators, and lecturers. The team also included 1 graphic artist. The first author assumed the core facilitation tasks. Participants were of different nationalities and from different countries (Brazil, Portugal, United States of America/China, Colombia, Spain, Switzerland). The schedule was set up to start mid/late morning in Central European Time, but some participants were in time zones three, four, and five hours earlier. The schedule was fixed across the days. It was highly interdisciplinary in terms of academic domains spanning biology, anthropology, psychology, education, geography, forest engineering, management, sociology, law, international relations, communication, and economics. The group was transdisciplinary in the sense that it aimed at addressing global challenges associated with the SDG framework, building alternatives that would transcend individual disciplines. On the other hand, it combined established career scientists with doctoral students as well as practitioners, working in different non-profit and public sectors, and activists. Many participants accumulated different

profiles, namely having some activist role as well as being an academic or practitioner. More details regarding the characteristics of the group can be found in the School's report (Campos et al, 2021).

### ***ETHOS AND FACILITATION GOALS***

The School was designed to operate as a collaborative event where the facilitators/lectures were considered as participants equally engaged in a co-learning and co-constructive process, bringing specific contributions to stimulate the discussions.

The design and facilitation processes of the School specifically aimed at:

- (i) supporting the creation of a positive and nourishing interpersonal group environment (sense of belonging, identity, trust, cohesion) allowing for rich and deep interdisciplinary interactions;
- (ii) overcoming the obstacles posed by the online setting, minimising fatigue and saturation;
- (iii) promoting a variety of (non-linear) interactions between participants and, above all, their ideas, favouring creativity as a form of emergence;
- (iv) promoting the creation, circulation, and exploration of a variety of types of inputs and information, and a variety of modes of processing them and their relations, towards creative and complex (differentiated, integrated, emergent) outcomes.

The School's facilitation relied on a combination of tools, including an interactive and collaborative online platform (based on the commercial platform Miro) providing a 'board' for the virtual interaction which was purposefully customized to support a variety of activities and different modes of (non-linear) interaction between participants and different modes of creating, circulating and managing information. Its activities and virtual spaces were conceived to promote both social exchanges (e.g., exchange of personal and emotional information) and academic interactions (e.g., at the level of ideas and concepts) supported by different information exchanges, modes of coupling between participants as well as circulation and management of the information. The virtual space was designed as a 'building' with different rooms and studios targeting different activities. The School aimed to help participants recursively relate to their individual and collective thinking and the way it unfolded assuming that recursiveness was a fundamental condition for evolving the complexity of the group towards more complex (differentiated, integrated, emergent), namely new ideas and levels of integration.

## **A COMPLEX THINKING INFORMED DESIGN AND STRATEGIES FOR FACILITATING INTER AND TRANSDISCIPLINARITY IN THE SCHOOL**

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The design of the School aimed to be methodologically congruent and informed by a complex systems perspective. In particular, we sought to operationalize a Complex Thinking Framework in the design of the activities, support platforms, and facilitation strategies.

Such a framework was applied at two levels. On the one hand, we assumed that the complexity of the thinking underlying the design of the School would contribute to its complexity and of its outcomes. We assumed that such a type of planning was necessary to activate key processes for the group to operate as a complex system and to activate and steer its creative potential. On the other hand, we assumed that if the activities of the School provided support for the collective enactment of properties of complex thinking, then it would be more likely to have richer, more creative, and complex outcomes, suited for the problems under focus.

This pragmatic approach to CT allows us to conceptualize both the complexity of the processes underlying the individual experiences, and the group's dynamics and the complexity of its outcomes, namely in terms of the differentiation, integration, and emergence (non-reducible novelty) of the thinking outputs (e.g., new ideas or their integration) and group dimensions (e.g., emergent shared

emotional climate). The School was designed assuming that the enactment of particular properties of a complex process, during the unfolding of individual and collective thinking, would facilitate the emergence of novel ideas that would not simply be explained by the sum of the individual or piecemeal contributions, nor reducible to them (Melo, 2020a). The School offered an opportunity to experiment with new methods informed by a complex thinking framework, namely the use of the 'Relatoscope,' which is being developed to support complex relational thinking in Interdisciplinary debates by weaving different contributions and to support emergence through relational dialogues (Caves & Melo, 2018; Melo, 2020b). The design of the supporting interactive platform and the School's, namely the Integrative Discussions (which used the Relatoscope method), was guided by the hypothesis that the enactment of a set of key properties of Complex Thinking, both at the level of the individuals and their coordination in the collective context would support: (a) the emergence of a positive experience of the group as a systemic emergent entity emerging from the interactions, but not reducible to them and with top-down effects over the individuals and their interactions; and (b) the emergence of new insights, views, perspectives and their novel integration (not simply reduced to the level of the inputs or the components of the group) in ways that could appear as relevant and fit to address the problems under focus.

The CT framework defines a set of organizing dimensions of complex thinking and respective properties. The activities and facilitation strategies methods were designed to support the enactment of a selected series of dimensions and properties of the (individual and collective) complexity of the thinking, namely: (i) structural, (ii) dynamic, (iii) causal and explanatory, (iv) observer related, and (v) narrative complexity. The choice of the properties was guided by preliminary hypotheses, raised in the context of this framework, that suggests that some properties may be more fundamental and critical for emergence to take place. Additionally, we targeted properties that could be more feasibly practiced, given the constraints of the School, namely its duration.

In terms of structural complexity the following properties were targeted: structural diversity and dimensionality (variety of types of information and modes of coupling, processing, and interacting); recursiveness (updating and re-integrating the emergent products in the process of thinking); and relationality (exploring different types of relations between ideas and considering each on the context of the others). In terms of dynamic complexity, multiple timescales were considered. In relation to causal and explanatory complexity, the following properties were considered: historicity (the extent to which the thinking tracks its own history in terms of the way it unfolds and the nature of the thinking movements and trajectories chosen); complex circularity (the extent to which the thinking is organized in circular terms, moves across and explores relations between different levels, managing its own constraints and part-whole relations); emergence (the extent to which the thinking leads to emergent outcomes that are used as constraints to re-shape and explore new information and itself). In terms of the observers' complexity, there were properties of multi-positioning (experimenting with multiple positions in relation to the phenomenon of interest, managing one's own contributions to the coupling in order to generate multiple perspectives), and reflexivity (turning the thinking process to oneself exploring internal and external factors and constrains shaping the thinking process; developing a view of the potentialities and limitations of the thinking). In terms of pragmatic complexity, the pragmatic value of the thinking was focused (the extent to which the thinking results in an expansion of pragmatically viable possibilities for action) as well as the complexity of the narratives that sustain its processes and outcomes in terms of differentiation and integration.

Table 1 lists the targeted properties of CT and how they were enacted and embedded in the practices of the School through particular design choices and facilitation strategies. Each of the activities was informed by and supported the enactment of particular properties of complex thinking.

**Table 1. Dimensions and properties of complex thinking and embeddedness in the design of the School's activities and facilitation processes**

Dimension and properties	Embeddedness in the School's activities and facilitation processes
<b>Structural Complexity</b>	
<i>Structural variety and dimensionality</i>	<p><i>Group diversity</i> (disciplinary backgrounds; domains of knowledge and practice; nationalities; gender; geographical location)</p> <p><i>Diversity of the themes of the lecture and poster presentations</i> (different perspectives, approaches, disciplinary inputs, inputs from 'real-world' practices. Seminar rooms and poster sessions had spaces for inputs brought by participants in response to the presentations.</p> <p><i>Different types of sensorial information and modes of manipulation</i> (e.g., audio, visual images; movements on the visual platform; kinesthetic information associated with craftwork)</p> <p><i>Contextualized information</i> (participants sharing of personal stories; photos from their contexts; cultural habits)</p> <p>The <i>Reconstruction of posters</i> presented at the beginning of the School builds upon the multiple contributions, variety of perspectives, and exchanges during the School</p>
<i>Relationality</i>	<p><i>Use of the Relatoscope method (Rmethod)*</i> to build and explore a variety of relations between pieces of information. A visual record of the collective relational thinking trajectories was always available as well as a record of the transformations.</p>
<i>Recursiveness</i>	<p><i>Use of the Relatoscope method</i> to ensure recursive loops in the creation, exploration, and manipulation of the information. The emergent outputs of the discussions and the participants' reactions to information were integrated and feedback to the discussion as new 'base' contributions.</p> <p>The <i>Reconstruction of posters</i> presented at the beginning of the School was fed by the multiple contributions and exchanges during the School.</p>
<b>Dynamic complexity</b>	
<i>Timescales</i>	<p><i>Different rhythms and times of engagement.</i> Participants were allowed to interact and react with the contents and activities of the School (e.g., lectures) at different paces or timescales: (i) faster and more immediate time scale/pace (e.g., using the Notes channel to record their 'stream of consciousness'); (ii) moderate timescale/pace in the collective reflexive and integrative moments; (iii) extended timescale/pace by having access to the information throughout the days and being able to comment on them, outside of the School's hours.</p>
<b>Causal and explanatory complexity</b>	
<i>Historicity</i>	<p><i>Virtual board and Records of the Day.</i> The virtual space/board retained a visual track of the collective discussions and the evolution of the thinking trajectory. A Records of the Day section collected snapshots of the board at the end of each day and records of the Notes Panel, capturing the individual reflections and collective dialogues in written form.</p>
<i>Complex circularity</i>	<p>The <i>Relatoscope method</i> ensured an: (i) intentional exploration of a multiplicity of relations between the <i>parts</i> (building blocks of information that were offered for discussion; base contributions; from the lectures selected by participants; reactions and base ideas added to the board) and <i>wholes</i> (integrative and emergent ideas) of the collective thinking; (ii) the contextualization of information.</p>

<b>Dimension and properties</b>	<b>Embeddedness in the School's activities and facilitation processes</b>
<i>Emergence</i>	The <i>Relatoscope method</i> (Melo, 2020b) was used to facilitate the emergence and the processes of circular complex circularity involved. Emergent ideas on recorded on the different Relatoscope spaces.
<b>Observer's complexity</b>	
<i>Multipositioning</i>	The diversity of the group, lectures, poster presentations, and interdisciplinary contributions allowed for the exploration of multiple perspectives on the target themes. With the use of the Rmethod, participants were invited to take an explicit position in relation to the subjects at hand. The use of the Rmethod associated with the Observatron invited the group to explore other perspectives on the subjects and the information discussed. The use of Story-telling and Crafts activities allowed for the experimentation of different ways of coupling (namely sensorimotor) with the themes and explored different positionings and modes of thinking.
<i>Reflexivity</i>	<p>The open 'Notes' section could support more reflexive stances from participants and the recording and sharing of their 'stream of consciousness. The labeling process of the individual constructions of ideas using the Story-telling process (producing images, a word, and small texts) invites a reflexive stance on one's constructions and positions. Participants received direct, synchronous, and asynchronous feedback and reactions from others on their ideas and constructions which could increase reflexivity. Participants were invited to reflect on the School's contents from their individual positionings in the world as academics, practitioners, individuals. The social spaces allowed for personal and contextual information to be shared which situate the participants and increases awareness of one's own constraints in relation to those of others. During the Story-telling and Crafts studio participants are invited to turn 'inwards' and reflect on their own internal reactions to the stimulus created by the School.</p> <p>Seminar rooms and poster studios include spaces for comments and reflections on the topics presented. The session of Poster reconstruction builds upon the participant's reflexive comments on them.</p> <p>The artist's graphic reporting reflects back to the group core contents and processes of the School.</p>
<b>Pragmatic complexity</b>	
<i>Pragmatic value</i>	Participants were invited to have a pragmatic focus, especially in the integrative discussions, and to explore implications and applications of the ideas discussed, namely for interventions and the communication of ideas.
<b>Narrative complexity</b>	
<i>Differentiation and integration</i>	The Story-telling activities supported the exploration of narratives that could hold and communicate the ideas being discussed. They were related to the Crafts activities since narratives were constructed around these products. The first Story-telling and the Crafts studio activities aimed at the production of a variety of narratives, expressing a multiplicity of ideas and expressions. In the final days, the association of the <i>Rmethod</i> to the Story-telling outputs supported the integration of the narratives and the exploration of their relations and the patterns that connect them.

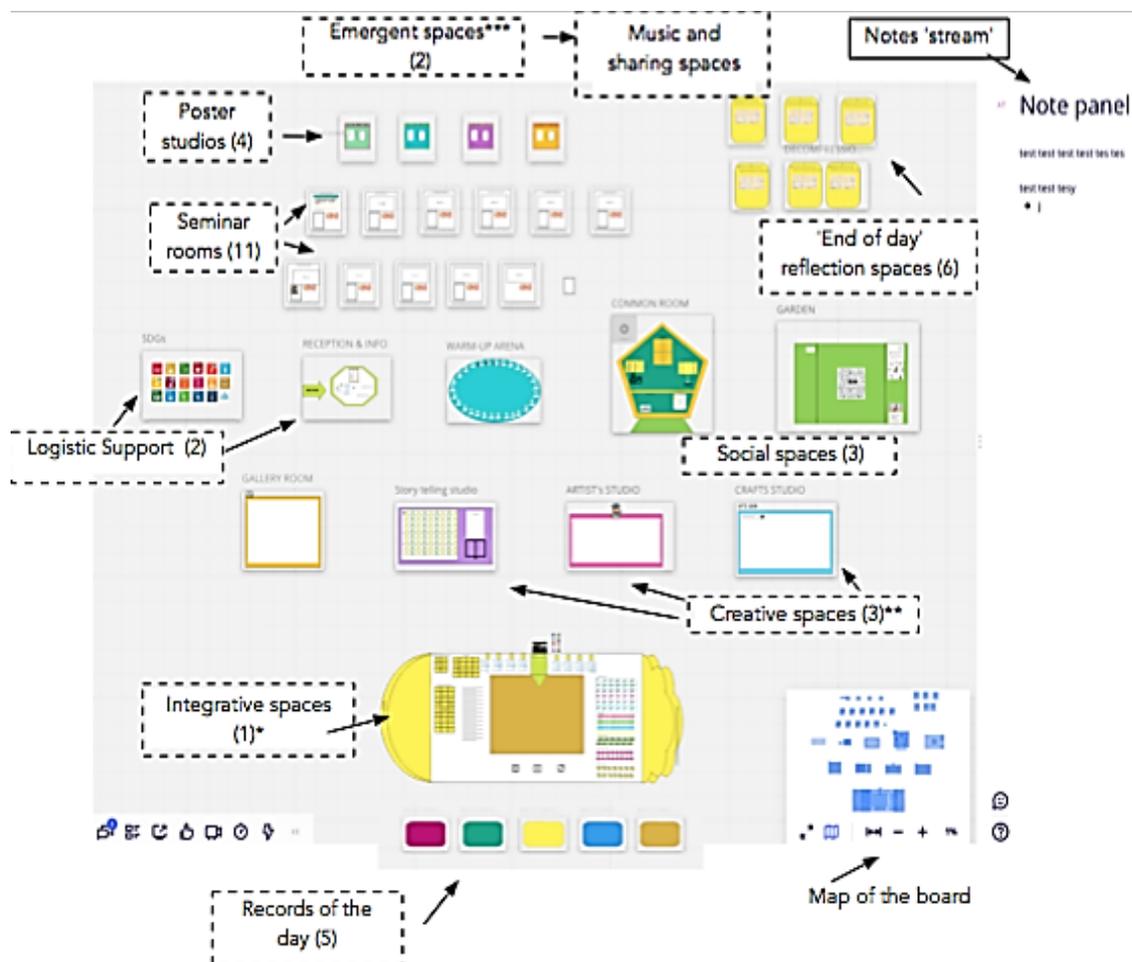
Note: \* cf. Melo (2020b)

In sum, the methodology was designed to support a creative environment favorable to rich and deep interdisciplinary engagement and the emergence of positive group experiences. It was assumed that multiple types and levels of interaction and the interplay and manipulation of different types of information were necessary for the creation and integration of new ideas. It was also assumed that knowledge has enactive, embodied, embedded, and extended foundations (Newen et al., 2018). Therefore, the activities were designed to allow for different modes of sensorial and embodied experience and manipulation of information; the virtual platform was used to support different types of ‘simulated’ movements and actions in exploring information. The School was designed to allow for virtual social interactions that appealed to ‘in presence’ modes, such as those that could happen in a “Common Room”, around meals and drinks, or in outdoor interactions (e.g., social walks). It created spaces that, for example, through the sharing of photos, allowed participants to share personal information that could create a sense of close engagement and contextualize their exchanges. The intent was to create a social and affective context marked by a positive emotional climate, trust, and a sense of proximity.

### *VIRTUAL SPACES, ACTIVITIES, AND FACILITATION STRATEGIES*

In this section, we provide a general overview of the design of the Virtual spaces, and activities and the overall features of the facilitation strategies of the School, in relation to the theoretical framework guiding its design. Due to space constraints, it is not possible to detail the design of the virtual spaces and the details of the activities they encompassed. A more detailed description is provided in the School’s report, available in Campos et al. (2021). The School was facilitated by its 4 coordinators. The first author assumed a more active role in the facilitation of the creative and integrative activities. The interactions were supported by two commercial virtual platforms (Zoom and Miro) used simultaneously. Participants were instructed to keep the written dialogues and conversations flowing in the Notes section of Miro, where they would be captured and recorded every day, along with other activities. ‘Participants’ is used here to refer to the 4 coordinators (also lectures and facilitators), the 8 invited lectures, and the 13 registered participants. The number of registered participants was limited to a maximum of 15 to create a climate of closeness and engagement and to allow everyone to interact and have a good view of the others in the available Zoom gallery view space. The Miro board was used simultaneously with Zoom and provided a different visual medium for interaction, allowing for more “motor” actions, supporting the manipulation of information. The board offered a shared focus of attention where everyone could ‘see’ the presence and movements of the others (marked by their cursors with name and sometimes photos), as well as all the information that was produced and manipulated, in relation to everyone who could take a stance. This shared focus was expected to facilitate coordination and cooperation. We also assumed that the shifting of attention to Miro could reduce the stressors introduced by intensive ‘mirror looking’ on the video call as well as a constant direct focus on each other and one’s own image. It offered a rich and diverse space where attention could be managed and directed in different ways and directions by each participant. The Miro board supported individual explorations of the information available allowing participants to have an active role in shaping the School by offering their own contributions to the collective thinking process in multiple modes. It also allowed each participant to have a more active role in interacting with others and choosing different modes (e.g., direct response or active dialogue in the Notes stream; sharing a reaction; connecting personal inputs; offering theoretical or practice-informed comments).

The Miro board was open throughout the entire duration of the School, both in-hours and off-hours. Figure 1 shows an annotated (Zoomed-out and with reduced detail) image of the Board, revealing the different virtual spaces at Day 0. A detailed explanation of each space and its affordances for the interaction is available elsewhere (Campos et al., 2021) as well as information on the transformation of the space. Each space supported different types of activities.



Note: The integrative space was multiplied during the school to support the integration of ideas generated in the creative activities (\*). The creative spaces were multiplied during the School and new studios were created to support the activities of each day, throughout the School (\*\*). Emergent spaces are spaces that were not designed prior to the School but their construction was driven by the interactions and proposals of the participants (\*\*\*). Also, two invited lecturers delivered a presentation together, hence only 11 Seminar rooms were created for the 12 lecturers.

**Figure 1. A zoomed-out overview of the “empty” space of the Virtual School by Day 0**

The School included 6 big categories of activities, associated with different interactional processes and finalities: (1) social and group building activities; (2) content/input activities; (3) creative activities; and (4) relational and integrative activities.

### Social and group building activities

The Social and group building activities were supported by spaces dedicated to warm-up and introduction, social interaction, and exchange of personal information, such as the Warm-up Arena, the Common Room, and the Garden Space. They recreated activities that could take place in ‘real’ physical spaces (e.g., choosing a drink or a meal and sharing with others). They were considered fundamental to build an environment of trust and cohesion and to engage participants in a shared experience upon which more academic types of other interactions could be built.

### **Content/input activities**

The School included activities dedicated to the sharing of contents and theoretical and practice inputs for discussion. These activities corresponded to moments of academic presentations by the 12 lecturers, the 4 coordinators and facilitators, and 8 invited researchers. Participants could react to these presentations (e.g., writing on sticky notes) immediately in the Seminar Rooms (one for each lecture). The rooms were customized for each speaker and could contain the presentations and supporting materials. On a Notes panel, or using comments functions, participants could engage, immediately, in discussions with each other as well as interacting with the speaker. The Poster Studios supported poster presentations by 4 registered participants. In a later session, these posters were 'reconstructed', based on collective comments and suggestions inspired by the School. At some point, participants spontaneously started to bring additional contributions to the School, such as sharing their own works, interventions, and professional experiences; in response, a dedicated Sharing Space was created for that purpose.

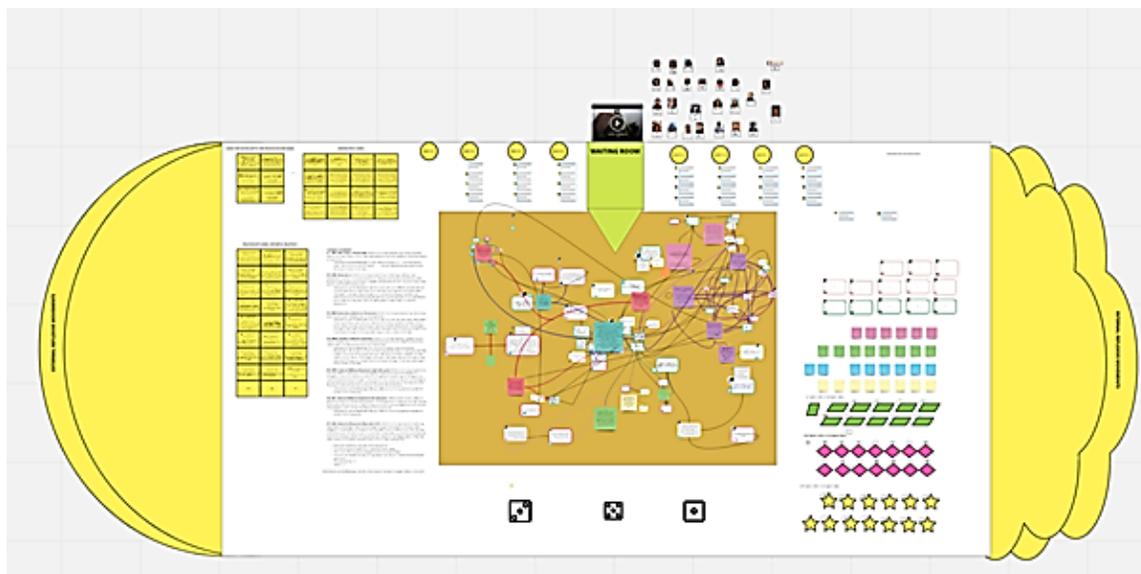
### **Creative activities**

A set of virtual studios were created to support the creative exploration of ideas, through different modes of coupling, processing, and embodied experimentation of the information. Participants were invited to express, rehearse or present their ideas and reactions to the School's contents by engaging in creative work. The Story-telling Studios invited each participant to create a mini-narrative 'for change' through presenting an image, a word, and a mini-text. The Creative Craft Studios invited participants to use craftwork. Participants had been previously instructed to have a set of creative support materials available to them. They were invited to explore their ideas and reactions to the School's inputs using drawings, constructions, plasticine work, collages, or any other type of craftwork. During the craftwork session, participants continued to share their screens while working independently; some spontaneous conversations and interactions emerged during this time.

Photos of the works were uploaded to the Creative Studio after which there was a round of 'Show and Tell', followed by a round of comments. A facilitator spontaneously shared music during these moments of individual work. The group responded positively and participants started to suggest different music to be shared and listened to collectively during the creative work. A space for Music Sharing was created on the board to accommodate this novelty in the interactions.

### **Relational and integrative activities**

At the end of each day, there was a period dedicated to a collective exploration of different types of relations between the inputs and contents and the ideas emerging from the different activities. These activities were guided by use of the Relatoscope and the Observatron, methods designed to support complex relational thinking and the emergence and integration of ideas in group discussions (Melo, 2020b). These methods were also applied to explore relations between the outputs of the creative activities and to support their integration. Figure 2 shows the image of a Relatoscope on the last day of the School. Different colored 'papers' and shapes represent different levels of integration and the threads connecting them represent the relations explored.



Note: The ideas are placed at the center. Different types of ‘cards’ (blank on the right and fill in the center) represent different levels of integration and the lines the relations explored. The cards on the left of the center panel contain prompt questions to explore relations and the Circles above are used to explore perspectives and multiple positions of the observer in relation to an idea.

**Figure 2. A zoomed-out snapshot of the Relatoscope [Integrative space] on the last day, showing the relational trajectories explored between ideas and the configurations explored**

## QUALITATIVE EVALUATION

We aimed to conduct an exploratory evaluation of the participants’ experiences and reactions to the School and the level of attainment of its objectives. Qualitative (open-questions) and quantitative (Likert-type scales) data were collected through a post-School online form. The quantitative analysis results are reported elsewhere, along with a more detailed description of each of the School’s activities (Campos et al., 2021). Given the innovation of the School and the lack of similar previous events, the qualitative evaluation was conducted in an exploratory way, aiming at understanding the nature of the participant’s experiences and reactions during the School and their recommendations and suggestions for future events.

### *ETHICS*

The qualitative study was approved by the Ethics Committee of the Centre for Social Studies of the University of Coimbra. At the beginning of the School participants were informed and consented to the possibility of the Coordinators using information collected during the School to report (e.g., in papers or reports) both its processes and the general evaluation outcomes without disclosure or use of personal or identifying information from participants. Any publication regarding the achievements of the group would be subject to specific agreements in relation to co-authoring. A new and specific informed consent was obtained, at the end of the School for the collection of evaluation data, which was done anonymously. By submitting the online forms, participants consented to the information being used for the purpose of the evaluation of the School, as well as communicated in scientific publications or meetings, or similar events. All other data (e.g., reports on the boards) were anonymized.

## ***DATA COLLECTION***

The qualitative data corpus includes the registered participants and invited lectures responses to the online evaluation forms administered at the end of the School, to which 12 participants and 4 lecturers responded. These lecturers did not have a direct role in the design of the School or its facilitation. Qualitative data were collected in a narrative section containing 3 open-ended questions, namely:

- (1) “Please share your commentaries and free reflections about the school, including forces and vulnerabilities, and about your experiences during the school or following it.”
- (2) “Please share your suggestions or recommendations to improve a future 2nd edition of the school or other related activities.”
- (3) “Please give us your suggestions for follow-up activities to the school.”

In addition, the corpus contained written feedback provided at the end of the last two days of the School, both in the Notes section and in comments shared by the registered participants in the “Decompression Chambers”, zones on the virtual platform dedicated to sharing reflections about each day. We retrieved 18 comments which were added to the corpus of data.

## ***DATA ANALYSIS***

The general data analysis strategy was exploratory. The authors assume a constructivist (Charmaz, 2006) and reflexive stance (Braun & Clark, 2020) in relation to qualitative analysis. Data analysis was conducted by the first author, using a bottom-up approach, guided by the sensitivity developed during the School and the first-person experience of its emotional climate. The second author reviewed the coding with the intention of assessing how well the emergent categories seemed to fit and capture the data. The analysis was conducted with the intention to capture the nature and diversity of the experiences of the participants.

### **First coding**

The entire corpus of qualitative data was subject to an initial reading to ensure familiarisation and to create a sensitivity to its contents and nature. The data was first coded using a mixed approach that was simultaneously both inductive, exploratory, and bottom-up, as well as directed and guided by the questions on the forms and which provided very broad general preliminary categories in which to organize the data, namely pertaining to experiences, suggestions, and recommendations (Hsieh & Shannon, 2005). However, most data analysis was inductive and exploratory. This was operationalized using an open coding approach (Charmaz, 2006; Saldanã, 2016). Each segment of data (a sentence or a paragraph) was subject to a first coding procedure which tried to ensure some differentiation from other pieces of data, while building an overall picture of what the data was about (extracting preliminary categories and/or arranging the data in such categories, informed by the questions that were posed to the participants). The data was coded with the following questions in mind: ‘what is this piece of data an example of?’, ‘what does this data pertain to?’, ‘in which general category does this fit and what is similar and different from other pieces of data?’, ‘what is the specific nature of the data and what is it about?’. These questions guided the open coding process which was supported by a constant comparison exercise (Charmaz, 2006), comparing each instance with other instances, the codes, and categories. Each unit of analysis was often associated with more than one code and was simultaneously allocated to a preliminary general category and a specific code. After the preliminary coding, two additional rounds were undertaken which served to check the first coding procedures and to refine the general categories created in the first stage.

### **Identification of patterns: Thematic categories**

A fourth round of analysis focused on comparing codes regarding their differences and similarities and aggregating them into themes (Braun & Clarke, 2006). A two-layered process of establishing

categories and defining both macro and micro aggregating themes was performed. We wanted to be able to aggregate the data under general categories and to extract some themes or “repeated patterns of meaning” (Braun & Clarke, 2006) under each category, capturing and registering the richness and diversity of the reports in relation to their contents and what they conveyed. While most of the coding was semantic, there were also some interpretative moves that were guided by our experiences of ‘how’ participants shared their experiences during the School and how the emotional oral and written content pointed to the relative importance and meaning of the information reported.

As some codes appeared together in the data corpus and were linked by the participants in their own statements, we were able to elaborate some hypotheses about: (1) the relative importance of the themes, namely what was the most salient information and what should be highlighted that defines or characterizes what the School represented or achieved for the participants; and (2) some explanatory links concerning how particular dimensions might have contributed or link to others. We then distinguished the salience of the themes by identifying those that were more recurrent and more frequently reported across participants. In identifying more salient themes we also considered when the participants’ reports, regarding those categories or sub-categories, were accompanied by strong emotional cues that stressed their importance and impact (e.g., reports of strong emotions or punctuations and paraverbal expressions conveying emotions, such as the use of several exclamation points or use of superlatives). The results presented here are focused on the participants’ evaluation of the School. Their specific suggestions for future editions of the School are reported elsewhere (Campos et al., 2021).

### RESULTS OF THE QUALITATIVE EVALUATION

Figure 3 presents a visual summary of the main categories and sub-categories resulting from the analysis and the more salient relations between them. The more salient categories are distinguished by a thicker border. In the following paragraphs, category labels are indicated with all capital letters, *italic typescript*, and enclosed in single quotes. Sub-categories are enclosed in single quotes and written with an initial capital letter and *italic typescript*. Illustrative quotes from participants are given in *italic* and enclosed in double quotation marks.

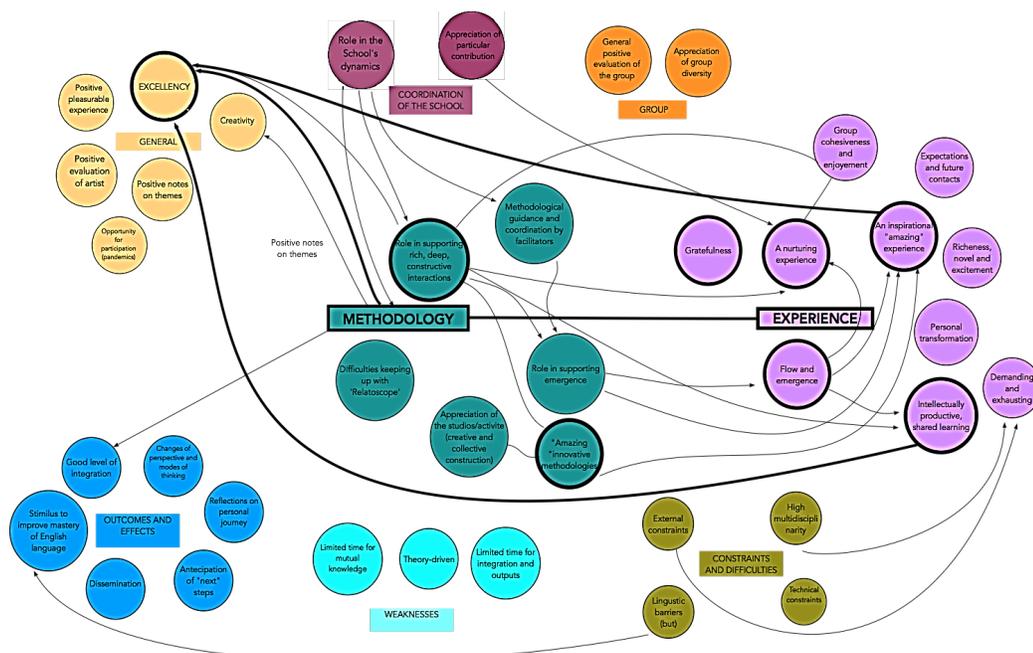


Figure 3. Schematic representation of the core categories (rectangles), sub-categories (circles), and key relations (lines) of the qualitative analysis. Line thickness represents salience

The categories with stronger salience relate to the School's 'GENERAL EVALUATION', namely its 'Excellency' in comparison to similar activities, its 'METHODOLOGY' and the nature of the 'EXPERIENCES' that it facilitated.

*"I was truly very impressed with the grandiousness of the School!"; "The School was, from an intellectual point of view, one of the best and most productive activities in which I participated for a while"; "It overcome all expectations"; "It was exceptionally well organised".*

The 'GENERAL EVALUATION' included some 'Positive notes on the themes', a 'Positive evaluation of the artist', notes on the School's overall 'Creativity' and descriptions of it as constituting a general 'Positive pleasurable experience'. There were notes on how 'Opportunities for [online] participation' were created by the pandemics.

The majority of the comments were focused on the 'EXPERIENCES', afforded and supported by 'METHODOLOGY', which constituted the most salient categories. Participants focused mainly on having had an experience characterized by internal reactions and transformations, something bigger than the individuals' own ideas, coming out of a collective and individual 'Flow and emergence'. They reported what seemed to be top-down effects of the emergent products and processes of the group. The participants report being "moved" by ongoing collective processes

*"Loved the collaborative energy flowing"; "I felt (...) just started to let things flow". "I was very moved by the kind of interactions that could emerge in a virtual environment, with unknown people, the emergence of discussions and dialogues"*

The School afforded a 'Nurturing experience', including 'Group cohesiveness and enjoyment' associated with some playfulness and with 'richness, novelty, and excitement',

*"I felt very welcomed and comfortable"; " I felt empathy and hosted"; "very gratifying and constructive"; "It was a very rich experience"; "I felt excitement in the beginning of each day"; "Great people (...) damn, did I enjoy your company"; "Today showed the cohesiveness of the group"; "I thank you all for this crazy space and experience"; "People are tired, but still committing to getting involved"; "I felt (...) kind of playful".*

The 'EXPERIENCE' stimulated reflections and 'Personal transformation' and was associated with 'Intellectually productive, shared learning'.

*"I am a little different now"; "I came out with the impression of (...) having known myself more, also"; " I think I am better"; "I have more hope inside me"; "I would like to say thank you for the intense moment of learning"; "new tools, thoughts and great, great people"; " I learned from each of you to see the world from other enriching perspectives"; "Thank you all for the ideas and new perspectives".*

Participants reported being 'grateful' and thankful for 'An inspirational amazing experience'.

*" It was an amazing experience"; "It was a very special week full of inspiration"*

Although most dimensions of the 'EXPERIENCE' were expressed positively, there were also some reports of more negative experiences associated with it being perceived as 'Demanding and exhausting', due to the long hours at the computer. There were also reports of 'CONSTRAINTS AND DIFFICULTIES', namely because of personal 'External constraints', like personal health issues or competing demands as well as 'Linguistic barriers' (many participants were not native English speakers), 'Technical constraints' (e.g., internet connection or limitations of the personal computers) and the challenges of the 'High multidisciplinary' (e.g., exposure to very different concepts and language). Nevertheless, these negative experiences were framed as co-existing with the positive.

*"I was exhausted and the activity was also exhausting requiring many daily hours in front of the computer". "In general terms, it was difficult"; "[difficult] but very gratifying and constructive";*

The experiences were strongly related to 'METHODOLOGY' which was very salient in the reports, described as 'Amazing, innovative' and as having a 'Role in supporting rich, deep and constructive interactions'.

*“I was simply amazed by the methods used and the emergent products following from it”; “Another high point was the methodologies used”*

The virtual spaces created to support the interaction and the way they were built were highly praised. In particular, participants appreciated the different studios supporting creative and collaborative co-construction.

*“I really liked the Miro”; “The different spaces at Miro allowed for a good integration between the participants, congratulations to the ones who idealize [designed] them”*

While some participants experienced ‘Difficulties in keeping up with the Relatoscope’ many commented on the methods and their ‘Role in supporting emergence’ (of new ideas and the collective group experience).

*“the methodologies, supported (...) showed a wide array of possible ways in which knowledge can be shared, built together”; “The methodologies that were proposed for the different form of interactions, the dialogues that emerged, the reflections that they promoted, as well as the general deep engagement of the participants and the guidance of the coordinators”*

There was an ‘Appreciation of the particular contribution’ of the ‘Coordination of the School’ namely its ‘Role in the school’s dynamics’, in supporting its emotional climate, and linked with ‘Methodology’ in promoting participant’s interest.

*“Organizing others’ ideas is not an easy task”; “In general, the dynamic of the School has been fantastic. I would like to highlight the great work and involvement of the coordinators (...) who maintained the interest and emotion of the school at all moments”*

The ‘GROUP’ as a whole was associated with ‘General positive evaluation of the group’, particularly in terms of its composition through ‘Appreciation of diversity of the group’.

While most evaluations of the School were focused on the participants ‘EXPERIENCE’, there are also some comments about its ‘OUTCOMES AND EFFECTS’, albeit less salient. In terms of outputs, the evaluation focused on the ‘Good level of integration’ achieved at the level of ideas leading to ‘Change of perspective and modes of thinking’.

*“This course has helped me to see more dynamically”; “I still hadn’t had the opportunity to think “sustainable development” or through the lens of complexity”; “You know there is a lot of discussion on how and why to leave academia, which I think is basically an arena for complex thinking. I had bought into the narrative that in order to be “normal” person, I must simplify. But it seems to me that this course has taught me that complex thinking is not only important but also very beautiful”; “I think we have come a long way in integrating ideas”.*

The School seemed to have effects in terms of the ‘Anticipation of next steps’ and the participants’ willingness to engage in ‘follow-up activities’ and the ‘Dissemination’ of its ideas. Participants anticipate collective work and the impact of the School on their individual work.

*“We are nearing the end of the week, but I am feeling something like new excitement for the next steps! Yay!”; “I can have a glimpse of new perspectives for my research”; “I can’t wait to share with others what I’ve learned here”*

Some of the perceived ‘WEAKNESSES’ of the School included mentions of ‘Limited time for mutual knowledge’ in relation to the amount of time spent together; the fact that it was mostly ‘theory-driven’ (vs. practice and question-driven) and the ‘Limited time for integration and outputs’

The composition of School’s participants was positive in ‘Appreciation of group diversity’ and ‘high multidisciplinary’ which was also associated with ‘CONSTRAINTS AND DIFFICULTIES’ as some participants experienced some difficulties in following parts of the contents.

## DISCUSSION

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In this paper, we reported how a Complex Thinking framework guided the design of an online Inter and Transdisciplinary event, in the format of a Winter School, which was intended to constitute a creative space for deep and rich interactions within and between academics and agents from civil society aiming at a collaborative and creative co-construction leading to the emergence of new, differentiated and integrated ideas. It was designed under the assumption that the enactment of particular properties of complex systems, at the level of the collective thinking processes unfolding during the School, and their embedment in its activities, would support the emergence of a productive group environment and lead to more complex outcomes, namely novel creative and abductive ideas. The design of the School was innovative in the way it attempted to operationalize a new theoretical framework for Complex Thinking (Melo, 2020b) applied to facilitating Inter and Transdisciplinary interactions in the construction of collective thinking. It integrated novel strategies to facilitate relational dialogues and support emergence. It was also innovative in the way it aimed at overcoming the limitations of virtual events, particularly through strategies that grounded the cognitive activities in embodied action and that aimed at stimulating a creative exploration of ideas. Nevertheless, the evaluation is mostly descriptive, situated at the level of the planning, and presents several limitations. The nature of the evaluation does not allow for a detailed analysis of the unfolding of the School's processes and interactions nor does it support strong inferences regarding the relation between its facilitation strategies, its processes, and its outcomes. The hypothesized relationships between the processes, outcomes, and methodology are based on the participants' reported perceptions. Nevertheless, the results of the qualitative evaluation suggest a central role of the methodology in successfully supporting rich, deep, and constructive interactions and in leading to the emergence of a collective group experience and the integration of ideas. It clearly revealed that some transformational processes occurred that elevated the School above the level of its individual participants, to the group operating as a complex system, with particular collective level emergent properties and outcomes (affective and intellectual) which had significant and meaningful impacts at the level of the individual's experiences. The experience of collective flow and emergence and its effects were very salient. The reports show the participant's surprise with the nature of the experiences afforded by the School, revealing their novelty in relation to similar events and experiences. The reported "amazement" might be associated with the fact that such salient experiences were not expected for a fully online event where participants had no previous contact and knowledge of each other.

The reports from the participants met the expectations associated with the design of the School under a Complex Thinking framework (Melo, 2020a). The careful intentional design of the School's activities and facilitation processes may have been critical in promoting unique experiences and building positive group processes (e.g., cohesion, trust, positive emotional climate, collective flow, nurturing environment) supporting deep interdisciplinary teamwork. These results add to other reports suggesting the relevance of further investigating the potential of a complex systems approach to the facilitation of scientific groups, meetings, and discussions (Jonas-Simpson et al, 2015), and show promise for a Complex Thinking-informed methodological approach. The level of the outcomes of the School was not as salient in the results as the level of the processes. This might be associated with the fact that albeit there was significant emergence of novel ideas, the level of integration of ideas achieved was not sufficient to clearly point towards new implications and applications. Reports on the limitations of the School point to the need for more time for the ideas which emerged to be more fully integrated towards clearer applications. Every participant offered creative contributions to the collective construction of ideas but the higher-order ideas emerging from the relational dialogues were not fully explored in terms of their implications and applications. This points to the relevance of adding time, in future events, to allow for this maturation. Despite these limitations, the results clearly justify future studies which should be conducted in a more systematic way, with a process and relational focus, exploring the role of the methodologies in

activating key processes and how these relate to the outcomes both at the level of the participants' experiences and the collective constructions. The results allow us to hypothesize that the methodology employed supports the enactment of key properties of Complex Thinking and that the activation of a number of key relational processes might lead to or boost the emergence of positive group experiences and the production and integration of novel ideas. We hypothesize that the particular focus on the structural dimensions of complexity associated with diversity, relationality, and recursivity were key in leading to the experiences of collective flow and emergence. In particular, the following processes might be critical: (1) a shared focus of attention combined with rich, nurturing interactions supporting both interpersonal and interdisciplinary coordination; (2) embodied actions (e.g., physical manipulation of information on the board; craftwork with metaphors); (3) a variety of modes coupling with the information created and the creative exploration of such information, through physical movement and in situated, affective, and contextualized manner, supported by a medium to "extend" and distribute collective thinking as well as affective exchanges; (4) non-linear and recursive interactions as key ingredients for the emergence of the group as a collective entity, as well as (and in tandem with) the emergence and integration of ideas; and (5) opportunities for both structured and "free" social interactions. The centrality of these processes and their relation to the specific properties of Complex Thinking that informed the methodologies described here deserve further exploration in future studies. Congruent with the hypothesis proposed by the guiding Complex Thinking framework, we hypothesize that it was not each method *per se* that was critical but that the overall methodological design weaved them together into an integrated mesh of (non-linearly) interacting strands. We believe it was the richness of these interactions and their synergistic effects that underpinned the rich experiences of emergence and collective flow, and for the affective experience of participants to be "touched". This would be congruent with the hypothesis set out by the Complex Thinking framework that the richer the interaction of the properties of complex thinking, the more complex its outcomes in terms of their differentiation, integration, and also emergence.

## CONCLUSION

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This study shows how complex relational processes and rich interactions may take place in virtual environments when sufficient attention is paid to their design and to the facilitation of the interactions between people and their ideas. This case study represents an idiographic approach with natural limitations in terms of the type of causal assertions that can be made and their potential for generalization. Nevertheless, it shows promising outcomes that warrant further attention in new and more systematic case studies, with process-focused complex research designs (Elliott, 2010, 2012), exploring how and which strategies may promote which (interaction of) properties of complex thinking and associated processes and how, and under which conditions, these lead to more complex and creative outcomes. One could consider the small size of the group and the ideographic nature of this study a limitation. While this may prevent generalization, the relevance of the study is not restricted to the facilitation of small scientific groups. It is possible that the processes activated by the facilitation may not be as easily activated in larger groups. Nevertheless, future studies should investigate the conditions under which an analogous suite of activities and processes could support similar experiences with larger groups. Finally, the experience reported in this paper highlights the role of the facilitation in Inter and Transdisciplinary scientific activities. This is an area that is increasingly recognized as demanding more attention, both in theory and in practice (von Wehrden et al., 2019), and which may open space for new critical roles for practitioners or practitioner-scientists as facilitators of scientific events and Inter and Transdisciplinary meetings and activities. It calls for the expansion of a new domain for action-based (Reason & Bradbury, 2008), applied research focused on the developmental evaluation of innovations (Patton, 2011) regarding the facilitation of scientific creativity and integration, within the scope of a Complex Thinking approach.

## ***ACKNOWLEDGMENTS***

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