Aesthetics and Design in Science

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The science problems of today are increasingly large-scale, complex and multivariate and require solutions that are creative, collaborative, and multidisciplinary[i]. In this, computational thinking harnesses technology's rapid advances for science, but that only tells part of the story. As the rate of discovery and progress increases, we have to ensure that our ability to share and talk about our work keeps pace. This includes our ability to collaborate and benefit from a diversity of thought (see Figure 1). We believe that aesthetics and design address these very human realities. Aesthetics catalyzes the message in science and increases its approachability, while the underlying principles in design are well suited for collaboration and the development of easy-to-use software tools. Our goal is to enhance the level of discourse within the scientific community including students, teachers and the public.

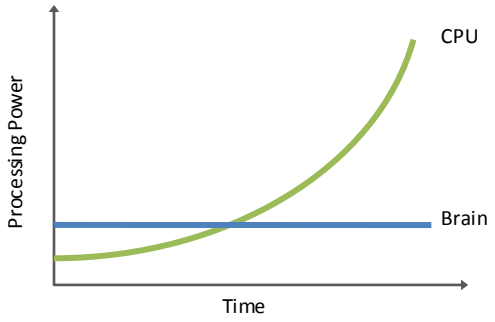

Figure 1 – Minding the gap between Moore's Law and God's Law (Bill Buxton). While processing power doubles every 18 months, the human capability to process information stays constant[ii].

Images and Meaning

Science to a degree needs to be an act of communication or its message is lost. In any such a communication, the success greatly depends on our ability to represent and explain the understanding of phenomena we desire to share. The lure of aesthetics and approachability of visual story telling are arguably two of the best tools in facilitating the sharing of an idea. Let's further explain this in an example. In a number of collaborative lab sessions and workshops we helped researchers and graphic designers think through problems and visual methods for displaying them. For example the before figure on the left in Figure 2, imaged by the researcher, tries to visualize properties on a chemically controlled surface, but fails to clearly articulate the main findings – there are distinct differences between the hydrophobic and hydrophilic areas. In refining the thinking of how to represent the phenomenon, the scientist reworked the sample in discussions with Felice Frankel to better express and refine the concept. This result is the photograph on the right. Here, deeply considering the communicative nature of the representation not only clarified the science to the viewer but also clarified the meaning of the science for the scientist. Anecdotally, the more appealing photograph brought a great deal of attention to the research when it appeared on the cover of Science. Similar approaches for other forms of scientific representation prove to bring similar results.


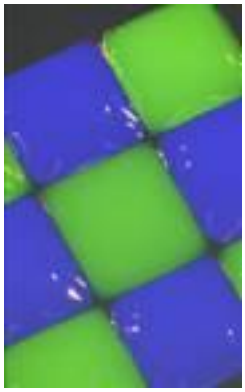

Figure 2 – Before and after comparison of two photographic attempts. The image on the right not just clarifies the science of chemically controlled hydrophobic and hydrophilic surfaces to the viewer, it also clarified the meaning of the science to the scientist.

While the aesthetic refinement of the representation increased its appeal and recognition, the development of its final form also helped the researcher refine the message.

Design and Collaboration

What holds for static images applies to the dynamic domain of software tools and interactions as well. The process of crafting and designing the rich behavior of software tools is called. A well design application is easily adapted and has a broad reach. Furthermore a designer's skill-set is well suited for collaborating with a diverse set of people and thought. A designer's sketching process encourages rapid exploration of multiple ideas and interactive prototypes help define and

build common understanding. For example, the close collaboration between researcher and designers in creating Microsoft Research's World Wide Telescope, led to the creation of an astronomy tool that appeals to astronomy experts, enthusiasts and new-comers alike. The WWT is a collaboration between MSR's Next Media Group and many others[iii].

Figure 3 – The World Wide Telescope is a scientific tool for exploring space data sets and aggregating research findings. At the same time though, it may act as an outreach tool for people new to astronomy.

The application brings together astronomical data from Sloan Digital Sky Survey, Hubble Space Telescope, Chandra X-Ray Observatory, Spitzer Space Telescope, WMAP microwave survey, 2 Micron All Sky Survey and others. While the researchers have an understanding for expert requirements (e.g. coordinate location right ascension, dedination, telescope frame of view, papers published about an object, FITS source image data etc.), the design team from Artefact in Seattle[iv] devised a user interfaces that helped first time users locate themselves in space.

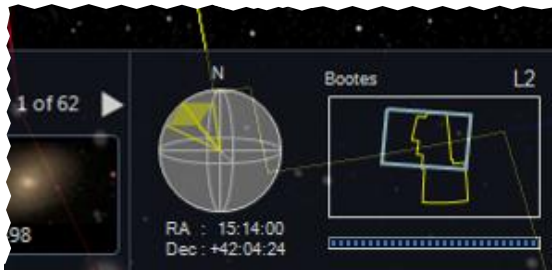

Figure 4 – Detail of sky navigator. The primary goals of this UI is to help novice users orient themselves in space, however it precision is useful for experts as well.

While the utility of the tool is grounded in scientific understanding, its meaning is expanded by making it easy to use for a broader audience. What started out as a tool for the few ends up being an application for the many to share, learn, discover and collaborate.

Best Practices

Bringing together computational thinking, aesthetics and design is inherently multi-disciplinary. At a university level we have found that project-based classes and workshop appear to be a particularly effective way to deliver such education; bringing students from different disciplines together to work on a common challenge allows the students to help educate each other, with faculty guidance, about their respective disciplinary knowledge and skills. A model to look at is the Stanford Graduate Summer Institute which offers multi-disciplinary classes that mix students from various academic backgrounds to great success or in the word of the students the "most satisfying learning experiences."[v]

Summary

The great challenges of today, such as globalization, healthcare, or the effects of human activities on the environment call for diverse, collaborative and multidisciplinary approaches. Computational thinking, and we acknowledge this is an oversimplification, gets us a better use of the machine. It is aesthetics and design that promote the discourse and sharing amongst the humans in the loop. We have to be equally good at representing and sharing our understanding in ways that is approachable and inviting, build tools that are engaging and flexible, and strengthen our ability to work with people from a diverse background of thought. The circle of knowledge is not complete, without means of sharing that which was understood and discovered.

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[i] Report of the Commission of Graduate Education, Stanford University 2005

[ii] Buxton, W. "Less is More (More or Less)", in P. Denning (Ed.), The Invisible Future: The seamless integration of technology in everyday life. New York: McGraw Hill, 145 – 179 2001

[iii] Jim Gray, Alex Szalay, Alyssa Goodman, Jina Suh and Paul Johns

[iv] While this is a commercial design agency, several universities offer programs in interaction design that could perform a similar role in an academic setting.

[v] Stanford Graduate Summer Institute 2007.