Paper as teacher: Challenging dominant learning norms in higher education through collaborating in Origami

Short 200-300 word bio for each author

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Dr Briony Supple is a Senior Lecturer in Design Thinking Pedagogy and Praxis at the School of Education, UCC and a Lecturer in Learning Enhancement in CIRTL. She has worked for several years in academic development and has published extensively on inclusive, learner-focussed approaches to teaching, learning and assessment and innovations in learning spaces. Briony's current practice includes creative, hands-on approaches to teaching and learning in higher education through facilitating Lego Serious Play workshops and collaborative applied rigid origami practices.

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Siobhán O'Neill is a Research Support Officer in CIRTL and a PhD Candidate in the School of Applied Psychology, UCC. She is an experienced researcher, having worked on a wide-range of research projects including curriculum and intervention design. Her PhD work explores daily life experiences and psychobiological wellbeing which frames her research practices. Her current research interests include the exploration of innovative and creative approaches to teaching, learning, and assessment with a focus on Universal Design for Learning and inclusive assessment frameworks.

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Alex Pentek is an internationally renowned artist with large scale site-specific artworks in Ireland, Uk, Australia, Canada and the US, that has featured in global news. His temporary gallery works have been shown in Ireland, UK, Germany, Australia and the US, where he explores rigid origami as a medium to explore contemporary scientific and philosophical ideas in cosmology and physics. His origami-inspired solo exhibitions include 'Folded Space' at the Royal Hibernian Academy Gallery, Dublin, Ireland, 2018, and 'Implicate & Explicate Order', Uillinn: West Cork Arts Centre, Co. Cork, Ireland, 2019. He has collaborated with Dr. Guangbo Hao, UCC to research origami as a materials led tool for robotics education, co-authoring 3 papers on this topic and is also currently studying for an MFA in Art in the Contemporary World at the National College of Art and Design, Dublin, Ireland.

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Dr. Guangbo Hao is a Senior Lecturer with University College Cork, Ireland. His research areas lie in design of compliant mechanisms and robotics and their applications in precision engineering, energy harvesting and biomedical devices. He obtained his PhD degree in Mechanical Engineering from Heriot-Watt University in 2011. He is a member of ASME and an elected member of the ASME Mechanisms and Robotics Committee. He is serving as the Editor-in-Chief of the IFToMM affiliated journal: Mechanical Sciences and the Associate Editor of ASME Journal of Mechanisms and Robotics. He has won some accolades including the 2017 and 2018 ASME Compliant Mechanisms Awards in a row. He has published over 160 peer-reviewed papers. Recently he has developed a strong interest in demonstrating how Origami creativity can inform Robotics/Engineering education.

Introduction

This chapter is a collaborative case study between two academic faculty members from teaching and learning (Supple and O'Neill), an artist (Pentek) and a senior lecturer in engineering (Hao), which highlights the use of origami to challenge dominant teaching norms in higher education. The chapter presents the theoretical and philosophical underpinnings of our work, followed by an outline of two collaboratively driven, practice-based examples of origami in 1) engineering teaching for students and 2) a teaching and learning workshop for lecturers. We then present evidence of how our work challenges dominant systems as guided by our conceptual framework.

The dominant systems which are still found in higher education institutions today are based largely upon the outdated 'master-apprentice' model (Chabot et al., 2013) - the lecturer as 'sage on the stage', and instruction and assessment which is heavily cognitively and linguistically biased (Troxler, 2015). Our collaboration challenges these dominant systems and practices. We are influenced by work on Piaget's (1973) notion that 'To Understand is to Invent', and Papert's ideas regarding Constructionism (Papert & Harel, 1991). We also draw on Vygotsky where learning happens "in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Our work is also informed by inclusive practice in education (Basit & Tomlinson, 2012; Slee, 2011; Supple & Agbenyega, 2015), material methods (Woodward, 2020) and the power of play in higher education (James & Nerantzi, 2019; Hao & Pentek, 2021).

The word 'art' has long been associated with skill; thus the art of a subject can also mean the total skill or gestalt of that subject (Read, 2014). Encompassing the entire programme while remaining open to inspiration from outside fields of knowledge and expertise, art is therefore an invariably decentralized resource in the teaching of disciplines (Hao & Pentek, 2021). Arts-based practices are the catalyst for further decentralising the dissemination of knowledge and learning via direct, hands-on, materials led experience. Artistic design incorporates playful materials-led experimentation to discover and resolve new challenges. This is in contrast to traditional, interpretive knowledge based approaches often found in engineering (Hao & Pentek, 2021).

Table 1 below is the conceptual framework governing our work. For the purposes of this chapter we focus on sub-themes pertaining to 'Collaboration'.

Table 1: Conceptual Framework: Dominant systems vs arts-based practices

Dominant Systems (outdated)	Arts-based Practices (future trend/modernised)
Assessment	
1. Failure is 'bad'	Failure is part of learning
2. Text-based	Flexible mediums of expression/materials
3. Focus on outcomes from learning over process	Focus on processes of learning over final outcomes
Collaboration	
4. Learning should be 'serious'	Learning as playful, fun and curiosity sparking
5. Disciplinary silos	multi/trans/interdisciplinary
6. Dendritic centralised power: the lecturer is the 'all knower'	Rhizomatic decentralised learning power dynamic. Collaboration/learn from others outside of the discipline/learn from students/peer-to-peer

Practice-based examples

1) Origami and robotics engineering

The Origami-led course in robotics engineering is delivered by a team (artist, Pentek and Mechanical Engineer, Hao) and includes three parts: a 2-hour lecture focussed on the theory of Origami and engineering applications and the kinematic mapping between Robotics and Origami and a 'warm up' folding session; and two intensive hands-on workshops of 2.5 hours each, focused on Origami. All teams starting from the same foundation folds (such as Miura fold and Waterbomb fold) aimed to create different Origami designs in the end. Each team is required to use at least two different folds in their final finish using their creativity with innovation in consideration. Origami-based projects also feature as continuous assessment in the Advanced Robotics module (Hao & Pentek, 2021) and these approaches continue to be developed (Liang, Hao, Olszewski & Pentek, 2021).

Image 1: folding demonstration

Image 2: students working on Miura folding

(Images courtesy of Hao & Pentek, 2021[1]).

2) Origami for teaching and learning

The hands-on workshop was designed to inspire academics across disciplines to engage in the process of origami and to use this as a vehicle through which to reflect on their own teaching. The aims of the session can be seen in Table 2 below. The workshop design was predicated on emerging evidence supporting the use of materials-led approaches (also known as 'making') as a tool for teaching reflection (e.g. Hughes, Morrison & Dobos, 2018; Kjällander, Åkerfeldt, Mannila & Parnes, 2018).

Table 2: Workshop aims

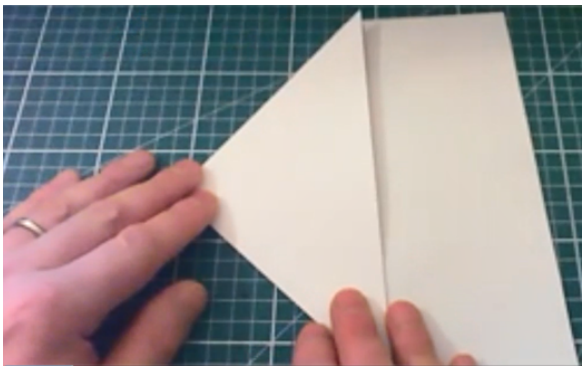
Describe	Create	Demonstrate	Evaluate	Discuss
Describe disciplinary applications for origami	Create a small origami installation based on a rigid origami fold	Demonstrate an origami fold to peers	Evaluate the process of origami for their own teaching and learning context	Discuss hands-on learning approaches such as 'making' and their application in teaching and learning

[1] Note to editors: Reminder re copyright of images. Author 4 (Hao) checked with the original place of publication and they informed him that he owns the copyright so is therefore able to reuse the images. Just double checking that you don't see any issue with this?

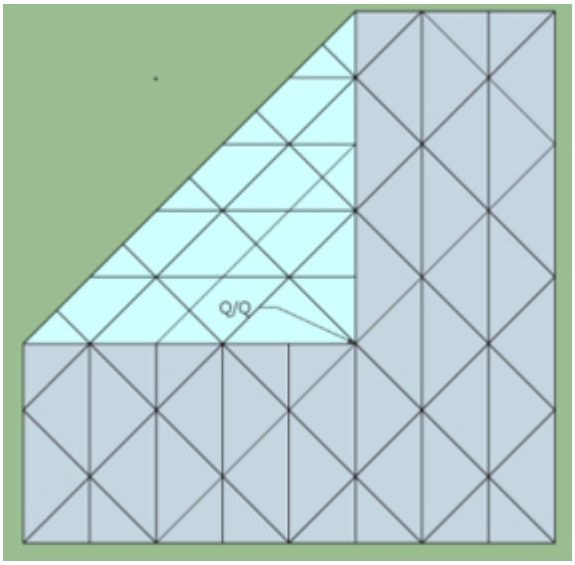
Participants were introduced to some of the applications for origami by both Pentek and Hao and guided through elements of the creation of the Miura fold by Pentek. Supple and O'Neill prompted participants to stop and reflect: What could a humble piece of paper teach them about the processes of interdisciplinary learning? The Evaluate and Discuss phase allowed participants to share their learning in a collaborative setting, reflecting on their own experience with origami and learning from other participants. This multi-person perspective fostered discussions on the diversity of students within classroom settings and collaborative 'making' as student engagement.

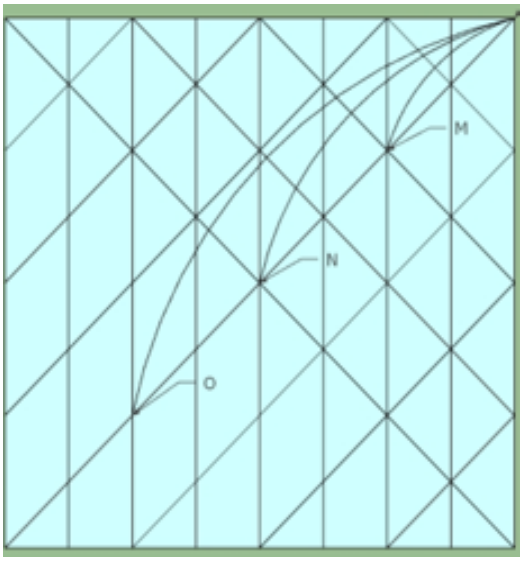
Due to COVID-19 this workshop was delivered via Zoom, with a live-video stream capturing the folds by Pentek, (Image 3), supplemented by diagrams of the folds, shared on screen (Images 4 &5).

Image 3: Live folding by Pentek during virtual workshop



Images 4 & 5: Supplemental diagrams by Pentek





Findings/feedback

Feedback was sought from a) students in the origami and robotics engineering sessions (Hao & Pentek, 2021) and b) from participants from the teaching and learning workshop. We categorise this evidence of our collaboration as per themes 4, 5 and 6 from our conceptual framework.

Theme 4: Learning as playful, fun and curiosity sparking
Hands-on learning is creative and playful, yet 'play' is not often associated with higher educational contexts. However, the processes of play are inextricably linked to experimentation, design and encouraging 'flow' states (Csikszentmihalyi, 2011) .

Engineering students:
I wanted to thank you for organising such an imaginative, original and very effective workshop. I learned a lot and thoroughly enjoyed it.

I have learned lots of Origami techniques as well as stimulated my imagination from it.

Workshop participants:
It was a brilliant way to spend a couple of hours on a Monday, in between lecturing and working on assessments, I feel quite revitalised afterwards.

I have few opportunities to work with my hands in my work. While I understand academia as a form of creative labour, there is something thrilling about putting myself in my students' shoes by learning something new and creating something in the process. It's great to feel the frustrations and satisfactions tied to the learning process.

Theme 5: Multi/trans/interdisciplinary
Origami has been used for designing foldable structures/robots by engineers (Nishiyama, 2012; Zhakypov et al., 2018), for "teaching geometry, thinking skills, fractions, problem solving, and fun science" (Hao & Pentek, 2021, p. 1). Origami therefore naturally lends itself to being multi/trans/interdisciplinary.

Engineering students:
Before taking this workshop, I thought that Origami is only about paper folding aimed to create something to play. I had never thought about the relationship between Origami and robotics application.

It was a unique experience to have some hands-on training with Origami folding patterns….I found it very fascinating to do some easy folds, that patterned over a sheet of paper, [and how this] would greatly modify the mechanical properties of this paper.

Workshop participants:
The workshop also stimulated thoughts on possible teaching activities using origami for energy engineering examples

We often refer to Origami in our teaching of both architecture and engineering students, and I feel there is an untapped potential interest for such workshops to be offered to students in both schools.

Theme 6: Decentralised learning
Another important part of the collaborative nature of origami practice as we have fostered is that of decentralised learning - situations where participants learn from one another and work together. Hands-on activities challenge learners to work with peers and "develop their own questions... discuss ideas, recognise and articulate problems that they meet along the way, look for solutions, evaluate progress, hypothesise, test and re-test…" (Harris et al., p. 8).

Engineering students:
There were also practical experiences in folding papers, and that experiences increased the student involvement and understanding.

In the last lesson, we were split in groups to figure out our Origami structure and solicited to be creative. It was a good way to work together and share ideas.

Workshop participants:
I learnt a variety of practical and aesthetic uses for rigid origami as well as some new techniques for modelling paper. I also enjoyed hearing some interesting comments from other participants about how they could apply this type of workshop in their own disciplines and teaching modules.

Great to feel the swap from teacher to learner, it gave me a sense of freedom to be able to follow the instructions and do the work with my own hands.

Conclusions and recommendations for praxis

Our collaboration has resulted in using Origami as: 1) a lab-based (design) tool to analyse and design robots within the discipline of engineering and 2) hands-on tool for reflections on learning and teaching approaches across disciplines. We continue to build our collaborative outputs, our aims going forward relate particularly to play, and pedagogy.

Origami for collaborative play & praxis
We aim to:

- Bring the language and ethos of 'playful learning', curiosity and experimentation into higher education via further collaboratively driven, hands-on workshops. In doing so we want to encourage interdisciplinary learning by encouraging a focus on non-traditional notions of higher education and learning through process and experimentation. We encourage others to do the same.

Origami for collaborative pedagogy & praxis

We aim to:

- Leverage the rich interdisciplinary, materials-led potential of origami in order to inspire educators to create learning opportunities for their students (An ongoing focus by Liang, Hao, Olszewski & Pentek, 2021).
- As a consortium, develop tools to help educators design their curriculum to include interdisciplinary, hands-on learning opportunities.

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