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SCIENCE COMMUNICATION IN HIGHER EDUCATION:
GLOBAL PERSPECTIVES ON THE TEACHING
OF SCIENCE COMMUNICATION

Strengthening interdisciplinarity in science communication education: promise, pleasures and problems

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Abstract

Science communication education is fundamentally concerned with relations between and within communities, cultures and institutions. Through exploration of these relations, it develops understanding of how knowledge is produced, shared and validated. Science communication operates at the boundaries and intersections of disciplines in its professional practice and it analyses them in research and education. At its interdisciplinary best, science communication is a continuing exercise in reflexivity on science and its place in wider intellectual and public culture. From this *premise*, this essay reflects on the *promise* of bringing perspectives from humanities, social sciences and natural sciences to bear on science, the *pleasures* of science communication as "joyously interdisciplinary", but also on the *problems* in fulfilling the promise and realising the pleasures. It closes with a *proposition* for giving interdisciplinarity a more prominent place in science communication education.

Keywords

Professionalism, professional development and teaching in science communication; Science communication degree programmes; Science communication: theory and models

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Introduction

The plurality of disciplines science communication contains and encounters is often mentioned in discussion of education and research in the field. It is much less frequently examined in any detail or with specific emphasis. Many assumptions are made on the topic, including that those working in the field recognise this plurality. This essay seeks (*essayer*, to try) to give cross-disciplinarity in its various forms a more prominent and explicit place in science communication education.

The focus here is on the professional education typically offered at postgraduate level in higher education institutions. Such education is informed by and feeds into

research, and many educators on programmes for future science communicators are also trainers on short courses for public-facing scientists. So, much of what is covered here also applies in those environments.

This essay draws on the author's previous writing on science communication education, but extending and emphasising the aspect of interdisciplinarity. The essay is in five parts, presenting the Premise, Promise, Problems and Pleasures of interdisciplinarity in science communication education and closing with a Proposition to give interdisciplinarity greater prominence.

The Premise: science communication involves multiple disciplines, necessarily and unavoidably

Our starting point is that thinking about characteristics and connections of different disciplines is not an optional extra in science communication education. It is a central part of what these studies address, and how they are conducted. Science communication is fundamentally concerned with relations between and within communities, cultures and institutions. Through exploration of these relations, science communication education develops understanding of how knowledge is produced, shared, validated and scrutinised. Science communication unavoidably confronts the boundaries and intersections of disciplines in its own professional practice, and science communication education necessarily analyses them.

In science communication education and research, the several disciplines that inform communication studies are already inescapably present. Even in the less common version, communication sciences, the plurality of approaches is represented. Psychology, philosophy, sociology, rhetoric and linguistics are just some of the longer-established disciplines that are at play.

The interwoven development of communication and cultural studies adds to the disciplinary mix, and focusing on the communication *of science* adds further to the range of methods and bodies of knowledge to be taken into account. Science communication studies have been substantially informed and formed by social studies of science, drawing mainly on sociology, but also history and philosophy of science.

Science communication has come to refer almost exclusively to public communication of science, as distinguished from peer-to-peer communication among scientists through research team meetings, workshops, conferences, publications and other means. But peers, despite the name, are not equal or the same and they are increasingly separated through specialisation. Rather than refer to communication of science we might more correctly refer to communication of sciences, as communities and cultures within the entity we call 'science' show considerable variation. This creates the need for forms of communication across sciences that are similar to those of public communication of science.

From its most rudimentary forms outwards, the professional practice of science communication negotiates relations between disciplines and communities of practice: ways of thinking and working that have developed in humanities and social sciences encounter experiences and perspectives from the natural sciences. The negotiation is continuous and, when science communication diversifies, for example, towards arts-science approaches, it becomes more complex. The negotiation can also become more fraught, given that the naming of some

disciplines as hard or exact sciences elevates them, at least implicitly, above soft or inexact sciences or non-sciences.

It is by now commonplace to refer to the most pressing societal issues as requiring contributions from several or many disciplines; naming these issues 'wicked' problems underlines their intractability. The COVID-19 pandemic has made more strikingly evident what was already apparent in the spheres of climate change, sustainable development and biodiversity loss. Due to the many dimensions of these issues, communication around them is challenging in ways that are different from and perhaps further-reaching than, say, the exposition of particle physics to lay audiences. In these broader circumstances, collaboration is essential, starting with a shared problem or question. How a collaboration takes form from such a starting point depends on the understandings of that problem and differences that may relate to the distance between those taking part, i.e. narrower-spectrum between branches of biology or broader-spectrum between any of those and ethics. The personal and organisational conditions and the hoped-for level of integration will come into play; in those contexts, the terms used to describe the collaboration's ambition are critical.

Discussion of science communication as a cross-disciplinary field shows loose usage of the associated terms. Inter-, multi- or transdisciplinary aspects are often referred to as apparently equivalent to each other. A search in the journal, Public Understanding of Science, for "interdisciplinar*" in the abstracts of papers published since 1992 produced nine hits, of which four referred to multidisciplinary/ity. Seeking to clarify the distinctions between different prefixes applied to -disciplinarity but recognising that usages vary widely,[1] I put forward these definitions as a means to categorise different types of collaboration:

- a multidisciplinary collaboration accumulates the contributions of different disciplines, acting jointly but separately
- an interdisciplinary collaboration integrates these contributions, working together
- a transdisciplinary collaboration transforms the relations, establishing a new paradigm, potentially a new discipline
- cross-disciplinary can refer generically to any or all of the above

For the purposes of the present discussion, the focus is on collaboration between communities representing disciplines with a more or less developed body of core knowledge. I consider disciplinarity, with all the implications of established theory and domain boundaries, as a precondition for cross-disciplinarity. In science communication, increasing attention is being given to various forms of public participation, including that of 'lay expert' communities who bring tacit or indigenous knowledge to the process and some have characterised this as interdisciplinary collaboration. For the reasons indicated above, I regard this as inter-community or intersectional collaboration, thus in a related but distinct category.

[1] For example, Rigolot [2020] states that "transdisciplinarity is often characterized by the inclusion of non-academic stakeholders in the process of knowledge production" (p. 1), and presents an argument for seeing transdisciplinarity as a "new discipline and as a way of being" (p. 1).

Developing students' awareness of and comfort with using these concepts appears to me a vital concern of science communication education. In summary, and based on a view of science communication education as exploration of cultures of science and science in culture as much as preparation for specific professional roles, I argue that students should be expected to acquire an understanding of various knowledge systems and to be able to assess the suitability of this one or that one to address specific issues. They should

- learn to recognise and respect many views other than that in which they have been educated previously;
- be able to describe and assess different research paradigms associated with different disciplines;
- anticipate what might happen when one knowledge domain and culture meets another.

The Promise: working across disciplines will support better research and deeper understanding, including in science communication

Call for a show of hands in favour of more collaboration across disciplines and the chances are that there will be a unanimous vote. It seems so obviously the right thing to do and it is hard to make a case against it. The identification of so-called grand challenges have fed into the consensus. There is a widely accepted imperative that expert or knowledge communities can and should work together and thus produce solutions to complex problems. Academic and other leaders routinely applaud such efforts.

Helga Nowotny, sociologist of knowledge and co-developer of the idea of Mode-2 science into which multi-, inter- and transdisciplinarity are deeply inscribed [Nowotny, Scott & Gibbons, 2001], wrote in an introduction to a collection of essays on interdisciplinary research: "In recent times hardly a concept has enjoyed so much popular consensus across a wide range of different funding agencies, university administrators, policy makers, politicians, and the media as the idea of interdisciplinary research" [Nowotny, 2017, p. 1]. In that vein, Mari Sundli Tveit, chief executive of the Research Council of Norway declares: "It is crucial to establish an organisational structure and culture that fosters cross-disciplinary cooperation within the agency".[2] Her remarks indicate that this is an aspiration more than an achievement. Indeed, aspiration and ambition are strongly represented in talk about cross-disciplinarity.

Starting from a shared question, such collaborations require good conversation, good listening, and a degree of humility, in order to appreciate how other communities work. The mutual respect required for good conversation is also required for a good collaboration. As in a good conversation, the benefits may be as much, if not more, for the party initiating as for the party responding; interdisciplinarity can offer crucial insights into one's own work. Collaboration and conversation, like any democratic practices, are also risky and unpredictable; acknowledging other perspectives or dissenting from entrenched authority may be difficult or uncomfortable.

[2]Speech on The Role of a National Research Funding Agency to conference of Irish Universities Association, Dublin, 10 May 2023.

In science communication, there has been an increasing emphasis on inclusivity. This echoes a similar preoccupation in other sectors, to ensure that all who wish to take part and those who do not yet know they might want to take part, have an opportunity to do so. Inclusivity concerns mainly diversity of publics and actors but it can extend also to interactions with other communities of practice.

The continuing discussion about science communication's status as a (possible) discipline is bound up with neighbourly relations. As indicated earlier, the boundaries of science communication are shared with many fields, including mass communication, risk communication, environmental communication, journalism, cultural studies and more. Recognising those boundaries is necessary to good relations but also to self-understanding.

The introduction to a volume of country-level reports on science communication states that "a consensus is developing across the field generally that in science communication we are talking about a young transdisciplinary field, still developing and evolving, but not yet regarded as a discipline" [Gascoigne & Schiele, 2021, p. 12]. In the terms I proposed earlier, interdisciplinary might be more appropriate; a field that has achieved transdisciplinary status might be said to be already a (new) discipline with norms and principles achieved through melding of various disciplines.

In the past decade one notion of science communication as a newly formed discipline has gained some influence. *The* science of science communication is a prescriptive view of science communication research that espouses methods drawn, for example, from social and experimental psychology that most closely match received 'scientific' standards. In this approach the promise of deeper intellectual understanding through pluralist engagement remains unfulfilled.

In science communication education case studies of individual programmes, e.g. McKinnon and Bryant [2017] on the experience at Australian National University and Mellor [2013] on that at Imperial College London, are instructive on the possibilities of crossing disciplines. Mellor writes that teaching science communication in a humanities context within a science-based institution enabled "both the critical approach common to the humanities and a focus on professional media production (also usually located in humanities or arts faculties), at the same time as giving students easy access to top research scientists … an interdisciplinary approach to the humanities was able to flourish at a science-based institution thanks to the relative absence of strong disciplinary interests, and thus competing interests, in humanities" (p. 924). Mellor quoted Imperial graduate, Alok Jha, a science journalist with leading British media, most recently The Economist, as saying that he learned through the programme that "you need to look at science from the outside, understand how non-scientists see it, to best communicate it" (p. 919).

McKinnon and Bryant, writing on one of the longest-running postgraduate programmes in science communication, recall that it started with the relatively limited ambition to prepare graduates to work with the Science Circus, a travelling science show. A thirtieth-anniversary survey of graduates showed, however, that they were working, or had worked, in a wide array of communication roles, including in training, government agencies and science centres. As one survey respondent said of their educational experience, "It totally broadened my skill set

as a science graduate. There were other courses of study that became appealing (eg genetic counselling) but also new career paths that I was now qualified to throw my hat in for like writing and editing, corporate communications, school programs, teacher training as well as work with museums and [science] centers" (p. 184).

More recently, science communication has been widely seen as simultaneously proliferating and cohering as an interdisciplinary field; its promise as a source of new knowledge and valued practice is very much tied up with that. Bringing perspectives from humanities, social sciences and natural sciences to bear on making sense of science is seen to reveal diverse ways of knowing the world around us.

The Problems: interdisciplinarity is difficult, facing institutional and cultural constraints

Science communication studies operate within structures that are largely bound by disciplines, competition for resources and sectoral self-protection. It is often left to individual and informal initiatives to facilitate the encounters at boundaries and crossings that spark the most searching questions and ideas. Views and experiences gathered from science communication educators in 11 countries already over a decade ago [Trench, 2012] reflected the awkward fit of science communication in many institutional and disciplinary settings. The challenges of dealing with different affiliations within the university and with different evaluation frameworks were mentioned, but I also noted that a common thread of a series of articles in this journal in 2009 on six masters programmes was "the engagement between disciplines of natural sciences, social sciences and humanities" [Trench, 2012, pp. 246–247].

Research on interdisciplinary collaboration gives much attention to the impediments to making such collaboration work well, Nowotny [2017, p. 1] noting that "the focus of a major part of this literature [on interdisciplinary research] is … devoted to examining failures". Among the impediments mentioned here and elsewhere is the difficulty of evaluating interdisciplinary proposals, arising from the disciplinary affiliations of qualified reviewers. Epistemic cultures are also a key consideration: Halpern and O'Rourke [2020] noted that science communication is a collaborative endeavour between communities of practice with different priorities and privileges and that the "hierarchical ordering of expertise and knowledge make for problematic power arrangements" (p. 4). The continuing influence within science communities of scientism, which accords unquestioned privilege to the natural and physical sciences as ways of knowing the world, supports such hierarchical ordering.

Introducing an account of their interdisciplinary collaboration around issues in climate communication, psychologist Bruine de Bruin and engineer Morgan [2019, p. 7676] present this ideology of scientism anecdotally when they say that "we know some [natural scientists and engineers] who hold the view that there is nothing in the social sciences that they couldn't invent themselves at a cocktail party on a weekend". However, the authors claimed success for their two-person collaboration on the basis of having shared research goals, making shared effort, and enjoying positive interpersonal connections, down to coordinating the colours of their slides and their clothes when making a joint presentation.

Monteiro and Keating [2009] recall that studies of interdisciplinary collaborations have identified problems in such collaborations as including "differences in epistemology and method, different ways of formulating research questions, and differences in communication styles between members" (p. 7). Their own focus is on language, which they approach through ethnographic study of collaborations between medical, biological and computer scientists, who manage their misunderstandings by "negotiating meaning during the presentations and conversations that happen in the meetings" (p. 17). Typically, this involves accepting partial knowledge of other domains, also acknowledging that some misunderstandings are "productive" (p. 23) and with further-reaching benefits: "Many in the group feel that this sort of experience adds greatly to their own expertise when they have a chance to be exposed to different knowledge domains through highly respected experts in their fields" (p. 18).

Chan, Gonsalves and Metcalfe [2011] examined the "fragility of creative collaborations" through a case study of artists and computer scientists linked to an Australian arts centre, referring to "numerous barriers" (p. 162) and "tension and pitfalls" (p. 165), and quoting a computer science PhD researcher as describing "every meeting [as] kind of just a series of misunderstandings basically" (p. 166). However, in a single sentence that neatly connects the promise, problems and pleasures examined in this essay, they also write: "Interdisciplinary creative collaborations are paradoxical in that they rely on both cooperation and conflict between different frames of references to set off the creative 'spark' to produce ground-breaking results" (p. 176).

The introduction to a set of commentaries on interdisciplinarity in science communication published in this journal, presented the remodelling of a Masters in Science Communication at TU Delft, Netherlands, as Communication Design for Innovation as seeming "to reflect better what is needed from science communication professionals today" [Kalmár & Stenfert, 2020, p. 1]. Two other members of the TU Delft team had earlier described their "field lab" approach to science communication education, stating that "complex science communication problems and [students] becoming adaptive practitioners demand collaboration between various disciplines and design processes, bringing up tensions, paradoxes and ambiguities as daily reality … The students have a background in various technical education programmes, ranging from Industrial Design to Applied Mathematics, and can therefore learn a lot from each other when they work together in multidisciplinary teams" [Wehrmann & van der Sanden, 2017, p. 5]. In a poignant reflection of the difficulties facing science communication at the boundaries of several disciplines and of "problematic power arrangements", the TU Delft leadership decided in 2023 that the Communication Design for Innovation track should be discontinued, as it did not fit with strategic priorities.

The Delft programme has been one of a minority where cross-disciplinarity is actively embraced; ten of 39 science communication Masters in 18 countries for which descriptions are provided in a database provided by the Teaching Forum of the PCST Network and the EU-funded Globalscape project[3] refer to crossing disciplines in one aspect or another of the programmes. These references range from collaborations between experts of various kinds in delivering the programme,

[3]See https://www.pcst.network/teaching-forum/science-communication-programmes-and-courses/, viewed on 28 May 2023.

to "great interdisciplinarity and a unique group dynamic" (Universitat Pompeu Fabbra, Barcelona, Spain) and a "highly interactive and interdisciplinary global curriculum" (University of Groningen, the Netherlands) to "interdisciplinarity is effected as a force that comes from the complexity of the very problems the area faces … [requiring] the invention of new research objects and new methodological approaches that pass necessarily by the dialogue between different disciplines and multiple forms of expression of knowledge, cultures, technologies, arts and sciences" (State University of Campinas, Brazil).

Studies on science communication programmes have tended to focus on structures and the balance of content between practical skills and theory [e.g. Mulder, Longnecker & Davies, 2008; Massarani, Reynoso-Haynes, Murriello & Castillo, 2016], or on particular aspects of content, such as the development of digital media skills. In this latter context, Fähnrich et al. [2021] propose a competences model for science communication training that operates at three levels, Picture of the world, Professional norms and roles and Working knowledge. The first of these relates to students' views of "the changing societal framework in which science communication takes place and how it affects the conditions for the interaction of science and society" (p. 11); the issues of disciplines or knowledge domains are not addressed.

An ambitious study [Lewenstein & Baram-Tsabari, 2022] sought to set out the full range of competencies — their term — that might be targets of shorter training sources and longer professional education programmes. These included, in the latter case, the students "understanding the difference between science knowledge and other forms of knowledge" (p. 300); this was the closest the authors came among their 100-plus points for curriculum development to acknowledging the place of interdisciplinarity in science communication education. Their framing in terms of competencies — similarly to that of Fähnrich et al.'s [2021] deployment of competences — situates professional education on a continuum with short-course training and this may explain the modest attention to intellectual inquiry and critical theory.

My perspective on science communication as "vital and vulnerable" in university structures related to its position at the boundaries and intersections of established blocs [Trench, 2012]. Elsewhere, a colleague and I observed that degree programmes in science communication were in many cases sustained by the efforts of individual enthusiasts or small groups, and "few universities have committed strongly and strategically to science communication as a new (inter-)discipline," [Trench & Miller, 2012, p. 725]. That assessment still stands over a decade later, and is represented in the wide variety of institutional settings for science communication programmes.

Writing on global responses to multi-dimensional challenges in climate, energy, politics and economy, Hughes et al. [2021, p. 372] present "a model of deep institutional innovation" on the basis that "many of the foundational social institutions upon which societies have relied for decades … are currently failing". We may consider whether a similar large-scale reinvention of higher education institutional frameworks is necessary for science communication to be adequately accommodated.

The Pleasures: science communication's interdisciplinarity is as stimulating and enjoyable as it is challenging

In a 2023 video presenting the new Masters in Science Communication at University College London three students discuss their experience of being on the programme. All have science degrees but, with smiles all round, they emphasise the benefits of having a mix of students, including graduates in literature, psychology and philosophy, exposing them to "different views" and "interesting discussion". Only slightly jokingly they "shed a tear" in talking about their cross-disciplinary collegial experience.[4]

Looking back on her experience teaching science communication over twenty years in United States, Australia and New Zealand, Longnecker [2022, p. 2] wrote: "With hindsight, I think our early teaching, students' learning, and research contributions to the field of science communication would have benefitted from more transdisciplinary collaboration to enhance creativity, intellectual enquiry, content, and innovation."

Students have acknowledged such benefits, for example, on the Masters in Science Communication at Dublin City University, Ireland, where graduates from the first 15 years were asked in a survey to identify impacts of their studies on their professional and personal lives.[5] Their answers included: "[the programme] provided much needed background in the humanities (philosophy/ sociology of science), which has made me a more rounded and balanced scientist"; "opened up my interests — no longer daunted by humanities"; "introduced me to ways of thinking about science which are still important to me". The discovery and pleasure were shared by academic staff. "Natural scientists have often reported that they found teaching in a more reflective manner and broader context especially stimulating, and the social scientists and humanists reported that they relished the challenge of engaging students with backgrounds in the natural sciences with the methods and logics of the humanities and social sciences" [Trench, 2012, p. 250]. Programme graduate and physics teacher Noel Cunningham [2017, p. 178] recalled many years later the impact of lectures on dendrochronology from a palaeoecologist: "I was fascinated both by the subject material and the idea that discoveries in science often pay no heed to traditional boundaries".

Science Gallery Dublin (SGD), established in 2008, developed an innovative interdisciplinary practice that has spread to an international network of similar centres based in universities in, for example, Melbourne, Bengaluru, Berlin and Atlanta. Through broadly-themed exhibitions they bring scientists of many disciplines into collaboration and "collision" with artists, designers and others. These centres are significant arenas of learning for practitioners and students of science education and science communication. The founding director of SGD, Michael John Gorman [2009, p. 10], disarmingly described the collaborative process based on "interdisciplinary conversation [as] very simple". An open call is issued for ideas from scientists, designers, artists and engineers for projects exploring the chosen theme and those selected are invited to develop their projects further. Gorman gives a sense of the pleasures when he adds that the open call process "attracts a very wide (and unpredictable) range of project ideas, and proposers of projects are usually very enthusiastic to be involved in an exhibition or festival,

[4]Video posted at https://www.youtube.com/watch?v=Owh2mXCILGA, viewed on 11 September 2023.

[5]The present author conducted this survey for guidance of programme leaders; it was not published.

frequently giving their time to participate in workshops and events in addition to their specific installation or exhibit".

What Gorman described as "very simple" is, of course, rich with risks as well as pleasant surprises. At the time of writing, Science Gallery Dublin has been closed for over 18 months as the host university, Trinity College Dublin, seeks a new, more sustainable business model. But risky and surprising collaborations and conversations are essential to addressing many of the key questions facing society, knowledge and learning. In his proposal to bring together different modes of thought through "consilience", EO Wilson wrote of rapprochement of humanities and sciences as "humanity's greatest task" [Wilson, 1999]. The challenge he was posing has an emotional as well as intellectual depth: there can be something uplifting and enriching about the experience of going outside one's usual space. Engagements between sciences and arts or sciences and humanities can induce a feeling of deeper insight, of being whole.

The pleasures of working in science communication studies derive in part at least from the rules and limits not having been set. Massimiano Bucchi and I have offered a view of "science communication as an inherently, even joyously, interdisciplinary field" [Bucchi & Trench, 2021, p. 2]. Metcalfe [2022, p. 2] suggests something similar, but also its flip side, in describing science communication as "a messy mix of academic disciplines and professional endeavours… [that] brings youthful strength, vigour and excitement to the field … [but] also makes the links between science communication research, theory and practice difficult to decipher".

The Proposition: science communication studies need to integrate prominently issues and practices of interdisciplinarity

University education in science communication can be more than the conversion of science graduates into science communicators, more than the teaching of practical skills in various communication formats, more than the preparation of students for professional practice and programme management in science communication, more than engagement with history and theory of science communication. It is all of the above but also education in ways of thinking about knowledge, where it comes from, how it is produced, by whom and for what. It can open students to a wide array of opportunities in communication, policy and administration (not only of research), and in further studies. It has an intrinsic value beyond a circumscribed role as professional education, and it takes its place alongside graduate education in the broad swathe of humanities and social sciences.

Mellor [2013] remarks that "to become a professional science communicator is to cease to be a scientist. Our students are *humanities* students, their scientific qualifications notwithstanding". Introductory courses on science communication at SISSA in Trieste, Italy, from where the present journal is published alongside journals in physics and neuroscience, include elements taught jointly by a research scientist and a communicator, usually including a talk on a hot topic in research together with an exercise in communication around that topic.[6]

[6]Personal communication, May 2023, with SISSA communications lecturer, Chiara Saviane.

It is in these mutual engagements and crossing back and forth between disciplines that much of the intrinsic value of science communication studies resides. Here are some recommendations for making interdisciplinarity explicit and prominent in science communication studies through measures in core content, staffing, delivery, and student recruitment:

- Science communication studies should be at least as much conceptual and critical work as focused on skills and professionalism;
- Critical analysis of science's workings and limits should be encouraged, developing resistance to the lure of scientism, a belief that science (and only science) can answer all questions about the natural world;
- Awareness of and respect for different research approaches — quantitative and qualitative, empirical and narrative — should be integral to science communication education;
- Programme content should include elements of sociology, history and philosophy of knowledge, the formation of disciplines, biographies of scientists, contemporary developments in science, science in literature and other arts;
- Programme delivery on such aspects could include examination and enactment of socio-scientific controversies, where, for example, ethics, environmental concerns or indigenous cultures are involved as well as natural and physical sciences;
- Staff teaching science communication programmes should come from a mix of backgrounds;[7] students should also be recruited from a mix of backgrounds, not solely among science graduates; it should be sufficient that they demonstrate active curiosity and interest in science;
- Delivery of individual courses should be mixed, including group work that brings students of different backgrounds together, field trips and 'lab' practicals adapted to communication projects.

In the early days of science communication education, Turney [1994] considered there were two types, one focused on practical skills and the other looking at the "big picture". E.O. [Wilson, 1998], arguing for "the unity of knowledge", observed that "the lack of interest in the big picture" among scientists was at least partly due to the fact that "scientists simply didn't have the requisite intellectual energy … [scientists] are professionally focused; their education does not open them to the wide contours of the world … The most productive scientists, installed in million-dollar laboratories, have no time to think about the big picture, and see little profit in it".

Wilson argued further that "every college student should be able to answer this question: What is the relation between science and the humanities, and how is it important for human welfare? … Most of the issues that vex humanity

[7] It should be noted that science communication teachers are often individually of 'mixed background', e.g. with qualifications and experience in sciences and communication.

daily — ethnic conflict, arms escalation, overpopulation, abortion, environmental destruction, and endemic poverty, to cite several of the most persistent — can be solved only by integrating knowledge from the natural sciences with that from the social sciences and the humanities. Only fluency across the boundaries will provide a clear view of the world as it really is".

What Wilson argued a quarter-century ago is surely more pressing today and directly relevant to science communication education.

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