Folding with Endless Potential: Origami as a Doorway to Innovation.

(Presented at the International Symposium for Structures and Materials Inspired by Origami (SAMIO), Shaoxing, China, 2023).

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Abstract:
Origami is many things; for example, at the international SAMIO conference held in China, 2023, origami inspired the following presentations:

- Infinite repeated folds by Tomoko Fuse.
- Meta-materials and robotics by Jiang Hanqing.
- Machine learning and applications by Lu Guoxing.
- Curved folding by Mitani Jun.
- Tunable meta-surfaces by Wang Yuesheng.
- Impact mitigating structures by Yang Jinkyu.
- Cogitative metamaterials by Chen Changqing.
- Deployable adaptive robots by Cho Kyujin.
- Reconfigurable origami tessellations by You Zhong.

This brief example illustrates the versatility of origami in a range of applications. Renowned origami artist Tomoko Fuse insightfully says that origami is not merely an act of creation, but of *discovery.* (Fuse 2015). In a spirit of discovery, and through our collective experience we propose it is no coincidence that origami is many things. Instead we propose this structurally implicates origami as a transdisciplinary real-world meta-material whose multiplicity resonates with deeper hidden orders of reality we can access directly through the experience of folding.

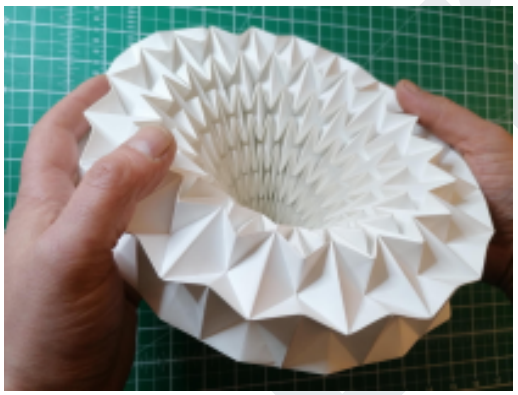
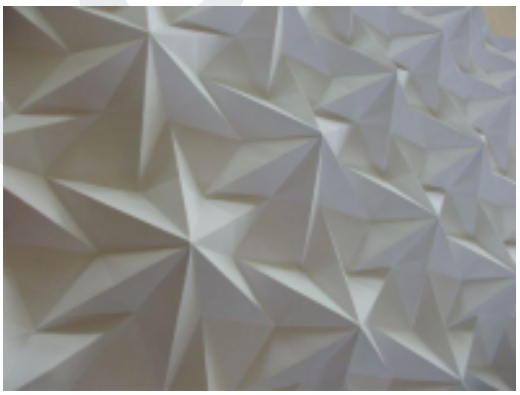
(a)  (b) 

Fig. 1: (a) Alex Pentek. Preparation for performance lecture 'Unfolding Realities', 2022, illustrating Michel Serres' idea of the vortex as a primal form that translates energy and information into itself before ultimately dissipating back into the field from which it arose. Image: Alex Pentek. Full video can be seen on https://youtu.be/AfkLOLAd6vs

(b) Alex Pentek. 'The Intimacy of Distance.' 2011. (Detail showing original star-fold pattern). Temporary paper installation folded from 10 x 1.5 m single sheet of acid free cartridge paper. Group exhibition Gravity, Crawford Gallery, Cork, Ireland. Curated by Peter Murray.

In the following, we hypothesise the fold as a process of becoming or *ontology*, through the writing of Levi Bryant [Bryant 16], David Bohm [Bohm 80], and Prof. Filipe de Salles [de Salles 21], where the endless pleated folds of origami are not only a metaphor for how things come into being, but are also an embodiment of wavelengths and holistic processes that store information and with which we can aesthetically resonate on many levels to create new

innovative outcomes.

We illustrate this by;

1. a method of artistic research called 'observationism' that allows us to see both on and beyond the surface of things, and access the above ideas and approaches through materials;[Pentek 2023];

2. a brief introduction to the ideas of Bryant, Bohm, and de Salles that form the theoretical grounding of this project.

3. a series of collaborations and publications [Hao, Supple, O'Neil & Pentek, 2023], culminating with a Living Lab pilot project at University College Cork, 2023.

The Living Lab project explores the fold as a transdisciplinary, materials-led, innovative research tool across disciplines including Contemporary Art (A. Pentek), Robotics (G. Hao), Design Thinking, (B. Supple), and Teaching and Learning, (N. Lorenzutti). By these examples, we propose the fold as a doorway to innovation, and conclude with a methodology that allows anyone to access to the endless potential of the fold.

Key Words: Origami, contemporary art, artistic research, observationism, folded ontology, resonance, transdisciplinarity, holistic processes, Levi Bryant, David Bohm, Filipe de Salles

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1. Observation-ism and the noetic turn

1.1 The noetic turn in higher education

For the past number of years, we have explored and published ways to bring artistic research methods to innovate teaching and learning in the areas of Design Thinking, Robotics, and Architecture. (See Relevant collaborations and team publications). This exemplifies a de-centralizing, contemporary shift in higher education towards collaborative and exploratory modes of knowledge, with a holistic approach known as the 'noetic turn'.

"Noetic Education [is] a constructive postmodern critique of higher education's hyper-rational emphasis as displayed in STEM-heavy curricula. Its holistic, integral approach sees humanity and the earth not as a collection of isolated facts, but a dynamic relational web. It calls us to a performance of our mutual connections of the coevolutionary body of life in what Theodore Roszak titled "the voice of the world." (Rojcewicz, 2021. 2).

1.2 Observationism

To focus and connect alternative forms of insight with academic study, we propose a method of artistic material-led research where the artist's gaze rests both on and beyond the surface of things to find other deeper meanings. (Stamm, 2008). When artists intuitively experiment with

various materials in the studio, unpredictable things are allowed to happen. In design terms, allowing 'happy accidents' to take place in this way can be called *'hill finding'*. This is the opposite of '*hill climbing*', where a proven methodology is predictably followed step by step towards a given outcome. (Do & Gross, 2007). Using materials to see both on and beyond their surface in this way and observe new ideas and approaches through a mix of metaphor, symbolism, cultural and personal resonance is a process we call '*observationism*'. (Pentek, 2023). Having flexibility to learn as new, unexpected observations and insights come to light is at the heart of this process.

Through the discipline of folding paper in this LL program, we propose a methodology where participants freely learn, practice and experience this technique for themselves, without pre-determining any single approach, such as the use of symbols, metaphor, semiotics, etc. beforehand. Instead, this intuitive choice remains with the individual after the sensory experience of folding is allowed to speak for itself. The term observationism was coined in a series of conversations between the authors and philosopher Professor Marcelo Stamm, Virginia Tech, Washington DC in 2021, which describes a material-led method of revealing personal, hidden connections between things and ideas.

Though we describe observationism as a doorway to new, holistic, and noetic approaches to knowledge, we do not lay any claim or ownership over this method. - Art theorist and critic Irit Rogoff discusses "research being an event in itself" and ways of "becoming research," by bringing unique aspects of our every day lives into artistic research methodologies. (Rogoff, 2019). In addition, whenever we bring different ways of looking at a problem by comparison or analogy, 'thinking outside the box' so to speak, we have become observationists. However, while describing observationism as already being common practice, we believe that *our novel contribution lays in combining these methods with rigid origami techniques within a living lab setting.* This unique approach provides a key to unlock potentially endless fields of new research and knowwledge. In addition to this, as outlined earlier, we believe origami is many things at a deeper level, and have chosen rigid origami for a number of philosophical, scientific and aesthetic reasons outlined in the following section.

2. A brief introduction to the ontology of Levi Bryant, the implicate and explicate order of David Bohm, and the aesthetics of Filipe de Salles.

2.1 The fold as a model for complex systems.

The ethos of the LL is to discover hidden connections between the known and the unknown, and bridge the gap between existing and potential new research. We propose that material led inquiry into the holistic, emergent properties of just three complex folded 'rigid' origami surfaces, (the herringbone/Miura fold, the Yoshimura/reverse fold and the the waterbomb fold); -provides us with enough complexity to inspire our thinking around any topic due structural processses taking place both in the act of folding and within folded surfaces themselves.

2.2 The ontology of the fold: Levi Bryant

In *The Interior of Things: The Origami of Being,* (Bryant, 2021), the fold becomes an ontological model for how things enfold and implicate information from their surrounding fields as they come into being, describing an 'orgamic' process of implication and explication of information. 'The Fold' refers to the utilisation of origami and transfers itself as both a practical and metaphorical construct across our programme of work. Bryant describes "An ontology of folds

and folding in which the minimal unit of existence is conceived as the fold between thing and field such that things interiorize the field out of which they emerge" (Bryant, 2016).

To visualise this universal folding/unfolding and emergent process, Bryant uses the images of "an infinitely expansive piece of butcher's paper that radiates outwards in all directions in time and space." - "The surface, in a word, is filled with turbulence, gradients, differences, and creases. As such, it is a mobile plane or a plane filled with all sorts of flows. In this regard, an infinite ocean with all of its depths, waves, and turbulence might be a better image of the plane of existence than a sheet of paper. We can say of the plane of existence what Michel Serres says of [Greek philosopher] Lucretius' ontology: *The world to which it testifies (...) is a place of turbulent flows, of chaos and the emergence of order by what classical metaphysics has taught us to call chance*." (Bryant, 2016).

While Bryant develops his ideas largely in opposition to the work of Graham Harman, (which we do not have time to expand on here), he finishes by describing a process of *implication* and *explication* through creative mutation and change. Here, the emergent processes that he describes are not deterministic but are unpredicatale, and owe much to the theories of physicist David Bohm.

2.3. The Implicate and Explicate Order: David Bohm

Wholeness and the Implicate Order, (Bohm, 1980), -looks at deep implicated orders of reality at a quantum level, that are explicated into a reality we experience through the senses. Bohm proposes that "Our theories are not descriptions of reality as it is, but rather, ever changing forms of insight that point to or indicate a reality that is implicit and not describable or specifiable in its totality." (Bohm, 1980).

Calling this *undivided wholeness in flowing movement*, Bohm introduces ideas of non-locality and the holographic principle where information is retained globally within the implcate order. For example, this is where an event such as a pair of quantum particles like electrons, are energized and then separated. When we measure the 'spin' of one of these particles as being 'up', we instantly know the that the 'spin' of the other wiill be 'down', no matter their distance apart. Bohm says these entangled particles do not communicate faster than light, but that both particles are part of a *single event that is counter intuitively spread over space-time,* everywhere and nowhere so to speak. (Bohm, 1980). Bohm also discusses aesthetic perception as a form of resonance; and a language experiment called the rheo-mode that bases its grammar around the verb and performative acts of becoming. (Bohm, 1980). While influential to Bryant, de Salles, and the LL ethos, we believe the implications of Bohm's ideas have yet to be understood in a broader contemporary context.

2.4 Radical Aesthetics: Filipe de Salles

The singularity of aesthetic perception: a psychic approach to artistic phenomenon based on the Jungian theory of Archetype and its correlation with the holo informational model of Karl Pribram and David Bohm, (de Salles 2021), -provides a radical new approach to aesthetics, founded on academic and scientific methods that both celebrate personal subjectivity and which see our broader underlying resonance with archetypal imagery as the unconscious and emotional basis for aesthetic experience.

De Salles combines the work of Pribram, Bohm and Jung to examine aesthetics from a radically broader reference point than has been traditionally held and/or rejected before now. Looking at

both Bohm's and Pribram's models of *non-local* information storage, de Salles introduces Jung's notion of the collective unconscious as another example of this type of process. Jung proposes we can access this information through the archetype, or repeated patterns of behavior, saying there "constitutes a common psychic substrate of a suprapersonal nature which is present in every one of us." (de Salles, 2021). De Salles describes this as a "depository of non-located knowledge distributed throughout the implicate order and accessible to anyone by resonance of psychic [psychological] energy." (de Salles, 2021)

Collectively, these ideas suggest noetic processes that may lay beyond our direct perception and point to the importance of seeing and perceiving beyond what is available to the senses. This reinforces ideas of personal resonance within the LL program as well as adding formal structure to the metaphysical aspect of our collaborative material-led enquiry of the fold.

3. Relevant collaborations and team publication outputs related to Origami:

The following list of awards and and publications document our colloborative research over the past number of years, culminating with the the Fold as a Living Lab, UCC, that was funded by the Strategic Alignemnt of Teaching and Learning Enhancement (SATLE), large grant award 2023.

Award: UCC President's Award for Excellence in Teaching 2023. (Team Award)
Hao, G., Supple, B., Lorenzutti, N., Pentek, A. (2023) *The Fold as a Site of Endless Potential: Transcending Disciplinary Boundaries through Origami.* University College Cork, Ireland.

Conference: Pentek, A., Hao, G., Supple, B., and Lorenzutti, N. (2023). Folding with Endless Potential: Origami as a doorway to innovation. *International Symposium on Structures and Materials Inspired by Origami 2023 (SAMIO 2023).* Shaoxing, Zhejiang, China, October 2023. (Extended abstract published and also invited talk delivered by Alex Pentek)

Book Chapter: Supple, B., O'Neill, S., Pentek, A. & Hao, G. (2023). Paper as teacher: Challenging Dominant Learning Norms in Higher Education through Collaborating in Origami. In S. Abegglen, T. Burns and S. Sinfield (eds) *Collaboration in Higher Education: A New Ecology of Practice.* London: Bloomsbury Academic.

Journal: Supple, B., O'Neill, S., Hao, G., & Pentek, A., (2021). Beyond paper folding: Origami and focused play to enhance interdisciplinary learning and teaching in universities. AISHE-J: The All Ireland Journal of Teaching & Learning in Higher Education, 3. DOI https://ojs.aishe.org/index.php/aishe-j/article/view/591/943

Conference: Hao, G., & Pentek, A., (2021). Art into engineering: Demonstrating how origami creativity can inform robotics education. *The 10th International Conference on Engineering Education for Sustainable Development (EESD2021)*, 14-16 June 2021, Cork, Ireland.

3.1 The Fold as a Living Lab

Based on our previous research and publictions, we successfully created a transdisciplinary "Living Lab" (LL) approach through Origami, open to both staff and students from different disciplines. 'The Fold' metaphor reflects the development of new systems of knowledge that recognise how things come into being, enfolding information from the various fields they emerge from. (Bryant 2016)

3.2 Quality of teaching

Innovation and creativity are fundamental to quality outputs in research, teaching and learning across higher education. To us, innovation occurs by mixing different areas of knowledge, under the banner of 'transdisciplinarity'. Although much needed, as a collective we argue that the current teaching infrastructures providing this crucial type of transdisciplinary engagement are sparse and newly emerging.

In order to contribute to innovations in teaching, learning and research across and within disciplines, in June 2023 we successfully implemented 'The Fold Living Laboratory (LL) programme' to **lead, generate and inspire new ideas and approaches in teaching and learning, informed by research and student collaboration**. "A 'Living Laboratory' (LL) utilises the knowledge and research capabilities of an institution's students and staff to solve issues relating to its infrastructure and practices" (Office of Sustainability and Climate Action, UCC). Seeing origami as a verb; an act of doing means the subject of origami will never be complete, making it a perfect material model of process-based philosophy.

Our holistic approach to innovative curriculum design combines artistic and academic research methods to create new systems of knowledge through a mixture of aesthetics, metaphor, and other non-linear or 'noetic' processes. Through material-learning of complex folded surfaces and by entering the 'flow state', students' personal insight and development enter into the equation and are allowed to become part of the research process. The Fold Living Lab therefore **enhances student engagement and learning, fosters critical thinking and challenges students**. As Phillip Wheelwright explains "The power of metaphor is visible when new meanings and values emerge from previously ungrouped combinations of elements, and we see more deeply into the real order of things" (cited in Rojcewicz, 2021).

3.3 Impact on student learning

Understanding the mechanism of the fold as a transdisciplinary and ontological model shows the importance of taking inspiration from dispersed practice without risk of becoming diluted by other fields. These 'origamic' processes of becoming can be described as a doorway to hidden but related fields of study. While our approach is very much 'hands on', this means at its deepest philosophical level, the Fold programme we have created searches for deeper, otherwise hidden connections which can lead to innovation on many levels both as pedagogy and praxis.

Through direct experience, this allows each individual student to refine and tailor both their own learning and research methodologies to find new outcomes and bridge the gap between existing and new innovative fields of inquiry. We believe the Fold programme can be constructively and impactfully used across all areas of teaching in UCC.

Our LL methodology was informed by a series of successful collaborative student engagements published previously (Hao & Pentek 2021; Supple, O'Neill, Pentek, Hao, 2021 & 2023), infused with the LL ethos. Using a sense of play and discovery and ideas of interdependence through the vocabulary of the fold, personal contributions by each LL participant formed the basis of this integrated teaching, learning and research approach thereby encouraging **self-reflection among students and promoting active learning**. By introducing an artistic research method we call 'Observationism' that sees both on and beyond the surface of things to see hidden metaphorical connections and meanings, and being provided with practical and philosophical means to innovate their chosen subjects, LL participants actively co-designed the research and teaching with us.

3.4 Innovative curriculum design

Our aim for the Fold Living Lab programme was to break new ground through co-design of learning, as influenced and informed by engineering, design thinking, arts-based practices, philosophy, education and architecture through which we **embraced innovative forms of assessment**. These spanned across haptic skills in folding, following and devising detailed instructions, personal development, communications skills, and weaving together disparate but related fields of academic research. No previous experience of any of these subjects from participants was required, but rather an open mind and willingness to experiment and learn from others.

The Fold LL programme was designed as a pilot that comprised of 12x2 hour hands-on, materials-led, interactive workshops facilitated over 6 weeks, focussing on a) the fold as a site of transformation; b) explorations of various complex folded surfaces at UCC led by Alex Pentek; c) innovative, co-designed and co-creational approaches/projects to innovative research, underpinned by an LL approach. A full outline of the programme and assessments can be seen in Appendix 1, and is summarised in the following flow chart.

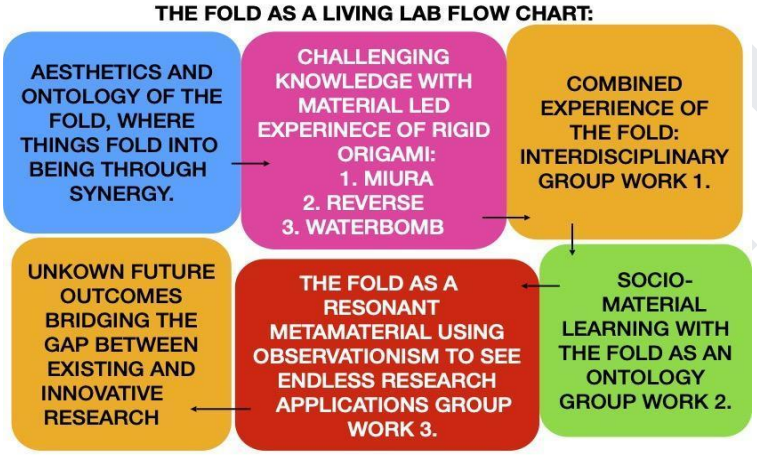

Fig.2

The following were central to the ethos of the Fold Living Lab programme:

- Developing a vocabulary of the fold, learning folds and combining these with different disciplines, ideas and concepts.
- Applying fold research and methodologies to participants' own practice
- Co-designing specific learning outcomes and assessment tasks with students as part of the Living Lab approach
- 'Solutioneering' - utilising inspiration from transdisciplinary collaborations and tools such as the camera obscura to challenge thinking around the sustainable development goals. (See sample video output from one student group.)

3.5 Collegiality/Leadership

Support through SATLE funds (2023, large grant; 2019, small grant) **has allowed us to collaborate** in the disciplines of Art, Robotics and Design Thinking, and to publish extensively on these subjects. As a collective we have worked as **champions and leaders within our own disciplinary practices as well as across disciplines** to promote this cutting-edge work.

In June 2023 we collaborated to bring our first pilot (phase 1) of the Living Lab into fruition. Participants were drawn from across the whole UCC community; a total of 12 (including UCC staff members and PG students) completed the pilot with a second phase planned for January 2024.

The completed first phase of the Fold LL programme has led to the several key deliverables:

1) Staff training: three members successfully completed the European Network of Living Labs Virtual Learning Lab 2023 - spring edition.
2) Extended abstract published in SAMIO 2023 (November 13-15, Shaoxing, China) and Alex represented to deliver an Invited Talk in Origami Art and Mathematics I Session (https://www.samio.org/program; see images below of contributions)
3) Data generated by students including artefacts and assessment tasks to reflect their learning outcomes (LO): a) Subjective experience of origami as transdisciplinary learning; b) Materials informed, experiential, reflective learning; c) Co-design and co-creation of learning through Living Lab
4) A showcase/exhibition day organised on 27 November, 2023, detailed below:

Registration and welcome speech by the fold team	09:15-9:30
Keynote 1 by Dr Matthew Gardiner, ARS Electronica	09:30-10:15
Keynote 2 by the Fold Team	10:15-10:55
Tea breaks social networking	**10:55-11:15**
Invited Presentations by Fold project students and others	11:15-12:30
Panel Discussions	12:30-13:00
Lunch	**13:00-14:00**

3.6 Scholarly approach to Teaching

Our scholarly thought has been influenced and inspired by **new pedagogies, new ways of thinking about origami, materials, movement, art and aesthetics, as informed by scholars** such as Assis and origami and metamaterial (2017), radical theories of aesthetics (de Salles, 2021) and reflective practice (Schon, 1992).

We introduced origami as a mechanism for the Living Lab model to solve real world problems, connected to the sustainable development goals. We see origami as a process-based philosophy that reaches beyond practical transdisciplinary applications into new unrelated fields. Seeing aesthetics as a form of psychological resonance with collective ideas, this holistic approach takes aesthetics as a first philosophy. Through the interconnected aesthetics of origami this combined, material-led method offers an alternative approach that is based on resonance and sociomateriality. In the Fold Programme we showed how anyone can access this untapped knowledge using just three rigid origami folds: The Miura fold, the reverse fold and the water-bomb fold. More than a means to an end: Origami is a medium and process of artistic expression and discovery. (Fuse 2015)

Our focus on assessment outputs as a way of exploring solutions in relation to the Sustainable Development goals is also an important alignment with UCC's Pillar 2 'Research and Innovation' (point 2.1, UCC 2022).

3.7 In summary - why the fold as a living lab (LL)?

- Transdisciplinarity = innovation
- A playful accelerated learning process with a rapid iteration/prototyping cycle
- Folding as an emergent, bottom-up process tailored to have a personal resonance with participants' own research, learning and teaching
- Deep insights through material-led research and 'observationism'
- Bridging the gap between existing research and innovation potential

- Holistic approach to problem solving inspired by rigid origami surfaces
- **Sustainability** through innovative pedagogy and future technology
- Unknown outcomes allow participants to explore the fold in new ways that are mutually beneficial to their own research and practice and the Living Lab concept
- Fluid thinking, flexibility and adaptability through collaboration
- Real-life problem solving with the Sustainable Development Goals.

Fig.3 Alex Pentek introduces the UCC 'Fold as Living Lab' team at the International Symposium for Structures and Materials Inspired by Origami (SAMIO), Shaoxing, China, 2023.

Fig 4 Panel discussions allowed latest origami-inspired theories to be shared with an international audience. (World renowned origami artist Tomoko Fuse shown sitting on the right).

Fig 5 On the second day of the symposium, Alex demonstrates the fold as a metaphor for information storage, where 'everything changes, and nothing is lost,' bringing the Fold as Living Lab ethos to new audiences.

3.8 Feedback from participants, collected via end of programme survey

In this section we provide the following: **images** from the Fold Living Lab, **feedback** from end of programme surveys, and **samples** of reflection diaries. These all serve as evidence of our innovative curriculum design, impact on student learning, collegiality/leadership and scholarly approaches to teaching. Our democratic space of the **class Padlet board** is also a rich repository of collaborative thought and inspiration. Note that we have received ethical approval via UCC's SREC to publish data in relation to this study.

Fig.6 The Fold as a Living Lab, UCC, began by introducing a vocabulary of complex rigid origami folds that were later combined and used by the group to gain deep insights in a range of subjects ranging from Design Thinking, Robotics, Law, and Microbiology.

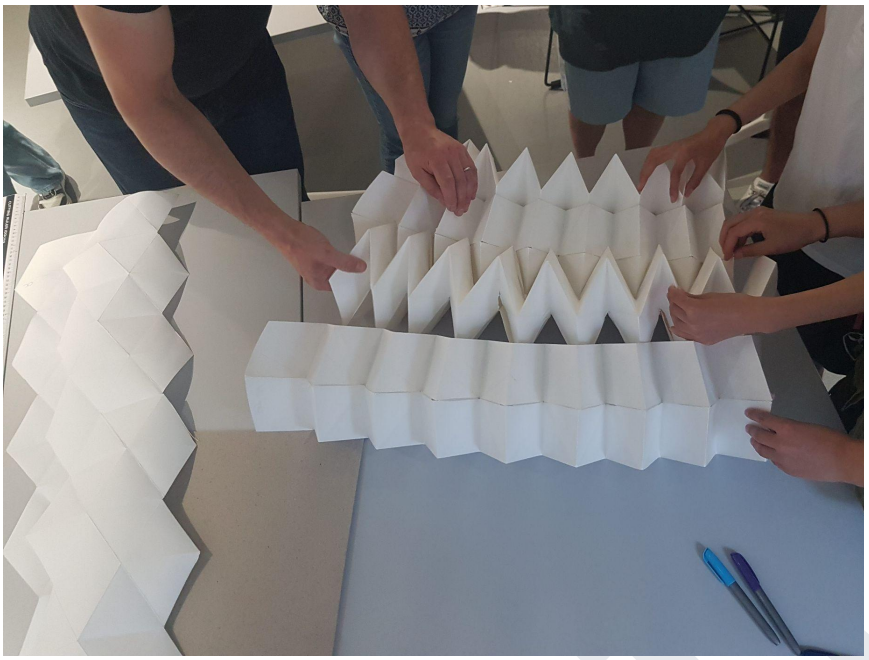

Fig. 7 Creating 'zipper tubes' (above), The Fold as Living Lab allowed participants to explore sociomaterial aspects of paper folding in group tasks. Thinking through materials fuses artistic and academic practices to create new outcomes through the endless potential of the fold.

Fig.8 Following group discussions around Ideas of aesthetics and resonance with collective experience, (and where the chemical Benzene happened to be mentioned), the group (above) then freely created a combined fold that resembled the image of a serpent eating its own tail ('Ouroboros', the symbol for infinity). The group later learned August Kekule wrote down the circular compound for Benzene following a dream of Ouroboros in 1865. (de Salles 2021)

Overall it was a really positive experience and personally very inspiring. I think there's a lot I could take away and apply into my own personal interests as well as my professional ones.

Alex is an inspiring teacher, patient and enthusiastic.

I have learned how to expand my mind and my hands-on skills have also been improved.

I feel that I learned and experienced many different things throughout the programme. Firstly, I learned a lot of basics of folding and origami in a different way, through listening, observing and handling the materials. Secondly, I think I got a better understanding of how I like to learn. I definitely prefer hands-on learning and I realise that I like to take my time digesting and reacting to ideas and materials. Thirdly, I think I learned more about the benefits of inter/trans disciplinary groups and that while on the surface putting together people of vastly different backgrounds may seem strange, the differences in opinions and speed of brainstorming has an extremely positive effect on a group work activity.

Very well facilitated by Alex and Guangbo, well-paced, well- explained with encouragement. Thanks to all involved.

3.9 Feedback from participants' reflection diaries

I think the folding lab has been an initial step, to open eyes into a field in which I have no previous knowledge. It creates curiosity, and curiosity is essential for research and [toexplore.

The experience has put me in the role of the student and make conscious of my own difficulties and challenges when approaching a new field in which I had no previous experience. It also creates a place for concentration, attention, and shared reflections. It made me stop, and re-think how my classes and research can be benefitted from what I am experiencing here.

Alex's teaching of the folds was an eye-opener to the fact that measurement, rulers and pencil lines were not necessary. Just folding was enough. This is an insight with charm for its elegant minimalism. Like a chisel: put it in the right place, hit it, it works. Nothing further needed. Favourite folds I brought home and taught my husband, or simply repeated, at scale. This was good digestion but also addictive. Big problem to stop folding a piece before it was finished.

The major lesson I have learned from "The Fold" workshops is that origami is a mindful activity. In folding, you find yourself connected to the moment, your mind fully occupied and so unable to ruminate on the past or ponder the future. When you're focused on the here and now, you give your mind a break, which helps lift mood and bring a fresh perspective. This mindful approach would be of pedagogical benefit to students I teach in Cork prison.

The Fold program has equipped me with a novel way to visualize complex biological data. I will continue to cultivate a spirit of open-mindedness, appreciating the value of diverse perspectives in problem-solving. I'm also inspired to explore further the concept of data physicalization, and how it can make my research more understandable and impactful. This process has underscored the potential of transdisciplinary approaches, and I look forward to applying these lessons in my future work.

The Fold program has not only provided me with a fresh perspective on data visualization but also stressed the value of diversity and collaboration. I am excited to bring these insights back to my computational biology work, to use what I've learned to enrich my research and broaden my approach. Just as importantly, this experience has reinforced my belief in the importance of

community. Working on the mural project, interacting with the wider Cork community, and seeing first-hand the potential impact of our work has underscored the importance of societal engagement in any discipline. I'm eager to continue developing this aspect of my work, connecting more deeply with my community, and finding ways to use my skills and knowledge to contribute in a meaningful way.

4. Conclusion; accessing the endless potential of the fold

This paper outlines a methodology of artistic research that we call 'observationism,' which takes aesthetics as a first philosophy. This alternative, playful approach to material-led research, (in this case origami), - uses a blend of metaphor, symbolism, and analogy to see both on and beyond the surface of things and gain deep insights into a range of fields. Using a mixture of this methodology and academic research, we show how our choice of rigid origami as a platform of enquiry is grounded on a number of contemporary philosophical and scientific texts.

The fold as LL program uniquely combines the above methodologies and ideas to access previously untapped research potential and bridge the gap between existing and innovative new research. In addition, we see this approach being parallelled and vindicated by the work of (Assis, 2017) where certain origami folds are viewed as 'real world meta-materials' that can go through phase changes from structured to chaotic forms; and also the work of (Rojcewicz, 2021) who describes a 'noetic turn' in 3rd level STEM subjects, shifting away from static, centralized learning towards new de-centralized, holistic, and participant led approaches to knowledge.

We broadly demonstrate through previous research and publications that this methodology has already been fruitful. With the Fold LL pilot program we test this methodology for the first time in a controlled laboratory classroom setting with participants as collaborative research partners. Here, the findings and data show strong qualitative and positive evidence as to the benefit to this new approach in a range of research areas that include Design Thinking, Robotics, Engineering, Law, and Microbiology. We believe there are no limits to the potential applications of this program across all subjects. Only as these processes manifest into new lines of enquiry and research by participants over time can the quantitive outcomes from this first phase of the LL program be known. We invite anyone interested in this research to adopt the entirety or any part of the fold LL program that resonates with them, and to collaborate with us in accessing and discovering the endless potential of the fold.

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