

# SEAD Exemplars: Evidence of the Value of Transdisciplinary Projects

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SEAD Committee

Report by: Alex Garcia Topete, Roger Malina, Carol Strohecker, Robert Thill

12/4/2017

## SEAD Committee Members

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Roger Malina, Distinguished Professor of Art and Technology, The University of Texas at Dallas.  
Carol Strohecker, Dean of the College of Design, University of Minnesota.  
Carol Lafayette, Director, Institute for Applied Creativity, Texas A&M University.  
Robert Root-Bernstein, Professor of Physiology, Michigan State University.  
Robert Thill, Independent Scholar.

## Curatorial Steering Group

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Roger Malina, Distinguished Professor of Art and Technology, The University of Texas at Dallas.  
Carol Strohecker, Dean of the College of Design, University of Minnesota.  
Alex Garcia Topete, Eugene McDermott Graduate Fellow, The University of Texas at Dallas.

## Curatorial Design Group

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Roger Malina, Distinguished Professor of Art and Technology, The University of Texas at Dallas.  
Cassini Nazir, Director of Design & Research of the ArtSciLab, The University of Texas at Dallas.  
Alex Garcia Topete, Eugene McDermott Graduate Fellow, The University of Texas at Dallas.  
Veronica Liu, Eugene McDermott Scholar, The University of Texas at Dallas.  
Emma Newkirk, Coordinator of the ArtSciLab, The University of Texas at Dallas.

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# Acknowledgements

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## Nominators

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- Laurie Baefsky, Executive Director, Alliance for the Arts in Research Universities (a2ru).
- Anne Balsamo, Dean of the School of Arts, Technology, and Emerging Communication, The University of Texas at Dallas.
- Matthew Brand, Research Fellow, Mitsubishi Electric Research Laboratories.
- Kathryn Evans, Senior Lecturer of Arts and Humanities, The University of Texas at Dallas.
- Angus Forbes, Assistant Professor in Computational Media, University of California - Santa Cruz
- Alex Garcia Topete, Eugene McDermott Graduate Fellow, The University of Texas at Dallas.
- Scot Gresham-Lancaster, Researcher at the ArtSciLab, The University of Texas at Dallas.
- Edmund Harriss, Clinical Assistant Professor of Mathematical Sciences, University of Arkansas.
- Sarah Horsman, Independent Nominator.
- Joshua K. Sherrill, Information Technology Specialist.
- Veronica Liu, Eugene McDermott Scholar, The University of Texas at Dallas.
- Roger Malina, Distinguished Professor of Art and Technology, The University of Texas at Dallas.
- Rachel Mayeri, Associate Professor of Media Studies, Harvey Mudd College
- Ignacio Nieto Larrain, Researcher of Art-Science, Lab ADyC.
- Stephen Nowlin, Vice President at Art Center College of Design.
- Thomas Rudin, Director of the Board on Higher Education and Workforce, National Academies of Sciences, Engineering, and Medicine
- Andrew Scott, Associate Professor of Art and Technology, The University of Texas at Dallas.
- Joao Silveira, Visiting Research Fellow, Harvard University.
- T. Michael Stephens, Founder of The Art Research Center.
- Carol Strohecker, Dean of the College of Design, University of Minnesota.
- Robert Thill, Independent Scholar.

## Executive Summary

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- The SEAD Steering Committee gathered a collection of “exemplar” works demonstrating effective intersections among the sciences and engineering with art, design, and the humanities.
- More than 100 exemplars from were submitted by 21 nominators during a 6-month call for nominations.
- The exemplars were analyzed according to disciplines, demographics, work models, and funding sources.
- The collection as a whole represents international diversity as well as diversity of practices and disciplines.
- A selection of exemplars can be found as a *webexhibit* at <https://SEADexemplars.org>; there will be a companion print exhibit.
- The exemplars provide evidence of the positive impact that disciplinary integration can have in education, culture, and economic resurgence, as well as contribute to the “STEM to STEAM” debate.

## I. Background & Motivations

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In recent years, the subject of integrating arts and design (and sometimes the humanities) into the STEM disciplines<sup>i</sup> (science, technology, engineering, and math) has become a staple of policy, education, and business debates around the world, generally referred in the United States as the issue of “STEM to STE(A)M.”<sup>ii</sup> It has been an important topic particularly in the European Union and the United States, as evidenced by the various reports by the U.S. National Science Foundation<sup>iii</sup> and the establishment of both a “STEM” caucus<sup>iv</sup> and a “STEAM” caucus<sup>v</sup> in the U.S. Congress that has resulted legislation related to STEAM<sup>vi</sup>, as well as the reports and efforts by the European Commission with the STARTS program<sup>vii</sup>. The question at the core of the “STEM to STEAM” discussion remains the same across domains and borders: *what is the evidence and what new arguments exist today proving any benefits from such integration?*

There have been several attempts to answer that question and provide some evidence of the positive impact of the integration, ranging from the study of individual genius (namely, of Nobel laureates<sup>viii</sup>), to the surveying of multidisciplinary research networks<sup>ix</sup>, to the analysis of relevant skills acquired by STEM college students thanks to courses in the arts, design, and humanities<sup>x</sup>.

Regardless of the relative novelty of “STEM to STEAM” as a policy and education point today, in reality this integration has been a common practice with a variety of exemplars to account for the effectiveness of integrated approaches, both historically

and currently. Such exemplars of creative work and educational strategies are presented here to serve both as primary sources of the benefits of integrated practices and as models of the transdisciplinary paradigm. They provide ample evidence not only of the diversity of opportunities for “STEM to STEAM” to happen, but also of the positive impact that disciplinary integration can have in education, culture, and economic resurgence, whether that integration be categorized as transdisciplinary, interdisciplinary, or multidisciplinary<sup>1</sup>.

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<sup>1</sup> All three terms, though different in their specifics according to standards established by UNESCO's International Bureau of Education (<http://www.ibe.unesco.org/en/glossary-curriculum-terminology>), have been used interchangeably throughout this report and the webxhibit of the exemplars.

## II. Taxonomy

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Following the collection and analysis of the information of the nominees, the matter of cataloguing the exemplar centered on issues of language and deciding what would be the target audience for the exhibits.

Regarding language, the curatorial committee settled for “*SEAD*” as the most inclusive and approachable descriptor for multidisciplinary projects from among the abundance of available options depending on the “basic discipline” and country of origin, including but not limited to *Art-Science*, *ArtScience*, *STEM*, *STEMM*, *STEAM*, *STEAMM*, *STEAMMD*, *ArtSci*, *SciArt*, *hybrid*, *T-Shaped*, *H-shaped*, *Third Culture*, and *Art4Science*, among others.

Having determined a purpose/outcome descriptor for each selected work, the curators' next step was to develop categories classifying the exemplars in ways that would highlight their importance and impact. Given the intention to showcase evidence of the value of transdisciplinary work for the broad public, the Smithsonian Institute's standards for exhibition design<sup>xi</sup> and audience-building<sup>xii</sup> provided appropriate bases for curation. The accompanying text for the exhibits (online and print), including the taxonomic category titles, thus includes as few technical or academic terms as possible, addressing on a non-expert public by following Allan Bell's principles of language style as audience design tool.<sup>xiii</sup>

The following rubric of curatorial categories also reflects the intention to communicate concisely the exemplars' impact and value. The rubric is based on the purposes of the nominated works and professional focuses of participants involved in generating the exemplars:



## Rubric

Category	Characteristics
<i>Innovating</i>	<ul style="list-style-type: none"> <li>• Patent awarded, filed or pending.</li> <li>• Business/economic activity; existence of companies.</li> <li>• New methodology used by others.</li> </ul>
<i>Exploring</i>	<ul style="list-style-type: none"> <li>• Consistent interdisciplinary practice.</li> <li>• First artistic engagement in a new environment.</li> </ul>
<i>Educating</i>	<ul style="list-style-type: none"> <li>• Establishes a program.</li> <li>• Creates curricula.</li> </ul>
<i>Bridging</i>	<ul style="list-style-type: none"> <li>• Brings together experts from different fields</li> </ul>
<i>Engaging</i>	<ul style="list-style-type: none"> <li>• The work led to significant public/non-expert engagement.</li> <li>• Impact outside the original fields (e.g. policy, business).</li> </ul>
<i>Questioning</i>	<ul style="list-style-type: none"> <li>• Generates new perspective on an established cross-disciplinary issue.</li> </ul>
<i>Pioneering</i>	<ul style="list-style-type: none"> <li>• Time-tested.</li> <li>• Being first of a field that didn't exist.</li> </ul>

### III: Gallery of Exemplars

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Webexhibit Address: <http://SEADexemplars.org>

#### INNOVATING

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##### *INDAPLANT PROJECT*

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The IndaPlant Project is an exemplar because it merges plants and robots in a way that creates an automated environment focused on the nurture of the plants. IndaPlant required adapting innovations from computer science and robotics in order to decode the plant-generated bio-information, and model solutions that allowed the plant-robots to seek sunlight and water. The *floraborgs* (plant robots) developed in the project could allow for automated biodomes that would benefit plants and humans alike. This project presents promising advances for sustainable agriculture.

Nominee: Elizabeth Demaray

##### *AEROCENE*

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Aerocene is an exemplar because it explores a number of innovative technical approaches to lighter than air travel that may result in achieving the longest, emission-free journey around the world. It engages diverse publics and introduces them to new technologies. The project has bridged organizations and experts from many fields, ranging from architecture to geography to technology, as well as bridging countries, including France, Argentina, Germany, and the United States. This project will influence transportation and telecommunication technologies. Aerocene allows for new means of communal creation and innovation for the new age.

Nominees: Tomas Saraceno & the Aerocene Foundation

## EDUCATING

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### *STEAM LAB*

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The STEAM Lab is an exemplar that shows how art and cultural engagement increase students' motivation to further explore the sciences, engineering, technology, and math. Using computer programming, visual art, and music, the lab has successfully engaged minority students with the STEM fields through interdisciplinary projects that look at cultural artifacts, such as quilt patterns, from the perspective of math and science. This project presents a novel educational practice. STEAM Lab proves to educational institutions that STEM learning can become more attractive and accessible to students through art, design, and cultural relevance.

Nominee: Nettrice Gaskins.

### *PROM WEEK*

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Prom Week is an exemplar of how making scientific model playable can enhance the way people learn and how those models are studied and applied. The project consists of a game simulating the social interaction experienced by kids going to prom. Prom Week required developing novel computer science simulation techniques and artificial intelligence models, guided by arts storytelling and humanities, media studies, and social sciences approaches. Thanks to its success in engaging players and its research output, Prom Week has become a basis for DARPA's Strategic Social Interaction Modules program, the European Union FP7 project SIREN, and other simulation games, both for education and entertainment. This project provides a new model for training that can be applied to kids and adults in a variety of skills.

Nominees: UC-Santa Cruz, Josh McCoy, Mike Treanor, Ben Samuel, Aaron Reed, Michael Mateas, Noah Wardrip-Fruin

## EXPLORING

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### *SUBTEXT ART*

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Subtext Art is an exemplar of how art can humanize the medical and scientific in a way that heals. The project consists of visual artworks based upon medical illustrations and scientific imaging, ranging from x-rays to therapeutic pictures. By adding an emotional charge to the clinical imagery, Jennifer McCormick explores the patient's experience beyond their medical record: family, selflessness, vulnerability, community, humor, the calming effects of prayer, and meditation. Subtext Art reaffirms the humanity and emotion to be as powerful as medical technology and the brilliant minds behind it.

Nominee: Jennifer McCormick.

### *SELF-REFLECTED*

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Self-Reflected is an exemplar because it combines art and science to revolutionize the way in which we think about the brain. The project fuses neuroscience, optics, mathematics, physics, and art to etch half a million neurons into large sheets of gold that are visualized explorations of the brain. The beauty, scientific accuracy, and technicality supply new insights among experts about the brain's functions, while it also inspires a broader appreciation among the general public.

Nominee: Greg Dunn.

### *MALAMP & SEASON IN HELL*

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Brandon Ballangee's works are an exemplar of how hybrid projects can both raise awareness through art and produce good research in the process. The projects involve diverse communities of artists, scientists, and local residents to create participatory science programs and art installations showcasing environmental issues, such as

deformed and mutated animals. By researching and working within their local environment, the public gains an overall understanding and awareness that each individual has an impact and can make a difference in our global environment.

Nominee: Brandon Ballangée.

## BRIDGING

### HYPERMUSIC

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Hypermusic is an exemplar of how arts can be the bridge among experts across scientific fields. The project is an opera in which the music, performances, and story were designed to represent a new model of space-time based on contemporary research and theory. Hypermusic intended to make this new space-time model more understandable for fellow physicists and other scientists, as well as experiment with the music and storytelling of the piece. The multi-dimensional opera accomplished to disseminate the basic principles of Lisa Randall's space-time model among the physics community and the artistic world. This project has had an impact by triggering discussions in the world of physics.

Nominees: Lisa Randall, Matthew Ritchie & Paul Desveaux

### HIEROGLYPH

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Hieroglyph is an exemplar of how art and storytelling can rekindle our grand ambitions for the future. The project brought together top science fiction authors with scientists, engineers, and other experts to collaborate on futuristic visions grounded in real insights from science, technology, and a wide range of other disciplines. Hieroglyph includes proposals for 3D printing in space, an alternative internet powered by drones, solar cities designed to mimic algae cells, and more. The project sparked a national

conversation throughout news outlets about the role science fiction plays in igniting the public's imagination and bridging our present with the future. This project has served as a model for futurism and its power to shape innovation.

Nominee: Arizona State University's Center for Science and the Imagination.

## ENGAGING

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### *THE ENEMY*

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The Enemy is an exemplar of how new technologies and experimental storytelling can foster more peace and understanding among people of different backgrounds. The project used virtual and augmented reality to showcase the humanity of fighters in real-world conflict zones, capturing their faces and body language in interviews that were used to design the virtual versions. By making the combatants present and more real to audiences in other countries, the public engages in a deeper understanding of the conflicts. The project has been a model of transnational and transdisciplinary collaboration involving art, technology, and journalism by showing the power of immersion.

Nominees: Karim Ben Khelifa, director; Camera Lucida, Producer; National Film Board of Canada, Producer; Dpt., Creative Studio; Emissive, VR Developer; D. Fox Harrell, HCI Producer.

### *KIATSU*

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Kiatsu is an exemplar because it made a scientific problem accessible and relevant to the general public. The project combined sound art, anthropological research, and acoustic science to study and represent the lived experience of residents living near and within two Japanese airports. The resulting installation of noise soundscapes improved

the public understanding of the negative health impact caused by constant exposure to unwanted sound. The project's findings ultimately led to policy changes in Japan and the UK regarding noise regulations.

Nominees: Rupert Cox, Angus Carlyle & Kozo Hiramatsu.

## QUESTIONING

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### *TRANSPLANT & LIFE*

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Transplant & Life is an exemplar of how artists can provide a new human perspective to scientific and technological issues. The artists photographed and recorded organ transplant recipients, live donors, people on the waiting lists, and specialists in the field in order to make an artwork that would add voices and faces to the impersonal sterility of the medical field. The project changes the understanding of this life-changing and emotional medical procedure, engaging the general public while also being a valuable humanizing resource for both patients and clinicians.

Nominees: Tim Wainwright & John Wynne.

### *APE CINEMA*

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Ape Cinema is an exemplar because of how common human practices can become means to explore other fields. The project consists of an original movie made expressly for a chimpanzee audience, who seem watching the same things as human primates: dramas around food, territory, social status, and sex. The project creates a prism for human beings to learn more about the complex social, cognitive and emotional lives of chimpanzees by watching a movie through chimps' eyes. This project has had an impact in biology, sociology, and their interconnections.

Nominee: Rachel Mayori.

## PIONEERING

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### *CHARLES CSURI*

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Charles Csuri is an exemplar of how an artist pioneering new technologies led to the creation of new industries. Csuri's pioneer research in computer graphics and animation has not only been applied to flight simulators, computer-aided design, visualization of scientific phenomena, magnetic resonance imaging, education for the deaf, architecture, and special effects for television and films, but also helped establish leading educational programs that trained the new professionals. His former students have worked for Industrial Light and Magic, Pacific Data Images, Metro Light, Pixar, Rezn8, Silicon Graphics Inc., USA Today, Rhythm and Hues, Xaos, Walt Disney Productions and others.



## IV. Methodology

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### 2.1 Mission

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This study aims to collect and catalog an array of exemplars of broadly transdisciplinary projects, with the purpose of presenting them as evidence of benefits, effects, and outcomes of integrating arts, design, and the humanities with practices and models of STEM education, research, and commerce. We have relied on professionals who are known for their relevant work, respected among their peers, and appropriately credentialed to nominate and evaluate these works. The result is a curated subset of exemplars to be showcased. The selections will be displayed in an online exhibit and printed for gallery exhibition.

### 2.2 Call for Nominations

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The study started with a call for nominations in the fall of 2016, transmitted via the network of the Sciences-Engineering-Arts-Design (SEAD) curatorial committee. The call requested nominators to submit either people or specific projects that they considered to be exemplars of transdisciplinary work. The information submitted included name, title of project(s), description of the work, and a short justification of why/how it was exemplary. Nominators were asked not to include their own projects, but if someone else suggested work by one of the nominators it became eligible. The nominators ranged from artists renowned for their technological or scientific slant, to academics and researchers with expertise in inter/cross-disciplinary fields. Initially, the duration of the open call for nominations was to be six months.

The expectation at first was that only a small number of nominators would reply with a few nominees, keeping the network relatively close-knit and aiming for about 20 exemplars to study and showcase. We also expected some overlaps and repetition amid the nominations. However, the call for nominations surpassed all predictions: by the established deadline the curatorial committee received more than a hundred nominees, with fewer than 5 cases of nomination by more than one nominator.

With such a sizeable sample of diverse nominees, the next challenges would be the analysis and classification of all nominees and the curation of the intended exhibit.

## 2.3 Statistics of Nominators

- ▶ 21 Nominators
- ▶ 19% committee members, 81% invited nominators
- ▶ 67% male, 33% female
- ▶ 18 U.S.-based, 3 international.

## 2.4 Collected Submissions

Nominee	Project Title
Dan Goods	The Studio At Nasa Jpl
Nagler, M.; Asche, J.; Gómez-Brandón, M.; Insam, H.	Soil Microbial Communities Along The Route Of A Venturous Cycling Trip
Nick Hristov And Louise Allen	Visualizations From Biological Field Research (UNC Center For Design Innovation)
Jill Pipher (Lead PI), Jeffrey Brock, Jan Hesthaven, Jeffrey Hoffstein And Bjorn Sandstede	Institute For Computational And Experimental Research In Mathematics (ICERM)
Jennifer McCormick	X-Ray Visions
Greg Dunn	Self-Reflected
Bradon Ballangee	Combining Art And Science For Conservation Outreach Of Ectothermic Vertebrates (Amphibians And Fishes)
Gerhard Trimpin	Seismofon
Art Research Center Group	Art Research Center Group
T. Michael Stephens	N/A
Doctor James E. Gunn	Gunn Center For Ssf
Doctor Herbert W. Franke	N/A

Clare Bryden	Particulart: The Art Of Knitting, Chemistry, And Gentle Protest
David Cope	Experiments In Musical Intelligence
Donna Cox	Edream (Among Others)
Francois-Joseph Lapointe	Biological Performances.
Luisa Randall, Hector Parra, Matthew Richie	Hypermusic: A Projective Opera In Seven Planes
Christoph Keller	Solar Mirror
Seth Riskin	Light Dance
Brad Samuels And Adam C. Maloof	The Expanded Role: SITU
Nancy Burson	Personas
Natalie Jeremijenko	N/A
Ryan Oakes And Trevor Oakes	Double Vision
Nickolay Hristov, Louise Allen, Tatjana Hubel, Dennis Nikolaidis	Moments In Flight
Zintaglio Arts	Light And Illusion
Glass House Collective	By The People: Designing A Better America
Edmund Harriss	Wood Gradient
Edmund Harriss	Harriss Spiral
Edmund Harriss	2d Crystal
Char Davies	Osmose
Charles Csurí	Csurivision
George Legrady	We Are Stardust
George Legrady	Swarm Vision
Heather-Dewey Hagborg	Stranger Visions
Joann Kucera-Morin, Lance Putnam, Luca Peliti	Hydrogen Atom Installation
Alicia Gibb	Lunchbox Electronics
UC Santa Barbara Allosphere Research Facility, Janey Marth, Joann Kuchera-Morin,	Allosphere
Sheldon Brown/Experimental Game Lab	Scalable City
MIT Imagination Computation And Expression Laboratory	Define Me: Chimera
Dr. Fox Harrell	The Enemy
MIT Imagination, Computation And Expression Laboratory	The Girl With Skin Of Haints And Seraphs
Andrea Polli W Time Dye, Metone Instruments, Chuck Varga, Social Media Workgroup	Particle Fallz
Katherine Moriwaki	Gadgiteration
"Leah Buechley David Mellis Emily Lovell Hannah Perner-Wilson Bonifaz Kaufmann Tshen Chew Jie Qi,Mit Media Lab"	Living Wall
Wellcome Trust Sci-Art Program, Dr. John Tchalenko And Chris Miall	Painter's Eye Project
High-Low Tech	Sew Electric
Veronique Caye, Livio De Luca, Christian Jacquemin, Laboratoire Victor Verite, La	Genius Loci

Cartreuse Of Villeneuve-Lez-Avignon	
Northwestern Univ, Drexel Univ	Animal Landlord
Los Alamos National Lab, Ut, Francesca	Contrasting Currents: Highlighting Ocean Structures With Nested Colormaps
Ucsanta Cruz, Josh Mccoy, Mike Treanor, Ben Samuel, Aaron Reed, Michael Mateas, Noah Wardrip-Fruin	Prom Week
Edmund Harriss	Curvahedra
Daniel Hill	Works - Pattern Paintings
Julia Buntaine	January In The Frontal Lobe
Angie Drakopoulos & Daniel Hill	Mythograph
The Einstein Collective	Black (W) Hole
Ben Shneiderman	Every Algorithm Has Art In It: Treemap Art Project
School Of Integrated Science And Humanity	SISH
Center For Science And The Imagination	Frankenstein At 200 Project
Imaging Research Center	N/A
Jim Campbell	Scattered Light
Lynn Hershman Leeson	Infinity Engine
Jennifer Parker	Openlab
Phil Ross	N/A
Dan Goods, David Delgado, Studio Kca	Orbit Pavilion
Margaret Wertheim, Christine Wertheim	Crochet Coral Reef
Lita Albuquerque	Stellar Axis, Antarctica And North Pole
Michael C. Mcmillen	Dr. Crump's Mobile Field Lab
Dmitry Bulatov, Alexey Chebykin	That Which Lives In Me
Gilberto Esparza	Nomad Plants
Rachel Mayeri	Primate Cinema: Apes As Family
Perdita Phillips	Green, Grey Or Dull Silver
Susan Soares	Bee's
Chi Po Hao	Lightscape
Viktoria Modesta	Counterflow @ Berlin's Music Techfest
Rupert Cox	Kiatsu: The Sound Of The Sky Being Torn
John Wynne	Transplant
Neil Breyer	I:Move
Donna Cox	Visaphors: High-Definition Stereo Visualizations
Roger Dannenberg	Mcllare: The Robotic Bagpiper
Roger Dannenberg	Resound! Fanfares For Trumpet And Computer
Ernest Edmonds	Shaping Forms Series
Tiffany Holmes	7000 Oaks And Counting
Pamela Jennings	Sui Generis
David Kretz And Funding Support From The Social Sciences And Humanities Research Council Of Canada And The Banff New Media Institute	Flowergarden
This Visualization Was Designed In	Aurora

Collaboration With Matthew Sloly, Word Frequency Data By Andrew Salway (University Of Surrey), And Photography By Don Lee.	
George Legrady	Global Collaborative Visual Mapping Archive li
Marcos Novak	Allobrain@Allosphere Project
Sabrina Raaf	Test People Series
Thecla Schiphorst	Exhale:Breath Between Bodies
Bill Seaman	The Hybrid Invention Generator
Christa Sommerer & Laurent Mignonneau	Life Species II
Martin Wattenberg	Thinking Machine 4
Oron Catts	Tissue Culture & Art Project
Nasa	Nasa's Art & The Cosmic Connection
Nettrice R. Gaskins	STEAM Lab Boston Arts Academy
Paola Guimerans	Think-Of-Silicone
Paola Tognazzi	Humanising Software
Brian David Johnson	Futurist In Residence Arizona State University
Marco Buongiorno Nardelli	Materials Sound Music
Tomas Saraceno & Aerocene Foundation	Aerocene
Neri Oxman	Wanderers, An Astrobiological Explorationmushtari
Elizabeth Demaray	The Hand Up Project
KeLly O'Dell	Endangered Animal Project
Suzanne Anker	Bio Art
Maira Fróes And Dandara Dantas	O CÓDIGO NEURAL ( THE NEURAL CODE)
Malu Fragoso And Staff Of NANO Lab	We Bees - S.H.A.S.T. (Housing System For Homeless Bees)
Michael Sommer	Sommercube
Edward Belbruno	N/A
Suzanne Dikker	N/A

### III. Disciplines & Diversity

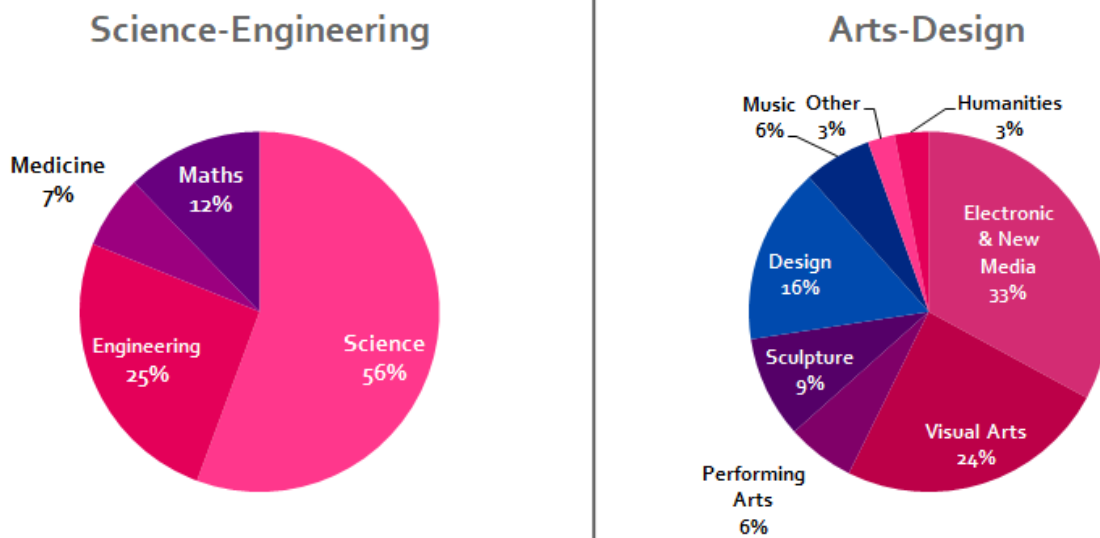
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#### 3.1 Disciplines

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In terms of disciplinary split, more than half of the exemplars involved “science” more than any of the other disciplines in STEM, while more than half of the nominees involved visual arts and electronic/new media on the art-design-humanities domain.

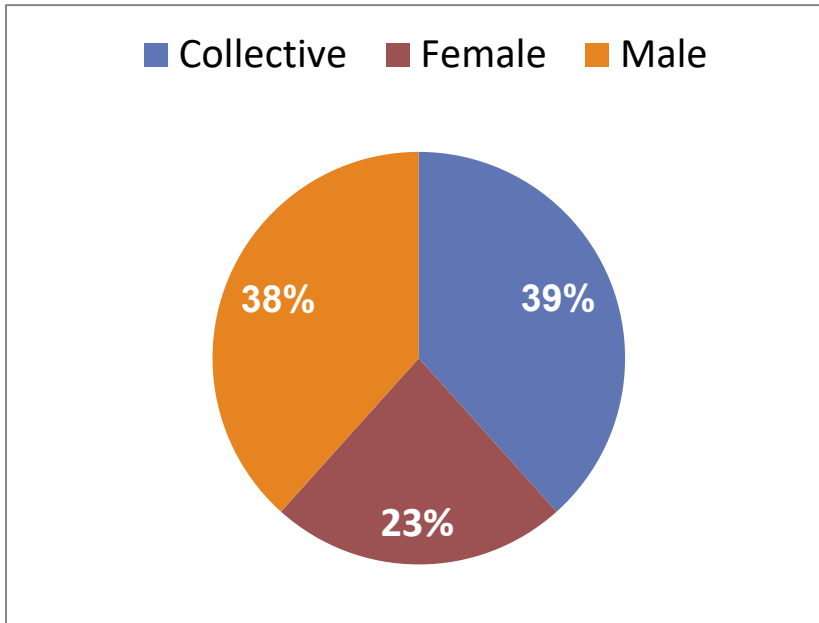
Nonetheless, there was enough variety in the mix of disciplines and subdisciplines to suggest that specific pairings or mixes across disciplines are the only options when it comes to transdisciplinary collaboration. For instance, math not only mixes with music, as could be naturally expected, but it also blends with electronic and new media arts, sculpture, visual arts, and the humanities, among others. The corresponding disciplines and subdisciplines for each nomination were accounted for in either the nominator’s entry or from the websites and materials of the nominee/project.



### 3.2 Gender

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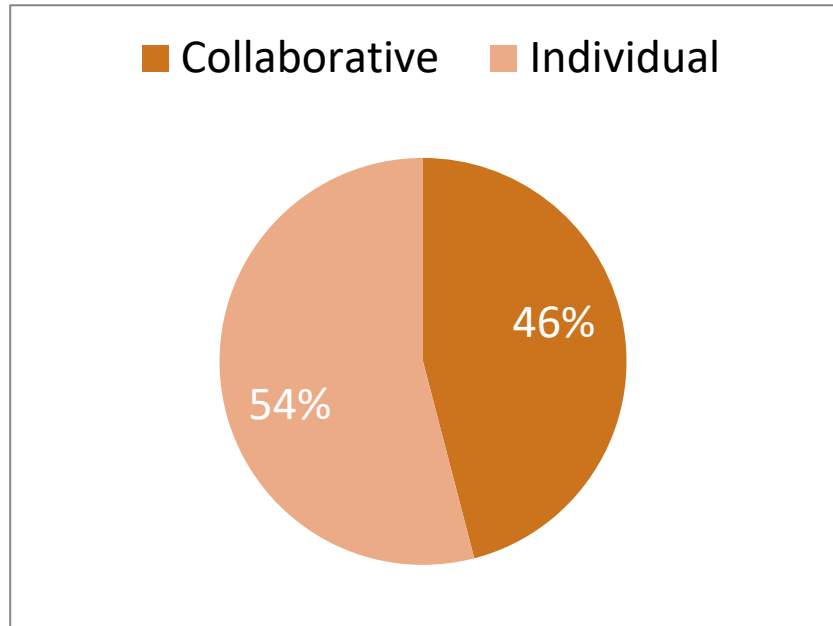
In terms of gender of the nominees involved, there was a fairly even split among all-male, all-female, and “mixed gender” collectives.



### 3.3 Work Model

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In terms of work model, there was almost an even split between nominated works that were collaborative or produced by an individual. However, it must be noted that many of the individuals who produced a nominated project have also been known to work on collaborative projects as well. In addition, some works were nominated as being by an individual, but there were additional individuals involved in the projects.



Work Model Statistics.

### 3.4 Purpose

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Descriptions submitted by nominators and found in websites related to the nominated works yielded eight distinctive, yet non-exclusive, terms for categorizing the main purposes and/or effects of the nominations:

**express | communicate | discover | invent | educate | heal | inspire | entertain**

Most exemplars covered more than one of these descriptors, signaling not only the multi-disciplinary nature of the exemplars, but also the typically multi-layered/multi-faceted quality of their outcomes.

### 3.5 Funding Sources

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Despite “funding” not being a required piece of information for a nomination (since that may have been unknown to the nominator), several submissions did provide information regarding the sources of financial support for the nominated project.



Funding sources included the National Science Foundation, DARPA, foundation grants, and a few corporate sponsorships.

## VI. Conclusions & Recommendations

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Several conclusions and recommendations emerged through the process of nomination and curation, made apparent by the data inherent in the exemplars.

- I) **Descriptor/term:** The sooner the broader community of experts on the subject of “STEM to STEAM” reaches a consensus about what to call transdisciplinary projects like the exemplars, the faster the general public (including policymakers and educators) will grasp the significance and value of such practices and projects. Currently, differences in disciplinary outlooks and country-specific terms create a terminology chaos that destabilizes even the study of the phenomenon itself. *SEAD* was chosen for this study’s title, but it still seems and sounds incomplete in terms of domains when spelled out (sciences, engineering, arts, and design). Moreover, it’s hard to communicate, let alone convince people of the value of something if there’s no identifiable or commonly-agreed name for it—particularly one that is inclusive of domains, jargon-free, and easy to understand in lay terms.
- II) **From Hybrids to Amphibians:** Most participant nominees, either as individuals or teams, could be classified as *hybrids* having expertise in more than a single domain—in this case, a mix of at least one science-engineering discipline and one from the art-design-humanities domain. However, these hybrids exist not because of research, academic, policy, educational, or art-world conditions but in spite of them. Academia, the scientific community, and the arts world have different (and sometimes conflicting) frameworks for valuing and legitimizing the work of peers, and therefore hybrid work tends to

be challenging to assess and it is frequently relegated to the periphery, making securing funding and building careers more difficult for practitioners. If such environments/frameworks became more open to transdisciplinary work, then the hybrid experts could become *amphibians* capable of living in more than one “world” instead of having to choose in what community to build their reputations and careers.

- III) **Multilayered Positive Impact:** A main commonality of the nominated exemplars is their having possession of more than one point of disciplinary influence. These transdisciplinary exemplars push boundaries of knowledge and/or promote innovative practices, engage audiences beyond field-specific experts, and have some level of underlying educational value.
- IV) **An Emergent Paradigm:** Ultimately, the exemplars provide specific evidence that transdisciplinary collaboration isn't the exception to the traditional rules of scientific research, technological innovation, art practice, or academic inquiry, but rather has emerged as a paradigm of its own in need of its own definitions, rules, and recognition of its value.

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