Director of Design, Innovation, and Strategy, External Relations Director- Dan Griner University of Colorado Denver

Beginning his design career in 1995 starting his own automotive graphics and signage company, Dan has been a serial entrepreneur starting his own design companies 3 times and running a non-profit, Making Progress.

Dan has also served as an instructor and professor in K-12 education in the USA and South Korea. Teaching Industrial Design for Metropolitan State University and serving as the Director of Materials and Processes at DSK International Campus in Pune, India.

His design work has ranged from restaurant interiors, zoo environments, theme park attractions, experiential marketing, props for commercials, permanent art installations, product design, and medical devices. He has led design departments for LInk Product Development, was the Manager of Design for Otterbox, and was co-founder and Design Teams Leader for Make4Covid.

He was a keynote speaker on the theme of design in 2016-17 in India (Bangalore, Hyderabad, Ahmedabad, Pune, and Mumbai) He

also was a guest speaker at the Odisha Design Council 2021 on the subject of Meta-design and Design Colonization, Moderated a panel on Designing for Public spaces at the Immersive Summit 2018, Spoke on the subject of Designing for Inclusion at the 2019 Immersive Summit, and Moderated a panel at the Smart Cities Week Conference on the subject of Smart technology and accessibility.

Currently Dan is leading a social impact design organization within the University of Colorado Denver, taking on a variety of needs across the community dealing with subjects like, homelessness, smart technology applications for accessibility, refugee aid, and disease risk assessment and mitigation strategies.

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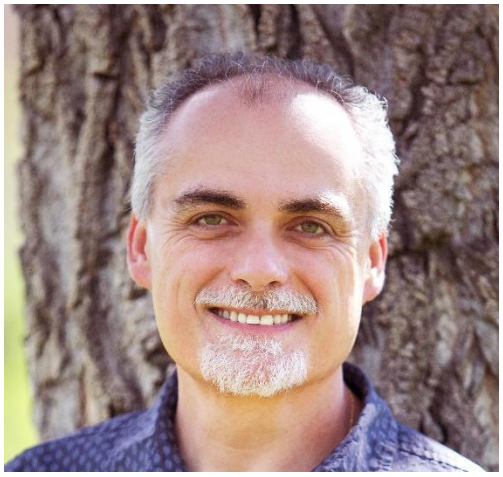

Owner of Tact-Ed Matt Gesualdi - MAEd

Matt Gesualdi of Tact-Ed has been researching design for the blind and visually impaired community since 1998. He has made four tactile exhibits for the Denver Art Museum, many tactile scale models and two interactive, immersive exhibits including a pitch-black puzzle room, Mission to Nocterra, for Maker Faire Denver 2018's main exhibit.

The Mission to Nocterra exhibit garnered many accolades as well as articles in 303 Magazine and The Denverite. The Denver Art Museum has included the Rembrandt: Painter as Printmaker tactile exhibit made by Tact-Ed many times both in their blog and their printed magazine.

Matt taught for 15 years as a professor of Industrial Design at the Art Institute of Colorado and as Adjunct Professor at the Community College of Denver, and the University of Denver.

Matt has a Bachelor of Arts degree in Industrial Design from the Art Institute of Colorado and a Master of Arts in Educational Leadership (emphasis on teaching the visually impaired) from Argosy University Denver. He is in the Denver Tactile Media Alliance and the Denver Art Museum's Access Advisory Group and is a long-standing member of the National Federation of the Blind.

Matt Gesualdi

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Getting in touch: a practicum of solutions for tactile experiences in the built environment.

Matt Gesualdi, Dan Griner

Entertainment and educational experiences have long benefited from an engagement of multiple senses to properly connect with the audience and to provide long lasting impressions on the subjects they were covering. Museums and Cabinets of curiosities sprang from the private collections of the very wealthy and powerful[27]. With this expansion into public use, delicate artifacts, exhibits and experiences all needed to be carefully monitored and planned for longevity and ease of maintenance. This has evolved into audiences getting further away and becoming less connected with the items they are trying to witness. Roping off and creating a carefully monitored corridor around a space is a common situation in most museums. To reinvigorate interest and bring a new generation to appreciate some classical works, they are being transferred into completely new media with audio visual displays and sensor driven experiences that make the, originally 2-d art medium, come to life[28].

image courtesy of gagosian
Grimani Palazzo Museum(The Grimani Family's donations in 1523 helped establish one of the first public museums)

[27] Simmons, John. (2010). History of museums. Encyclopedia of Library and Information Sciences.
[28] https://vangoghexpo.com/

Advances in experience

With audio/visual media able to be played for individual exhibits, an additional sense was added back to allow for engagement and sharing of additional information from static images or exhibits. Today augmented reality, staged actors and performers, robust visuals, and elemental effects all can be employed to bring about a more lifelike or exhilarating experience. Most of these are used in themed amusement parks where the entire experience is scripted to achieve a specific experience for the audience. Escape rooms and immersive theater also provide another level of interaction with the audience, often becoming a part of the show or needing to solve or manipulate the environment for a desired result.

Museums responsibility and opportunity in education

The gap between historical education and historical artifacts has always been a challenge undertaken through display of artifacts and examples of antiquity. The fossil record and archeological study have unearthed myriads of examples of historical artifacts to provide better learning for the sighted. This manifests into professionally photographed full color pictures inserted into articles and books. There is rarely a chance for physical manipulation of objects or experiencing them with other senses.

Even when physical examples exist to display, they are not often copied or used to create tactile displays. This limits the experience and understanding of the significance for sighted and visually impaired alike. Often the true scale of the example is lost in a photograph. For sighted students the real size of a building such as the Eiffel Tower is difficult to discern from a photograph, for a visually impaired student the scale is totally lost on them. Even alt text for a photograph won't always cover the important aspects of

scale much less texture, color and materials.

Cost, storage, and maintenance all prevent most schools from having physical artifacts or models for teaching aids. To fill this gap, field trips and visits to museums and exhibitions are encouraged and often a part of the curriculum. If these institutions have not accommodated the needs of the many types of visitors then they often provide an unintentional ableist approach to the user experience.

© Christian Bertrand | Dreamstime.com
Pictured above, the Mona Lisa at the Louvre, as it is displayed currently.

Accessibility vs Vandalism

With works of art and one of a kind antiquities on display, it is not uncommon for multi-million dollar pieces to be kept under extreme safety measures and with strict visitation guidelines. Some works have been attacked and used for political or social

protest and require extreme measures[29]. The Mona Lisa shown above, now is housed behind a glass enclosure with a railing and further cordoning of viewers an additional 3 meters away. This leaves even those with excellent visual acuity unable to enjoy the original works at a distance that showcases its details.

Tools of the trade

3D scanning and printing is less expensive and more accurate than ever. 3D scanners used to be large machines which required the object to be scanned to be moved to the scanner's location. The object would then be covered with registration dots for the camera to read. The process could take several hours for the camera to move and have the information uploaded to a computer.

Now handheld scanners with just as much accuracy can be brought to the object and moved around the object with no need to apply any foreign materials to the surface. This is a great relief for conservators who no doubt would hesitate to pack up a priceless object for scanning.

The Einscan HX handheld 3D scanner

[29] https://www.indiaherald.com/Viral/Read/994507188/The-Famous-Mona-Lisa-Smeared-With-Cake

3D printers have also improved in quality and available materials while coming down in price. The most popular types of 3D printers are Fused Deposition Modeling (FDM), Stereolithography (SLA) and Selective Laser Sintering (SLS). There are many more, but for the sake of simplicity, these three are well known and will be referred to in this article.

In 1987 when Charles Hull invented the SLA printer, it would cost around USD $300K to buy one. In 2022 you can buy several models for less than USD $1000.

That availability and affordability can make a huge difference when it comes to making tactile reproductions for museums. These reproductions can take the need away from having to use originals on display. There are even 3D printers that use clay instead of plastic making it possible to recreate the shape of pottery which would later be painted and fired to mimic a museum piece for tactile display.

3D printing should not be considered the end-all of creating tactile interactions. One 3D printed object can have many different textures and patterns depending on the type of 3D printing used, the resolution of the machine and the type of material used. Many times, the textures left by the printing process are not the proper textures to accurately convey tactile information. Objects which are 3D printed must be coated with other materials to smooth or change the texture. Adding other materials can also improve tactile information.

Challenges in designing for differentiated users
The design of exhibits, museums and public spaces has evolved greatly over time with considerations of user flow, attraction spread, multi-generational users and timing of use to make the most of the space and the amount of users needing access.

Elements like lighting, sound, barriers, queuing, theming, have also been honed to maximum effect to allow for the experience to be immersive, informative and engaging. Designing for those with visual impairments focuses on other senses that often are not highlighted or designed for. Also, the range and "viewing area" is shrunken significantly to arms reach for tactile information, leaving scale, and items displayed overhead completely lost to those unable to see.

©*Szeke*

Pictured here is the Smithsonian Air and Space Museum. With the majority of the artifacts hung many feet in the air, how much of this space is accessible and able to be experienced by those with visual impairment?

Those with mobility issues are often faced with similar difficulties. Difficult to navigate spaces without accommodations for wheelchairs will frequently prevent these users from having a similar experience to those without mobility challenges. Sightlines, knee walls, railings and limited viewing angles are all challenges preventing good experiences for this type of user.

Planned depreciation and wear.

Recently one of the authors was asked to consider a permanent tactile display in a prominent establishment. The subject of a permanent display was discussed which brought up the following concepts.

Whether a tactile exhibit is for one week, one year, one decade or many decades, tactile objects on display will break in some way, this must be an acceptable and expected fact. Whether the damage is by mishandling, accidents or through cleaning, tactile objects will break down in some way. Short-term displays may not show damage before the exhibit is over, but long-term exhibits will need maintenance before they end.

If this fact is considered, then manufacturing techniques will reflect that decision. Molds can be used to recast items, 3D computer models can be reused to 3D print or Computerized Numerical Control (CNC) an object or mold i.e., additive or subtractive manufacturing. These can be time- and money-consuming, simply put, you have to make something to make something else, but it's well worth the effort. The point is the objects first created can be recreated making replacement objects possible.

The choice of manufacturing materials is a very important decision and a possible point of irritation with a client. If we just consider 3D printing with Fused Deposition Modeling (FDM) the materials greatly vary in strength and durability. Polylactic acid (PLA) is popular with makers because it is low in cost, has a low melting point and can be biodegradable. What it gains in ease-of-use it loses in durability. If we compare PLA to acrylonitrile-butadiene-styrene (ABS), PLA does not perform as well for long-

lasting applications[30]. Although the cost of the materials is comparable, the difference is the up-front cost of the printers. A low-cost printer that can only use PLA can be as low as USD $200 as compared to a high-quality printer that can use ABS and other materials may cost more than 100 times more.

Other materials in just the 3D printing category can include wood, resins, ceramic and many kinds of metal. Most of these are very durable and can accurately reproduce the original object's materials.

When to make these replacement items is another consideration. Making them as part of the initial project is logical but convincing the client to pay for extra parts before they need them can be a difficult sale. How many they need and what the costs would be are difficult to calculate because they depend on an estimate of future use and abuse.

© Matt Gesualdi

This tactile embossed paper was created to show how a copper plate print is created. There were 12 embossed pieces of paper made for the client knowing that paper would be uncleanable and could rip.

[30] https://www.hubs.com/knowledge-base/pla-vs-abs-whats-difference/

Real vs replica

Just because an item can be touched doesn't mean that it should be used as a tactile piece for the visually impaired. When considering a tactile exhibit, it's important to recognize the difference between an object that can be touched and an object that can teach. For instance, if the femur of an animal is the object to be taught, then the actual femur would be the first choice as the teaching object. There's no need for translation of information, the femur is the object and has the correct texture, weight and material temperature. If the actual femur needs to be conserved, then making a mold and using a resin to match the temperature and weight should be easy.

If the intended object is less convenient to obtain or is of the wrong scale to display, then a translation of the object is necessary. Let's use a building for this example. When you shrink down a building in a scale model all the details are shrunken with it. Some of those details are very important and others less important to identify or educate about the building. It may be necessary to enhance the important details by enlarging them in a way that the viewer can feel those details over others. It's a bit like making a word in a sentence stand out by making it bold or if necessary, by making it in ALL CAPS. It's not deceitful or misleading, it's just emphasizing details that may get lost with scale.

© *Matt Gesualdi*

A tactile architectural model of a clocktower in Denver, Colorado USA. It shows some exaggerated details of a building's features. The enlarged details can be apparent if you compare them to the people near the building.

Translating for effect

Translation can also be used when representing a 2D object in 3D. Here there are many choices, but they come down to the same point as above; what are the important details that would help a person be able to identify and remember the features. In this case let's use a painting of one of Frida Kahlo's many self-portraits. Besides her skin there are often fabrics, objects and nature represented. But, in truth they are just painted on a canvas or board, so what textures do you use? The paint texture or the imagined textures of the materials shown? Back to translation. The texture of the paint and brush strokes could arguably be represented to show the artist's techniques, but what would a blind person see from that? If we were to use smooth materials

for her skin, rougher textures for fabric and other textures for the different objects, natural and manufactured we would get much closer to making an image in someone's brain. But temperature when used can offer a much more enriching tactile experience. If real fabric is used instead of a fabric texture on a 3D print or casting, the viewer will understand that what they are feeling is fabric. Fabric is softer and warmer than resin and will make the translation much easier. When speaking about this subject of using different materials Dr. Lynette Jones of MIT stated that " On the basis of these changes in temperature, people can identify the material composition of objects, for example, whether the object is made from copper or wood"[31]. The consideration of temperature when designing a tactile exhibit is crucial to being successful.

Sometimes to represent something that is too large or too small to be directly translated to an easily shown size, we must use scale. As mentioned earlier, scale can offer choices of what to emphasize and what to deemphasize. If something is very small like a mosquito then enlarging it to the size of a small bird can be useful. But in an effort to not make people believe the frightening thought that there are mosquitos the size of birds, it's important to show relative scale. A mosquito can be 10mm in length. If you enlarge that mosquito ten times to 100mm, then have a common object enlarged to the same scale. A one euro coin, around 23mm in diameter, could be easily recreated to 230mm and give the viewer a relative scale in which to compare the true size of a mosquito therefore guaranteeing the viewer a good night's sleep. The same concept can and should be used when representing very large objects like buildings. It is easy to purchase or make scale human figures so the viewer can relate more easily to the scale.

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[31] Jones, L (2009) Thermal Touch, Scholarpedia 4(5): 7955, Thermal touch - Scholarpedia

Choosing your materials

When interviewing a top virologist for the state of Florida in the United States the subject of cleaning tactile objects was discussed. He began to describe the types of disinfecting and sterilizing chemicals he uses to clean test equipment. When asked what materials could withstand such chemicals his answer was metal and glass. The kind of severe and complete sterilization done in testing and health care environments is difficult to match in the museum environment, but we have to consider cleaning tactile objects as one of the challenges (D. Brewer, personal communication, September 22, 2020).

When possible, non-porous materials work best for cleaning but may not always be the appropriate match for the temperature and texture for tactile accuracy. Powder coating is a very hard, durable and chemical resistant coating. It is mostly made for metals but a variation can be applied to plastics. "Powder coating is based on polymer resin combined with pigments, curative, flow modifiers, leveling agents, and several other additives. All ingredients are melt mixed together, then cooled and ground into a powder[32]".

Automotive paint can withstand much more chemical cleaning than brushed-on house paint. Even weaker would be spray paint from a spray can; the thinness of the paint layer makes it easy to rub through. So, when considering material colors, it would be more durable to find materials which are already the color, or close to it, that is needed. An example would be finding red acrylic

[32]https://www.ametals.com/post/everything-you-should-know-about-powder-coating-finishes#:~:text=Powder%20coating%20is%20a%20dry,both%20functionality%20and%20overall%20look.

sheet material rather than painting acrylic red. The red acrylic may wear during cleaning, but the color will remain.

Hygienic Approaches

There are many ways to "clean" an object. The quotes were used because the Florida virologist made it clear that what the general public think are clean is vastly different from what the testing and health care industry think are clean. We must settle for something more than the general public's view and substantially less than the testing industry. There are many chemicals that we can apply to rid surfaces of germs to use a simple term for viruses, bacteria, bugs and anything else that causes irritation. We can spray or wipe surfaces with antibacterial/antiviral chemicals. These are very likely to disturb any easily dissolved surfaces like paints, porous materials, and delicate details in weaker materials. Just the act of getting some materials wet can change the shape and integrity of them. Often the chemicals we use to clean items are themselves dangerous and must be cleaned away with water. As the virologist made it clear and is important to remember, a cleansed item is not truly clean until it has been cleaned and thoroughly dried.

We can expose surfaces to ultraviolet (UV) rays using portable or non-portable UV emitters. These can be effective if used for hours at a time, something that may be difficult during the day at a museum. UV cleaning can be less effective for items with many contours. UV cleans by line-of-sight meaning that the surface not facing the UV emitter may not get as clean as the surface facing the emitter. The effort and time needed to make UV cleaning effective may be prohibitive to museums. Without careful use,

large UV units may also spill harmful UV rays onto nearby artifacts and could create permanent damage[33].

In 2018, before most of the world had heard of the coronavirus, the authors created a tactile immersive event where people were asked to use antibacterial wipes on their hands before entering. The premise was that the germs and oils on human hands would deteriorate the "alien" artifacts that had landed on Earth[34]. The real reason was that there would not be time during the 3-5-minute reset period to clean all the interactions, besides the fact that not everything could stand up to cleaning agents. Every person who entered and touched the objects inside came in with clean hands. This was a simple solution which the authors believe could save museums and other institutions many hours of cleaning time as well as preventing the deterioration of tactile objects.

[33] https://www.davincimedicalusa.com/purify-one-uv-wand
[34] https://303magazine.com/2018/10/maker-faire-denver-october-2018/

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