

Interdisciplinary Research Unmasked: a new curatorial model for multi-audience engagement

Susan Liggett and Mike Corcoran*

Abstract

This paper proposes a new curatorial model, presenting research as practice and combining publication with discussion and public exhibition, as a valuable tool in overcoming the communication challenges of contemporary interdisciplinary research, when the following criteria are met:

- 1. That the information to be communicated is technical and discipline specific.*
- 2. That communication is between technical and non-technical multi-discipline audiences.*
- 3. That high-level analysis of interdisciplinary opportunities is required.*
- 4. That public and stakeholder engagement with interdisciplinary research is required.*

The proposed model is situated with respect to theoretical models of communication and assessed with respect to its application at Carbon Meets Silicon, curated by Liggett and Corcoran at Oriol Sycharth, Wales, UK as part of the International Technologies and Applications Conference 2017. Three of the works presented through Carbon Meets Silicon are examined with respect to their alignment to the model's criteria, and performance against its intended outcomes.

The paper suggests applications of the new curatorial model, and further research required to support its development.

Keywords: *Art/science, collaboration, communication, curating, interdisciplinary, multidisciplinary, public-engagement, trans-disciplinary, research as practice.*

The challenge of communication in interdisciplinary research

Interdisciplinary research can be a slippery concept to pin down.

As the United States National Science Foundation observe, "the definition of a 'discipline' and discussions of the varieties of interdisciplinary, multidisciplinary, and trans-disciplinary research have occupied much scholarly debate. Although there is not always agreement on these definitions, it is clear that areas of research are dynamic -- continually emerging, melding, and transforming. What is considered interdisciplinary today might be considered disciplinary tomorrow." (National Science Foundation, 2018). They go on to propose the following, from a United States National Academic Report, as a pragmatic working definition:

"Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized

knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice." (National Academies, 2004).

The development of new knowledge when conducting research can be more productive when working across disciplinary boundaries: global challenges are better understood with a diverse team of researchers working on solutions together (Liggett and Corcoran, 2017). Not only that, but it can be argued that when existing disciplines become well established, that brand-new disciplines emerge along the boundaries of existing ones, rather than within them (Kuhn 1962).

Communication is essential to all research, interdisciplinary or otherwise. When we communicate, we say something, to someone, for some reason, by some process. More specifically, we impart or exchange information, with another individual, group or entity, motivated by internal and external, conscious and subconscious influencing factors, through the use of mutually understood signs and

semiotic rules. In their 1949 paper 'A Mathematical Theory of Communication', Claude Shannon and Warren Weaver proposed a model of communication, from which many contemporary models are derived, extrapolating a general theory of communication from the process through which radio technologies function (Shannon & Weaver, 1949). The model identifies five parts from which all communications are comprised, namely:

1. An information source: which produces the message to be communicated.
2. A transmitter: which encodes the message into appropriate signals for transmission.
3. A channel: the medium through which signals are transmitted. As signals propagate through the channel, they are vulnerable to 'noise', interference which can block, interrupt or distort signals.
4. A receiver: which decodes the signal to reconstruct the original message.
5. A destination: the individual, group or entity for whom the message is intended.

Take this paper. We the authors are the information source, having produced each of the messages being communicated. The transmitters for the communication include our faculties of language, translating our messages into English prose, and our word-processing software, translating this prose into binary code, compressed and suitable for electronic dissemination. One channel of communication is the world-wide-web, with the paper accessible internationally (but at risk of interference from sources of noise including coding errors, software crashes and computer viruses) and the other channel is through physical print, produced and disseminated by our publisher (and susceptible to sources of noise ranging from mis-prints to spilt cups of tea!). E-readers, laptops, pairs of glasses and crucially the readers themselves all operate as receivers, reconstructing our intended messages, and as you read this and reflect on its assistance to your own research and practice, you are the intended destination of our message!

The model provides a simple and useful tool for assessing any communication in terms of its constituent parts, and Shannon and Weaver proposed three levels of communication

problems which could be specifically investigated with respect to each.

1. Technical problems: relating to how accurately messages can be transmitted.
2. Semantic problems: relating to how precisely meanings can be conveyed, and
3. Effectiveness problems: relating to how successful received messages are in bringing about their desired effects.

In interdisciplinary collaboration, communication presents a unique and significant challenge, one which becomes apparent when each of these problems is considered in turn.

Technical problems arise in virtue of the multiple and diverse information sources which communication requires, and the many transmitters and channels through which this communication must pass. The information sources are the researchers themselves, often eclectic mixes of theorists and practitioners, each providing highly technical, discipline-specific insights. These insights are transmitted through many iterations of papers, demonstrations, performances, discussions and otherwise, before the work of a researcher in one discipline finally enters the consciousness of a researcher in another (consider what it would take for the latest research in dance to reach the desk of a professor in physics). With each iteration, comes an increasing probability of 'noise': degradation, mistranslation, and dilution of the message: 'the Chinese Whispers' effect.¹ These researchers can also be susceptible to inherent subject bias. As Ehud Shapiro observes "Scientists who leave the safe haven of their home discipline to explore the uncharted territory that lies outside and between established disciplines are often punished rather than rewarded for following their scientific curiosity." (Shapiro, 2014).

Semantic problems arise in virtue of the lack of universally understood language amongst all stakeholders in any interdisciplinary research process. The definition of 'interdisciplinary collaboration' offered by the US National Library of Medicine even includes

¹ Chinese Whispers is a popular children's game where a message is passed in the form of a whisper from one player to the next, until the final player to receive the message announces it to the group and compares it to the original. Typically, many errors will enter the message throughout its transmission.

reference to “differences in patterns of language usage in different academic or medical disciplines.” (US National Library of Medicine, 2018). Over and above the international make-up of the typical research group, each discipline develops its own highly technical vocabulary and standard points of reference, with accurate interpretation often contingent upon contextual understanding of the wider subject, and translation invariably coming with a loss of precision. Funders, policy makers and members of the general public are also often key stakeholders in interdisciplinary research projects, with each requiring yet further translation, simplification and dilution of precision.

Effectiveness problems arise, in part, due the many competing motivations for communication within interdisciplinary research, with each communication often seeking to achieve multiple objectives. We propose that communication takes place between, but is not limited to, the following audiences, with the following broad motivations:

- Intra-research group: researchers from various disciplines, comprising one interdisciplinary research group, will communicate with each other to establish research aims and objectives, define and measure outcomes, compare, analyse and evaluate results and to facilitate collaboration in the delivery of given research tasks.
- Inter-research group: researchers and research groups focussed on activity within one discipline will communicate with those focussed on activity in another to identify common objectives, synergies, scope and motivations for forming interdisciplinary teams and projects.
- Researcher-stakeholder: researchers will communicate with senior management within their respective institutions, with funders, policy makers and other stakeholders, to ensure continued support in achieving their research goals.
- Researcher-public: researchers will communicate with the general public, to garner popular support for their work, to raise the profile of their teams and institutions, and to influence attitudes and behaviour.

In their guidance for project participants in the Horizon 2020 research programme (European Commission, 2014), the European Commission suggest that over and above achieving the core research objective themselves, communication is essential to:

- Increase the success rate of proposals.
- Draw the attention of national governments, regional authorities and other public and private funding sources.
- Attract the interest of potential partners.
- Encourage talented students and scientists to join partner institutes and enterprises.
- Enhance reputation and visibility at local, national and international level.
- Help the search for financial backers, licensees or industrial implementers.
- Generate market demand for the products or services developed.

To achieve such objectives can be complex, nuanced and highly resource intensive.

The new curatorial model: Show-Talk-Do

Though the challenges of communication in interdisciplinary research are considerable, they are not insurmountable. The ‘Show-Talk-Do’ model presents a clear and simple way to achieve multiple, simultaneous communication objectives within interdisciplinary research environments, in a way which optimises resources, removes subconscious biases, and provides a landscape of equality where research can be introduced, analysed, and the scope for collaboration assessed.

In its idealised form, the model comprises three steps, as follows:

Step 1: SHOW IT

Firstly, an exhibition should present research as practice.²

All exhibitors should be researchers (including those from both intra and inter research groups) operating within the scope of a defined project. For example, this may be researchers all connected by their roles in a

² ‘Research as Practice’ should not be confused which ‘Practice as Research.’ Where Practice as Research incorporates practice into methodology or research output, Research as Practice sees methodologies and research outputs presented as artefacts, irrespective of how they were created (Adams, S. 2014).

multi-discipline, multi-agency funded project or researches connected by their interest in a common theme or contemporary issue. The 'research as practice' presented, should be the organic products of ongoing research. This will be specific to the researchers or research groups, and may include (but is not limited to):

- Work in progress including artworks and performances.
- Documentation of practical research activities.³
- Visualisation of 'live' research data.⁴
- Interactive demonstration of a process or procedure under development.
- Artefacts created through the research process, though superfluous to the research objectives in and of themselves.

The exhibition should be curated as to allow each work to be considered in isolation, as well as all considered in combination (that is, a curator should not deliberately arrange and combine works so as to create new hybrid-pieces, with new and additional meaning imposed upon them). Exhibit labels (if used) should not refer to exhibitors' subject specific disciplines, their academic status or seniority, and should provide no information about the research presented.

The exhibition should be made open and accessible to all the defined project's stakeholders, including researchers, funders, policy makers, and the general public. Visitors (including the exhibiting researchers themselves) should be encouraged to explore the exhibition with an open mind and reflect upon their spontaneous thoughts and feelings regarding the individual works and the combination.

Step 2: TALK ABOUT IT

Next, exhibiting researchers should discuss with one another, the context in which their exhibit (and by proxy, their research) is situated. This discussion should be semi-structured (for example, taking the form of a facilitator led symposium), be located within the exhibition itself, and obey the following ground rules:

³ This could come in any form, but include, for example, images and video footage of lab or field work.

⁴ 'Live' in the sense of still being in development or undergoing a process of change, as opposed to 'static' data, which is finalised and no longer subject to change.

1. Keep it simple: Unless understood by the whole group, to the same degree, all and any highly technical and subject specific language and reference points should be avoided.
2. Talk around your research: Discussion should not simply offer a narrative account of a research methods and findings, but address why the research activity was necessary and desirable, what has influenced the research activity as it has unfolded (inclusive of personal, institutional, political and economic influences), where the research is situated (with respect to the wider knowledge base and discipline), how the research activity has impacted upon the research team (over and above the direct research findings themselves).
3. Talk around the room: Discussion should be an interactive dialogue, with audiences asking questions both to any given speaker, and to one another with respect to a given speakers comments.
4. Be fair: Each individual in the discussion must be treated equally, given equal time to talk, and be given fair hearing by their audience.
5. Be positive: Discussion should be positive, genial, and focussed on sharing experience and developing common understanding.

It is recommended that discussion is recorded and stored for the future reference of the group (and if desired, made available as an open resource for wider project stakeholders and the general public). Participants should be encouraged to reflect upon the relationship of their initial thoughts and feelings regarding exhibits, to the context in which each has been discussed.

Step 3: DO IT

Finally, research papers should be made available to researchers (and wider project stakeholders and the general public as appropriate). Papers should relate directly to the practice exhibited, and the context discussed through steps one and two. Papers may include technical, subject specific language, if it is essential to accurately and precisely designate elements of the research process, findings and

applications, but it is recommended that all such terms are clearly defined upon first usage.

Participants are encouraged to study in-depth, the papers which resonate with them in virtue of their thoughts and feelings regarding the exhibits presented, and discussions surrounding them, and to reflect upon the scope for, and potential benefits of, collaboration between themselves and the papers' authors.

THE SHOW-TALK-DO MODEL

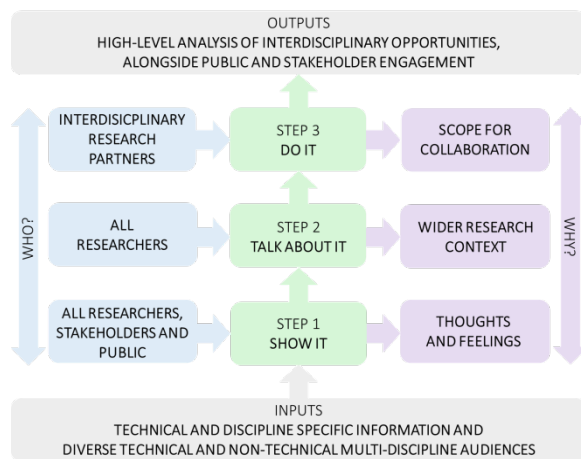


Figure 1. The Show-Talk-Do Model

When this simple process is followed, the technical, semantic and effectiveness problems encountered in interdisciplinary collaboration can be appeased.

Technical problems are addressed by removing the traditional silos of research and research dissemination. All researchers are brought together, on neutral ground as equals, and initial responses to research are elicited through subjective experience, devoid of inherent bias. The process involves only three transmitters (artefacts, spoken words and written text) and three channels of transmission (exhibition, discussion and paper) with clear ground rules and close control of variables reducing the chance of noise and interference.

Semantic problems are addressed by refraining from the use of any technical and discipline-specific vocabulary and reference points until step three of the process. By this point, initial feelings towards works have been established through exhibition, and those feelings put into context, and refined, through discussion. This process allows for a broad assessment of synergies (or tensions) between research aims, objectives, methods or otherwise,

to be identified before any detailed understanding of technical vocabulary and reference points are required. Where a detailed technical grounding in a discipline is necessary for collaboration to take place, the time, energy and resources required to achieve this can now be deployed more strategically. The process also allows for the nature of the collaboration (the roles and responsibilities of individual research partners and the relationship between them) to be better defined.

Effectiveness problems are addressed by providing three communication outputs, each appropriate to multiple audiences, and each open to interpretation in a variety of ways. For researchers, the effectiveness of each step is enhanced by that which came before it: an understanding of research papers is supported by discussion of their context, and discussion of their context is supported through interaction with the artefacts of research themselves. Each step can also be tailored to the needs and requirements of wider stakeholders, as well as the general public. The exhibition can generate positive publicity, provide general insights into research processes, and engage audiences with high-level research concepts, within a controlled, accessible, welcoming and safe environment. Statements drawn from discussion, papers or otherwise can be produced to guide and enhance the visitor experience. Discussion can be witnessed by stakeholders and the public (either in situ, via live streaming, or through the discussions' recording) building their own contextual understanding, providing a 'human face' to interdisciplinary research, and informing and influencing their behaviour and decisions. Papers can also be read in isolation by those already in possession of the necessary vocabulary, reference points and context required for accurate and precise interpretation, and if desired, the steps followed in reverse, with the paper's reader referring to the discussion and exhibition thereafter to enhance their reading and introducing them to additional research areas outside of their direct subject specialism.

Inevitably, with the move from an idealised model to its practical application, comes a degree of compromise and unpredictability. However, testing of the model to date, suggests that such a reality check does not mean that the Show-Talk-Do model's intended outcomes are sacrificed.

The testing of the curatorial model at Carbon Meets Silicon II

Carbon Meets Silicon II (CMSII) was the second in an exhibition and symposium series held as part of the biennial International conference on Internet Technologies and Applications (ITA) at Oriel Sycharth Gallery, Wrexham Glyndwr University, in September 2017. The exhibition and symposium (which were made open to all) used carbon and silicon as metaphors for the changing face of art practice in the digital age. CMSII brought together the work of sixteen diverse audio-visual artists, scientists and technologists across a range of disciplines, who had all collaborated with specialists outside of their immediate field of enquiry. From an international open call, artworks were selected, with accompanying papers contributing to the proceedings of the ITA 2017 conference.

The following three contributors to CMSII have been selected as examples to demonstrate how the Show-Talk-Do model can be applied in practice.



Figure 2. CMSII (2017) Oriel Sycharth Gallery, Wrexham.

David Dobson

David Dobson is an artist and Professor of Earth Materials at University College London (UCL) and was the first Scientist in Residence at UCL Slade School of Art from 2017/18.

Through the exhibition, Dobson presented *Pmm Table* (2017) a sculptural work made from blemished and stained teak and oak originating from an old scientific laboratory. The table adopted subtle and complex symmetries⁵,

visible to the observers irrespective of their mathematical understanding, whilst maintaining a simplistic overall appearance, and served as a tangible example of how Dobson's scientific knowledge directly contributes to his artistic making process.



Figure 3. *Pmm Table* (2017), David Dobson (courtesy of the artist)

Through the symposium, Dobson explained the significance of the mathematical classification of a two-dimensional repetitive pattern that is based on the symmetries that occur frequently in decorative art, architecture and nature. The discussion revealed that although these mathematical symmetries served as an initial stimulus, Dobson's primary concern is with 'making as thinking philosophy', the table serving very much as a part the 'thinking' process (Dobson, 2017).

The accompanying paper allowed interested audiences to deepen their knowledge of what 'making as thinking philosophy' means to both science and art. Dobson argues that craft skills are vital to experimental science, but often overlooked by practitioners, thus resulting in a fragmentation of science practice. Whilst acknowledging that reproducibility is important in science he suggests that allowing a degree of random variability in some aspects of experimental science can create the conditions leading to new insight. He advocates a 'let's see what happens if...' attitude or 'controlled chaos'

⁵ ... allowing the classification of the table to the two-fold axis and two mirror plane Pmm symmetry group from the 17-planar symmetry (or wallpaper) group. The offset in the cross piece of the table destroys

the four-fold symmetry operator, stopping the table from being a member of the *P4m* subgroup. Dobson, D. 2017).

that can be a useful tool in modern science (Dobson, 2017).

Dobson's motivation for participating in CMSII was to contribute to the wider adoption of the 'making as thinking' philosophy, and to the use of art practice within science. His exhibit was seen by a large public audience (engaging with the metaphor of mathematical rules encapsulated in a physical object), the discussion featured over 50 researchers, students and amateur scientists (inspired to change their perceptions of the relationship between art and science practice), and his paper served as a clear instruction to those academic practitioners in attendance who wished to take this inspiration, to inform their own teaching and practice.

localStyle

localStyle is a collaborative platform founded by Marlena Novak (artist and Adjunct Professor at the School of Art, Institute of Chicago) and Jay Alan Yim (sound designer and composer who teaches at Northwestern University, Chicago). Together they create intermedia artworks including video, sound, interactive installations, live performances, and audience participation.

Two short films *Scale* (2009-10) and *Bird* (2012-2014), were exhibited.

Scale documented an interactive installation which "involves live electric fish from the Amazon River. Twelve different species of these fish comprise a 'choir' whose sonified electrical fields provide the source tones for an immersive experience" (Novak and Yim, 2017). *Bird* documented a collaboration with artist and engineer Jesus Duran, focusing on the sound of the Eurasian Blackbird to create an immersive interactive experience for the audience, who were invited to enter a zone of "spatialized blackbird singing, with the overhead sounds moving unpredictably around the room" (Novak and Yim, 2017).

Integral to both *Scale* and *Bird* was the feelings they induced in their audiences. In *Scale*, one of the goals of the project was to "foster wider public awareness of the scientific contributions of the electric fish and the fragility of their environment in the Amazon River Basin," motivating action, and in *Bird*, one goal was to recreate the "impression of having experienced the indigenous artifacts of a non-human culture" (Novak and Yim, 2017).



Figure 4. Installation Shots, *Scale* (2009-10), Marlena Novak and Jay Alan Yim (courtesy of the artists)

Through the symposium, involving extensive discussion with multiple audience members, the main thematic interests of the artists, and their relationship to the presented works, were explored, from social issues, to climate change, and the definition of cultural and political boundaries.

The accompanying paper paid natural complement to each of these elements, outlining the research process which both *Scale*, and *Bird* followed from start to finish, and the learning gained through collaboration, arguing that "many of the most fruitful projects blur the lines between art and science to yield a result that is clearly infused with both yet also greater than the sum of its parts, that strong collaborators contribute ideas and insights outside of their respective disciplinary strengths, and that this boundary-crossing defines in the most productive terms why this manner of working can result in expanded approaches by the collaborators when they return to further work in their disciplines." (Novak and Yim 2017:351).

For those who observed the exhibitions films in isolation, a heightened awareness of, and empathy with, the ecological plight of the Amazon River Basin, the cultures of non-human animals, and the potential of science-art collaboration to realise creative and social projects, was achieved. Through discussion, the relationship of these outcomes to the intentions and motivations of their artists became clear, and through their paper, a rigorous examination provided invaluable insight to those researchers pursuing similar endeavours and involved in similar collaborative processes.

Manoli Moriarty

Manoli Moriarty is a composer, performer, maker and academic researcher at the University of Salford, UK. His work is interdisciplinary and usually involves collaboration with dancers, choreographers, actors or electronic musicians and takes the form of live mixed media performances, interactive installations or electroacoustic compositions.

Moriarty exhibited *DeviceD* (2017), an interactive performance with dancer Lucie Lee, that monitored social media interactions, translated them into commands using bespoke bidirectional feedback technology in the form of vibrating motors worn by Lee, who then interpreted them as instructions for her performance.



Figure 5. *DeviceD* (2017), Manoli Moriarty (courtesy of the artist)

The symposium discussion allowed Moriarty to describe how the organic collaborative process in his work has become the focus of his research in recent years. He articulated how he has developed a framework for collaboration informed by the biological phenomenon of symbiosis⁶, and associated notions of ‘interspecificity’, ‘closeness’, and ‘persistence’ that have been identified in science. He explained how his framework provides artists with a set of actions that can be employed during all stages of the collaborative practice, including “authorship and hierarchy in creative control, aesthetics, artistic development, and live interaction” (Moriarty, 2017).

Through his paper, Moriarty expanded upon his framework, providing “practitioners with a set of actions and precepts that can be employed during each stage of collaborative

practice”, couples with case studies from his own practice and the practice of others (Moriarty, 2017).

The exhibition of *DeviceD* provided Moriarty with live data to feed into an ongoing research project, and well as allowing all to engage in ‘symbiosis’, irrespective of whether the word and notion were familiar to them. Discussion allowed for reflection on this experience, its similarity to other research collaborations (and to researcher-stakeholder, and researcher-public relationships) and for the general terminology of symbiosis to be introduced. Finally, for those satisfied that a framework inspired by biological symbiosis could benefit them, Moriarty’s paper provided a detailed account of how the framework should be put to use.

Next Steps

Initial testing of the Show-Talk-Do model points to certain scenarios in which it will be of greatest benefit to interdisciplinary research projects.

It is of greatest use when communication is bolstered by an understanding of ‘how things feel.’ The conveying of how things feel, or ‘experiential knowledge’⁷, is often the hardest to translate through traditional research dissemination routes (formal papers written in technically constrained language), but the most important to motivate the desired actions in the communication’s recipient. For example, for Moriarty’s audiences, symbiosis becomes a more tangible concept once one knows how it feels to engage in a symbiotic process within a controlled and structured environment.

It is of greatest use when communication within the boundaries of the defined project would traditionally include multi-channel transmission. Typically, which will be the case where the parties for communication are *prima facie*, separated by the greatest distance. For example, communicating the findings of fine art research to an applied art researcher, will create less ‘noise’ than communicating the findings of astrophysics research to a linguist. For example, Dobson’s research in Earth Materials has implications for those in all areas of the arts and sciences, and CMSII provided an environment in which these audiences could be reached directly, and simultaneously.

⁶ a close and long-term biological interaction between two different biological organisms.

⁷ As opposed to propositional or procedural knowledge.

Finally, it is of greatest benefit where large-scale engagement of public and non-technical audiences is integral to success. A natural by-product of the model's application is the production of an accessible exhibition, permitting high levels of managed public engagement, with tailored visitor experiences supporting multiple agendas simultaneously. By capturing activity through film, image, audio and text, re-usable resources can also be created to engage children, non-expert adults and all stakeholders in any given project. For example, localStyle's *Scale* and *Bird* toured the world extensively before their display at CMSII, influencing the many thousands who experienced them. Yet hundreds more saw them and were moved by them during their time on public display at Oriel Sycharth Gallery.

That is not to say that the Show-Talk-Do model is 'all things to all men', and it is important that its limitations are understood.

It cannot replace the 'hard yards' of interdisciplinary research. It can communicate broad conceptual principles and permits high-level analysis of, and comparison between, research activities, but does not provide the detailed knowledge, skills and understanding to subsequently make those collaborations successful. Rather, it provides a means to identify which collaborations are worth perusing, and to allocate time and resources more strategically.

It cannot single-handedly subvert a culture of siloed working within academia. The influential scientist and novelist C.P. Snow acknowledged the tensions surrounding different understandings brought about by the varied discourses resulting from the Scientific Revolution. Collaborations between the arts and sciences has a long history of interdependence, but also tension and antipathy (Snow, 1959). As Earnshaw comments, "It is also well-known that interdisciplinary research tends to be less well understood by reviewers from the established disciplines because it is not regarded as sufficiently pure or traditional, or it may cut across the norms and conventions that have been established within a particular discipline." (Earnshaw et al. 2015)

When interdisciplinary research is carried out in universities or research laboratories it

often involves working across organisational and resource boundaries, with structures set in place to support existing disciplines such as resources or budgets that are not always flexible within a university context. Nevertheless, it is heartening to see that today traditional barriers between existing disciplines are being broken down allowing current knowledge to be increasingly interdisciplinary.

The true value of the Show-Talk-Do model to interdisciplinary research activities will only become apparent with time.

More practical application of the model is required, with varied messages, audiences and purposes, so as to build a richer picture of 'what works and why?':

- Does the model work better with some combinations of disciplines compared to others?
- Do the lengths of papers, discussions and exhibitions effect the model's intended impacts?
- Can the model be applied in virtual environments, or is live interaction essential?

These other questions must be explored before the model's real value can be adequately assessed. A longitudinal study, measuring the impacts of varied, clearly defined interdisciplinary research projects which adopt the model, benchmarked against comparable projects which do not, would be one means of approaching the answers.

The time has come for such questions to be asked.

Interdisciplinary research is not a fad, but a new and essential way of doing things, to meet the challenges we face over the coming decades and beyond. As Fabiola Gianotti, particle physicist and the Director General of CERN put it at the World Economic Forum in 2018, "We need to break the cultural silos. Too often people put science and the humanities, or science and the arts, in different silos. They are the highest expression of the curiosity and creativity of humanity." (World Economic Forum, 2018).

We believe Show-Talk-Do can make a very small, but not insignificant, contribution to meeting this great challenge.

Bibliography

- Adams, S. (2014). *Practice as research: A fine art contextual study*. Arts & Humanities in Higher Education, Vol. 13(3) 218–226.
- Dobson, D. (2017). *The Role of Craft and Cottage Science in Modern Science Practice*, in 'Internet technologies and applications' (ITA) proceedings of the seventh international conference, Picking, R., Cunningham, S. et al. editors, pp. 365–367.
- Earnshaw, R.A., Liggett, S. & Heald, K (2015). *Interdisciplinary collaboration methodologies in art, design and media*, in '2015 Internet technologies and applications' (ITA15) proceedings of the sixth international conference, Picking, R., Cunningham, S. et al. editors, pp. 381–388.
- European Commission: Horizon 2020 (2014). Communicating EU research and innovation guidance for project participants. Available at: http://ec.europa.eu/research/participants/data/ref/h2020/other/gm/h2020-guide-comm_en.pdf. (accessed: 29 March 2018).
- Internet Technologies and Applications (ITA) Conference (2017). Wrexham Glyndwr University. Available at: <http://www.ita17.net/> (accessed 28 March 2018).
- Kuhn, T. (1962). *The Structure of Scientific Revolutions*, University of Chicago Press.
- Liggett and Corcoran (2017). *Carbon Meets Silicon II*, Oriel Sycharth Gallery, Wrexham Glyndwr University. Available at: <https://www.glyndwr.ac.uk/OrielSycharthGallery/Exhibitions/CurrentExhibitions/CarbonMeetsSiliconII/> (accessed 9 March 2018).
- localStyle. *Scale*. (2010–2011). Available at: <http://www.localstyle.tv/scale/scale.html>. (Accessed 11 April 2018).
- US National Library of Medicine (2018). *Interdisciplinary Communication - MeSH Descriptor Data 2018*. Available at: <https://meshb.nlm.nih.gov/record/ui?ui=D033183>. (Accessed 11 April 2018).
- Moriarty, M. (2017). *Symbiosis: Interspecific associations in collaborative practice*. Internet Technologies and Applications (ITA) Proceedings of the Seventh International Conference. Editors: Picking, R. & Cunningham. et al. pp. 372–376.
- National Science Foundation (2018). *What is Interdisciplinary Research? National Science Foundation*. Available at: https://www.nsf.gov/od/oia/additional_resources/interdisciplinary_research/definition.jsp. (Accessed 11 April 2018).
- National Academies (2004). Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering, and Public Policy. *Facilitating interdisciplinary research*. National Academy Press. p. 2.
- Novak, M., Yim, J, A. (2017). *Scale, Bird: Working with Others*. Internet Technologies and Applications (ITA) Proceedings of the Seventh International, Picking, R. & Cunningham, S. et al. editors, pp 351–353.
- Shannon (1948). *A Mathematical Theory of Communication*. Bell System Technical Journal. Volume 27 (July and October). pp. 379–423, 623–656. Available at: <http://math.harvard.edu/~ctm/home/text/others/shannon/entropy/entropy.pdf> (accessed 5 March 2018).
- Shapiro, E. (2014). *Correcting the bias against interdisciplinary research*. *eLife* V3. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3971457/> (accessed 11 April 2018).
- Snow, C. P. (1959). *The Two Cultures*. Cambridge University Press, Cambridge, UK.
- World Economic Forum. (2018). *The future of education, according to experts at Davos*. Available at: <https://www.weforum.org/agenda/2018/01/top-quotes-from-davos-on-the-future-of-education/> (accessed 11 April 2018).

Biographical note

Dr Susan Liggett is Reader in Fine Art and School of Creative Arts Research Centre Head at Wrexham Glyndŵr University, North Wales, UK. She has a PhD from the University of Wales, a Post Graduate Diploma in Painting (MA) from the Royal Academy Schools, London and a BA (Hons) Fine Art from Nottingham Trent University. She is an artist and curator and has exhibited widely in the UK and published work on the interface of art/science often with a focus on arts in health.

Mike Corcoran is an independent consultant and curator specialising in designing creative solutions to communication, education and engagement challenges. He has worked with Universities, public, private and third sector organisations across Europe, Asia, Australia and North America, and with audiences of all ages and abilities. He has a BSc (Hons) in Physics and Philosophy from Durham University, is an Associate Fellow of the Higher Education Academy and has published works in creative education and engagement approaches.