Re-Envisioning the Communication of our Science

Daniel J. McGarvey and Christopher A. Mason

Design and presentation matter. We validate this every time we peruse a rack of greeting cards or wrestle with an unnecessarily detailed map. So why has science training, as most of us have experienced it, remained so devoid of basic design principles? With limited time to teach communication skills, most graduate programs focus primarily on technical writing. This is a rational strategy because technical writing ability is so essential to the aspiring scientist; work that is not vetted and published in a technical journal is, after all, of little or no value to the scientific community. But a very different set of design skills is needed to communicate scientific knowledge to broad audiences in an accessible and engaging way (Trumbo 1999). Consider successful media outlets like National Geographic Magazine, Science Times (The New York Times), and NOVA (Public Broadcasting Service). They are effective because of their aesthetic production and meticulously refined storylines.

In Fig. 1, we have recreated Raymond Lindeman's iconic "ooze" diagram from Cedar Bog Lake, Minnesota (originally Fig. 1 in Lindeman 1941). All of the structural information from the original diagram is included in our version, as are the annual production estimates from Lindeman's Table 4. We present both versions here as a kind of visual argument: the original has served the scientific community well for more than 70 yr, but we believe the re-envisioned diagram has greater potential to engage and educate general audiences. The colors and shapes are eye-catching and the slightly enigmatic (but not overly complex) design creates a puzzle that is intended to draw the viewer in. The new diagram is also a good example of the kind of visualization that a student with basic training in graphic design and computer illustration can create.

Ecological and Environmental Science Perception v. 2.0

Recently, the Center for Environmental Studies and the Rice Rivers Center at Virginia Commonwealth University (VCU) teamed up with faculty from the VCU School of the Arts (one of the top-ranked arts schools in the country) to begin an interdisciplinary, graduate-level experiment in broad science communication training. Dubbed Ecological and Environmental Science Perception version 2.0 (eESP$_{2.0}$), this program has three main objectives. First, we want to identify specific technical skills that will be most useful to young scientists as they begin to communicate their own work. Should we focus on digital illustration? Perhaps photography or video would be more useful? We are entering uncharted waters here and will spend the next 2–3 yr formulating a serviceable answer to this question. Second, we seek to empower our students with the knowledge that they possess a novel and valuable skill set. Third, we intend to create and distribute a record of this process, inclusive of course curricula, program logistics, and measures of student success.

eESP$_{2.0}$ currently consists of two new graduate courses: one in digital illustration and design, and a second in documentary storytelling. The first, entitled Infographics—the Visualization of Scientific Data, was launched in August 2014. Course content includes lessons on typography and legibility, complimentary color schemes, effective use of space in poster and infographic layouts, and an introduction to Adobe Creative Suites software (primarily Adobe Illustrator and Adobe Photoshop). The second course, Getting the Science Out—Communicating Your Science to the Public, is about to be taught for the first time. It will include an introduction to photography and video, inclusive of the recording and editing stages, as well as storyline development and nontechnical writing for general audiences. Graduate students who wish to develop broad communication pieces from their own research have the option to enroll in either or both courses.

The 2014 Infographics course was a combination of informal lectures and computer exercises, working with the students' own research materials in Illustrator and Photoshop. We began with simple typographic assignments in which students experimented with the selection, orientation, and layout of different typefaces, learning first-hand how typography can enhance (or constrain) the impact and clarity of a message. Assignments then became more technical as students learned to use the drawing tools in Illustrator and to import and modify digital images in Photoshop. Two examples of student work are shown in Fig. 2. Throughout the semester, students were offered opportunistic "tricks of the trade" to improve their individual assignments; some examples, including text hierarchy and the use of repeating images, central dominance, and the use of color and bleeds, are shown in Box 1. The class culminated in a final poster or large-format infographic that was designed to be equally accessible to technical and non-technical audiences. A juried critique of the final projects was then used to award travel grants to two of the students, allowing them to showcase their work.

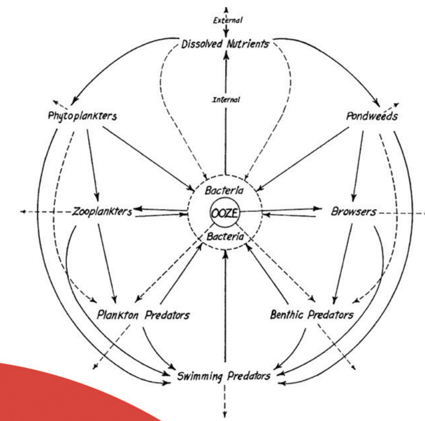
This first cohort of Infographics students met or exceeded each of our curricular expectations. Each student left the class with a basic understanding of graphic design principles and the technical skill to create more engaging visualizations of scientific information. But we observed something else in the students that we did not previously anticipate. They relished the opportunity to explore the creative, artistic side of science communication. Every class period was a lively, fun event and the students were clearly proud to share their work in group critiques. In fact, most of the students requested after-hours access to the Adobe computer lab (located in an Arts facility) to continue working on their projects. A critical evaluation of the effectiveness of eESP$_{2.0}$, relative to the professional development and success of our students, will obviously have to wait until our students have moved on to the next stages of their careers. But we can say with certainty that each member of the first cohort felt the Infographics class was an enriching and worthwhile use of their time.

Part of a larger science communication movement

Our students' interest in communicating science, and not just conducting it, mirror a larger trend within the scientific community. The National Science Foundation (NSF) recently solicited new ideas in graduate training through the 2013 Innovation in Graduate

Rice Rivers Center VCU

eESP 2.0 ecological and environmental science perception



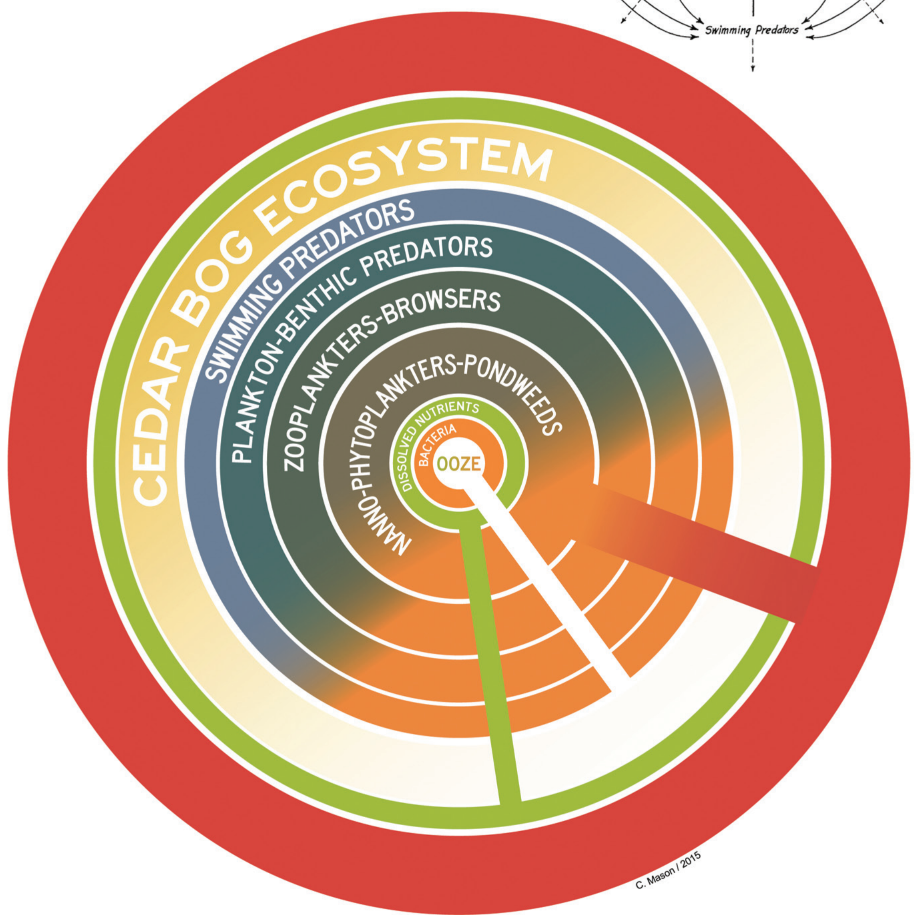


Fig. 1. A re-envisioned diagram of the food-cycle in Cedar Bog Lake, Minnesota, created by graduate student Christopher Mason (Virginia Commonwealth University). All of the structural components and major pathways from the original graphic (Fig. 1 in Lindeman 1941, shown at upper right) are preserved in the new graphic. Solar radiation is the primary source of energy for aquatic (nannoplankters and phytoplankters) and semi-aquatic (pondweeds) primary producers; this one-way subsidy is depicted by the solid "bridge" between the external solar radiation ring and the interior nanno-phytoplankters-pondweeds ring (trophic level 1). Trophic links between producers and their consumers are represented by the four concentric rings, with higher trophic levels at more distal positions. The widths of the four trophic level rings reflect the summed (aquatic + semi-aquatic organisms) mean annual production within each trophic level, as reported in Table 4 of Lindeman (1941); the original production data (in cal/cm^2/yr) were ln-transformed to prevent the size of the primary production ring from overwhelming the graphic. The benthic ooze at the center of the diagram is depicted as a mix of bacteria, dissolved nutrients, and decaying tissue from each of the four trophic levels; the shaded transition to orange within each trophic level ring represents the decay and settling of plant and animal tissue. The direct connection between the ooze and the boundary of the Cedar Bog Ecosystem represents the availability of the ooze as a general resource within the lake. Finally, dissolved nutrients are an essential, basal resource within Cedar Bog Lake but are also connected to external sources; the direct link between internal nutrients and the external nutrient ring reflects the modern threat that anthropogenic nutrient loading now poses to many aquatic ecosystems. The original Cedar Bog food-cycle diagram is used with permission from The American Midland Naturalist.

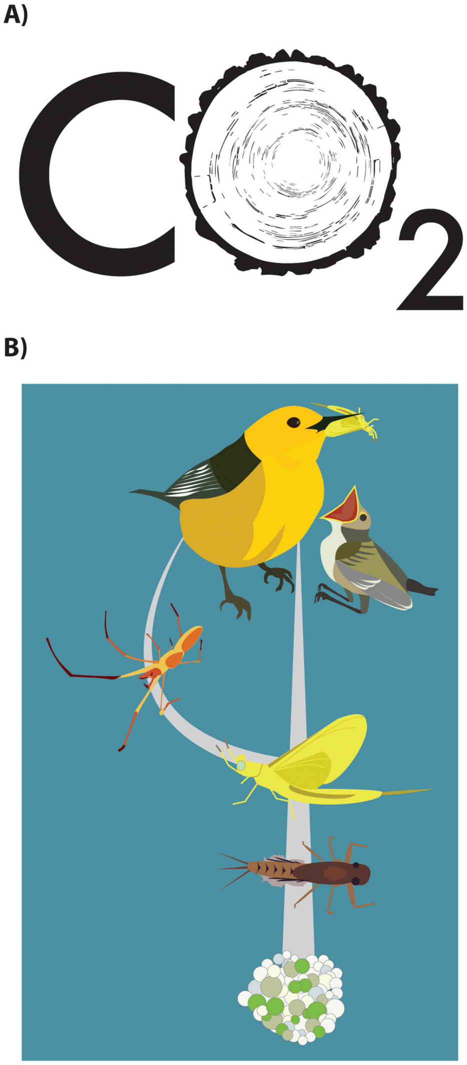


Fig. 2. Examples of student work prepared during the Fall 2014 Infographics class. Panel A is the logo that a student created to "brand" her research on forest carbon sequestration; it combined basic typography with a tree cross-section photo that was edited in Photoshop then imported to Illustrator (credit: Amy Schmid). Panel B is a food-chain diagram of the potential connection between a toxic cyanobacteria (*Microcystis sp.*) in the James River, Virginia and the Prothonotary Warbler (*Protonotaria citrea*); it demonstrates the level of technical illustration skill that some of our students achieved (credit: Nicholas Moy).

Education Challenge (www.nsf.gov/news/special_reports/gradchallenge/). Graduate students within any STEM discipline were eligible to propose new curricular opportunities that would best meet their anticipated professional needs. Proposals were then evaluated and scored by a mixed panel of peers (i.e., graduate students) and established experts in graduate education. Eight proposals were selected as winners, three of which sought to enhance public engagement through broad communications training: (i) The Scientists with Stories Project; (ii) Communicating Science to the Public—A New Graduate Course and Practicum; and (iii) RELATE—Researchers Expanding Lay-Audience Teaching and Engagement.

Other notable indicators of "supply side" interest in enhanced science communication capacity include the Integration and Application Network (IAN) and Freshwaters Illustrated. IAN is a faculty initiative at the University of Maryland Center for Environmental Science that teaches scientists to apply design and digital illustration tools (similar to our goals for the Infographics class) through multiday workshops and online training modules (http://ian.umces.edu/). IAN has also published an excellent text on science communication (Thomas et al. 2006) and created a free, web-based application for building conceptual diagrams of aquatic and terrestrial environments (essentially a lightweight version of Adobe Illustrator), complete with an extensive library of thematic icons (mixed fauna, flora, and physical habitat elements) and photos. Freshwaters Illustrated is a collaboration of scientists and artists that use underwater photography and video to educate general audiences (www.freshwatersillustrated.org). Their strategy is simple: use stunning images to help audiences connect with aquatic organisms and their native environments.

Impacts and rewards of enhanced communication

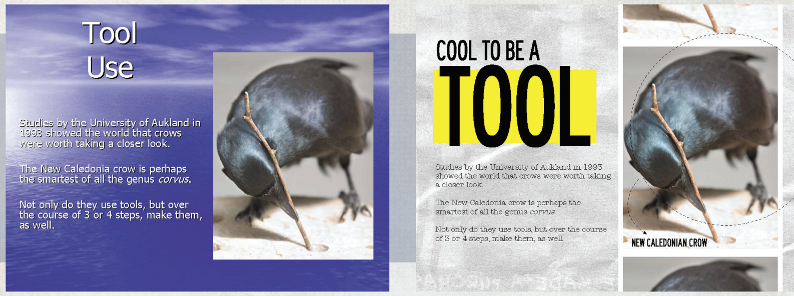
The examples of science communication resources and training opportunities provided here are anecdotal. Readers seeking a more thorough treatment of this topic should consult Holliman et al. (2009) and Besley and Tanner (2011). For now, it is enough to emphasize that we are not alone in our intent to overhaul the science communication process. But having the skill and capacity to communicate science effectively is only one side of the coin. To facilitate a complete communication process, there must be demand by an audience. Previously, we stated that we want to empower our students. This was not a platitude. The recent popularity of science outlets like IFLSCIENCE! (www.iflscience.com/) and Information is Beautiful (www.informationisbeautiful.net/) lead us to believe that public demand for the kinds of technical capabilities we are providing is on the rise. And if this intuition proves correct, then our students will be empowered with highly marketable skills.

There are also disciplinary incentives for scientists to polish their communication skills. For instance, new research on the "science of science communication" is starting to show that scientists who self-publicize their work through new media/social media channels are more influential and highly cited among their professional peers (Liang et al. 2014). A focused effort to communicate with general audiences is clearly one of the most direct and intuitive options that a scientist has to satisfy the Broader Impacts criterion that is now required for all NSF proposals (Nadkarni and Stasch 2013). (Note to graduate students: think about how good a personal science blog, complete with "professional" graphics, would look in a NSF Graduate Research Fellowship Program proposal.) Scientists with design training might even be of special value to regulatory agencies that consistently prepare and circulate documents for public review (Gallagher and Jacobson 1993).

Finally, we point to a less utilitarian reason for scientists to polish their broad communication skills. In a democratic society, publicly-funded research is made possible through a social contract: we do work that will, presumably, be of some benefit to the general public, now or in the future (Lubchenco 1998). This contract does not assume we will all cure cancer or invent vulcanized rubber. But it does entail a reasonable expectation that scientists will engage with and educate the populace (Doubleday 2009). And we believe there is much room for improvement here. Think back to the 2008 U.S. Presidential election, when a vice-presidential candidate famously criticized the NSF for funding fruit fly research. (We kid you not!) Scientists were simultaneously amused and annoyed, but the joke was on us. It is bad when a high-ranking politician demonstrates ignorance of basic science. It is much worse when many thousands of voters unknowingly applaud that ignorance. By providing young scientists with modern communication skills, we hope to improve scientific literacy and, in our own way, reaffirm the social contract.

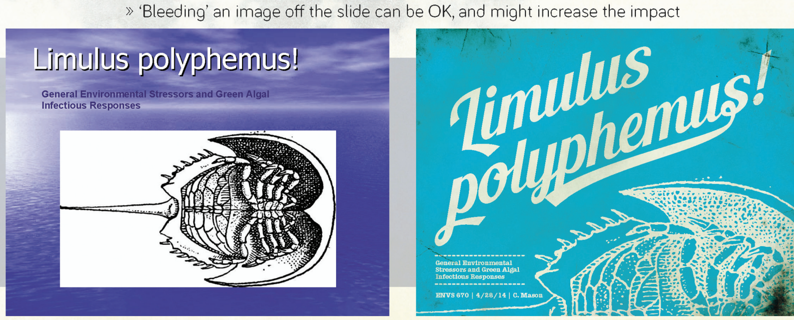
BOX 1. Examples of technical design tips to improve the appearance and impact of presentation slides. Before-and-after slides are shown in left- and right-hand columns, respectively.

TEXT HIERARCHY & REPEATING IMAGES: » Draw attention to your headline and/or subject
» If you have few images to work with get creative (e.g. 'filmstrip')



CENTRAL DOMINANCE: » Use art/images that cover the entire slide to create dominance
» Plan your text around the art/images, not vice-versa

COLOR & BLEEDS: » Sometimes, one color is enough
» 'Bleeding' an image off the slide can be OK, and might increase the impact



Acknowledgments

We owe a huge debt of gratitude to Robert Meganck (Communication Arts, VCU Arts) and Laura Chessin (Graphic Design, VCU Arts) for stepping forward to teach the initial eESP$_{2.0}$ classes. Without their skills, energy, and shared vision we would not have an eESP$_{2.0}$ program to report on. We also thank the students for choosing to be a part of our experiment and taking one of our classes. Financial support is being provided by multiple partners at VCU, including the Rice Rivers Center, the Center for Environmental Studies, the Vice Provost for Life Sciences, and the Quest Innovation Fund. David F. Brakke graciously shared the cover photo of Cedar Bog Lake. Finally, we thank Adrienne Sponberg for reaching out and inviting us to share our work with the ASLO community.

References

Besley, J. C., and A. H. Tanner. 2011. What science communication scholars think about training scientists to communicate. Sci. Commun. 33: 239–263. doi:10.1177/1075547010386972

Doubleday, R. 2009. Ethical codes and scientific norms: The role of communication in maintaining the social contract for science, p. 19–34. *In* R. Holliman, J. Thomas, S. Smidt, E. Scanlon, and E. Whitelegg [eds.], Practising science communication in the information age: Theorising professional practices. Oxford Univ. Press.

Gallagher, T., and W. Jacobson. 1993. The typography of environmental impact statements: Criteria, evaluation, and public participation. Environ. Manage. 17: 99–109. doi:10.1007/BF02393798

Holliman, R., E. Whitelegg, E. Scanlon, S. Smidt, and J. Thomas. 2009. Investigating science communication in the Information Age: Implications for public engagement and popular media. Oxford Univ. Press.

Liang, X., and others 2014. Building buzz: (Scientists) Communicating science in new media environments. Journalism Mass. Commun. 92: 772–791. doi:10.1177/1077699014550092

Lindeman, R. L. 1941. Seasonal food-cycle dynamics in a senescent lake. Am. Midl. Nat. 26: 636–673. doi:10.2307/2420739

Lubchenco, J. 1998. Entering the century of the environment: A new social contract for science. Science 279: 491–497. doi:10.1126/science.279.5350.491

Nadkarni, N. M., and A. E. Stasch. 2013. How broad are our broader impacts? An analysis of the National Science Foundation's Ecosystem Studies Program and the Broader Impacts requirement. Front. Ecol. Environ. 11: 13–19. doi:10.1890/110106

Thomas, J. E., T. A. Saxby, A. B. Jones, T. J. B. Carruthers, E. G. Abal, and W. C. Dennison. 2006. Communicating science effectively: A practical handbook for integrating visual elements. IWA Publishing.

Trumbo, J. 1999. Visual literacy and science communication. Sci. Commun. 20: 409–425. doi:10.1177/1075547099020004004

Daniel J. McGarvey and Christopher A. Mason, Center for Environmental Studies, Virginia Commonwealth University, Richmond, VA 23225, USA, djmcgarvey@vcu.edu, masonc@vcu.edu