The Public Understanding of Scientific Information:

Communicating, Interpreting, and Applying the Science of Learning

Stephen P. Norris and Linda M. Phillips

On 15 August 2002, the national media alerted Canadians to the results of the OECD PISA Study, a study into the reading, mathematics, and science performance of 15-year-olds in almost three dozen countries.[1] For instance, with allusions to the dangers of the London Underground, the Montreal *Gazette* beamed: "Mind the literacy gap: In survey after survey, girls surpass boys in reading and writing. Experts blame classrooms that are out of touch with male interests."[2] Similarly, harking back to the problem identified three decades ago with boys' lack of fluency with simple arithmetic, the Ottawa *Citizen* pondered: "How to get Johnny to read: In survey after survey, girls outperform boys in reading and writing."[3]

The headlines were repeated in major dailies across the nation. The texts of the reports were, with minor variations, identical. They opened with a story of Daniel Vosburgh, a ten-year-old from Lachine, Quebec, who was involved in a summer reading club sponsored by a local library. Then followed some broad generalizations from the OECD PISA Study, including the one that prompted the coverage: "In every country surveyed, girls were better readers." The remainder of the reports concentrated on offering some possible explanations of the results from reputed experts and non-experts:

- … it's generally much easier to teach girls to read. – Jeffrey Derevensky, a Montreal child psychologist;
- Schools seem to favour girls' learning style and reading interests. – Helen Amoriggi, a reading specialist in McGill's Faculty of Education;
- I feel strongly that sitting still, being quiet and not touching anybody in class is geared toward girls. – Julia Scott, a nine-year-old boy's mother;
- [Boys] don't seem to care nearly as much as the girls for novels. – Jennifer Mohammed, a children's librarian in a Montreal library.

They went on to suggest possible actions to address the perceived problem:

- …the introduction of computers and other media in teaching reading to boys – Quebec's Conseil Superieur de l'Education;
- …more men [teachers] in those classrooms [Grade 1 or Grade 2]. – Helen Amoriggi;
- … schools need to adapt to boys' reading styles – Jennifer Mohammed;
- …reading programs for boys featuring more male role models, readings by male guest authors and books and magazines geared to boys' interests – Durham District School Board in the Toronto area.

Studies of science reporting by major daily newspapers point to omissions, misrepresentations, and sensationalizations that risk promoting misunderstandings in the minds of the non-scientific public.

In the OECD PISA Study, there is an opportunity for scientific findings on learning to find useful application in educational contexts. What must be in place for that opportunity to be realized? First, given that parents and educational practitioners rarely have the time and often do not have the expertise to keep abreast of the scientific literature, the communication in the popular press must portray accurately the scientific knowledge that has been developed. Yet, there are important limitations in current translation practices that we shall discuss below. Second, no matter how well scientific findings are communicated, practitioners must be able to interpret what has been communicated. Communication, after all, requires uptake as well as delivery. We shall examine some significant issues in the interpretation of scientific writings and then point to notable shortcomings displayed by even highly educated audiences. Third, even in the context of sound communication and interpretation and the best of intentions, successful application is not assured. We will look at how the application of scientific knowledge must draw upon knowledge that lies outside of the science itself.

Science and Scientific Language

We first need to have some understanding of the texture and structure of science and scientific language. In texture, scientific language reveals a wide range of certainty. Some scientific statements are put forward with considerable doubt. Indeed, in scientific research reports, it is not unusual to find many statements that are speculative and conjectural. There are even statements that are known to be false, because for some reason the scientists want to call attention to their falsity. Scientific reports also posit statements with a high probability of being true and sometimes even make claims that are beyond a shadow of a doubt. In general, however, scientific findings are hedged and nuanced, often in subtle ways. Popular reports of science must portray this texture accurately, and practitioners must interpret it accurately, if the science of learning is to find useful application.

Scientific statements also reveal a structure. They report observations, empirical generalizations, causal claims, and conjectures; some describe method, and others provide the motivation and significance of the research; some provide evidence for conclusions, others are conclusions drawn on the basis of evidence; some name phenomena, and others provide models to account for them. The different roles of statements in shaping the texture and structure of science are rarely made explicit. They must be inferred from the context, and must be inferred accurately if the work is to be understood and the science of learning is to be applied properly.

Communication

Studies of science reporting by major daily newspapers point to omissions, misrepresentations, and sensationalizations that risk promoting misunderstandings in the minds of the non-scientific public. For instance, reports rarely provide comments on research findings from impartial scientists, either of a critical or a favourable nature. Furthermore, fewer than two-thirds cite any previous and related research, and fewer than one-half cite any limitations to the research.[4] The failure to address

EN BREF

Ni les reportages médiatiques ni les cours de sciences ne préparent le public à comprendre ou à interpréter les résultats scientifiques. Des études sur la couverture scientifique des principaux quotidiens mettent en relief les omissions, les déclarations trompeuses, et le sensationnalisme qui risquent d'insuffler un savoir erroné dans les esprits non scientifiques. Divers exemples de reportage sur l'étude PISA de l'OCDE illustrent assez bien le problème. Les manuels de science n'aident pas les élèves à juger d'un œil critique les reportages scientifiques, lesquels ne fournissent aucun argument pour justifier les conclusions qu'ils présentent comme des certitudes scientifiques alors qu'en réalité celles-ci ne sont jamais entièrement certaines et sont toujours sujettes à interprétation.

limitations is sometimes defended by the press using the patronizing assumption that the non-scientific public will not recognize the significance of findings that are as carefully hedged as they usually are in published scientific research. Therefore, the aim is to make an impression of significance based upon an appearance of certainty. The cost is lack of accuracy. Research has documented the varieties of errors found in scientific news reporting: omission of information on method and on results, misquotation of the researcher, omission of qualifications, and misleading headlines.[5] Other studies paint a bleaker picture, finding no more than 15% of reports mentioning any limitations or any of the process or context of the inquiry.[6] These oversights are important, because how journalists present the intrinsic uncertainty of science can enhance or diminish how readers, viewers, and listeners perceive it.

As problematic as media reports of science are, one of the greatest potential resources for non-scientists in preparing them to be life-long consumers of science – their school science education – is perhaps at least equally problematic. For instance, we know that junior high school science textbooks and media reports of science exhibit a number of important differences.[7] First, although some media reports of science contain argumentation, that is, text directed at providing reasons for the scientific conclusions advanced, junior high science textbooks contain no argumentation. Second, almost all statements in junior high science textbooks are presented as being certain. Although a very high proportion of statements in media reports is also presented as being certain, some media reports of science present statements that are less than certain, uncertain, and even likely to be false. Junior high science textbooks portray a structure of science largely limited to observational words, words that describe the process of doing research, and some relational words, such as "cause." By way of contrast, many media reports portray a structure of science that is more complex, though not as complex as it ought to be. Science textbooks at other grade levels appear no different.

But even if school science textbooks perfectly matched media reports of science, there are still important concerns because, as we have already indicated, the media reports themselves are flawed in a variety of ways. In the Ottawa *Citizen* report, as in the other reports that appeared across the nation, we find a loosely connected mixture of OECD PISA Study results, expert commentary and opinion, semi-expert opinion, and non-expert commentary and opinion. Yet, they are all presented as if they have the same standing in knowledge. The explanations for the results offered by the child psychologist, the reading specialist, the children's librarian, and the nine-year-old boy's mom are all put forward with a high degree of reported certainty, and no attempt is made to discriminate among them. Although the original scientific report claims that it "does not lend itself to developing explanations for these disparities [between boys and girls]",[8] the press report makes no mention of this fact and offers many explanations all based upon opinion rather than upon evidence.

The journalists might defend their approach on the grounds that it is not their role to make judgements, it is merely to report the facts. However, like other media reports of science that have been studied, the newspaper reports reveal judgements in their failure to make any reference to previous or related research, even though such research exists, some of it challenging to the findings in the OECD PISA Study.[9] The newspapers also reveal judgements in omitting all of the hedges of the original study, all of the limitations of the reading assessment instrument, and the facts that in mathematics the results tend to favour the boys and in science the results favour neither boys nor girls. They fail also to offer information to help the reader grasp the extent and significance of the difference between boys' and girls' reading performance on the testing instrument.

Interpretation

What might we conjecture about how the public and educational practitioners would interpret the reports in the nation's newspapers? Some studies suggest a fairly positive picture. For example, one examined the percentage agreement between the original source of the scientific information and the understanding of it by non-scientific receivers and found an agreement of about 65%.[10] But this would be an overly optimistic expectation based on other studies.

For example, cream of the crop high school students[11] and first and second year university students[12] were asked to read five media reports of science describing recent scientific research and findings. The students were asked to interpret and make judgements about the texture and structure of science as discussed previously. Both high school and university students displayed a bias in rating statements as more certain than they were reported, confused cause and correlation, and had difficulty distinguishing explanations of phenomena from the phenomena themselves. The university students provided self-assessments of their knowledge, interests, and reading difficulty that showed they had an inflated view of their ability to understand the media reports.

In another study,[13] university students who were asked to critically evaluate news briefs sought additional information on the scientific theory and methods underlying the research. This finding is somewhat ironic, because it is the theory and method of science that is most technical and inaccessible to critique by non-scientists, in contrast to the social context of research (e.g., Did the funders of the research have a vested interest in the results turning out in a particular way? Are the scientists from a reputable institution? Do scientists from other reputable institutions concur with the results? Do the scientists appear to be influenced by political interests irrelevant to the science? etc.) where non-scientists have the most leverage for critique.[14] The students did not seek additional information of this latter sort that might have been useful to them in their evaluation. Not a rosy picture.

The newspaper reports on the OECD PISA Study create the full array of challenges for the reader. Difficult inferences are required about the certainty of statements, simple generalizations must be distinguished from causal claims, and credibility judgements are required of all of the opinion contained in the reports. For instance, readers are told that the reading specialist, Helen Amoriggi, believes that "only one child should read while the others close their books and listen." The reader must judge how to take this claim: is it speculation, is it an evidence-based opinion, is it a claim she is currently researching? Given the way the statement is reported, there is a risk that it will be taken as a truth provided by an expert and based upon evidence. To take another example, how will readers take the statement attributed to the librarian, Jennifer Mohammed, that "it doesn't matter what they are reading as long as they are reading"? Ms Mohammed says it is her opinion. Does this mean it is a belief without real support, or is it based on some evidence? Making such distinctions as these is difficult for the reader, even for the sophisticated one. Yet, such distinctions are absolutely essential to the application of the science of learning in educational contexts.

Application

Even if results from the science of learning are communicated and interpreted well by practitioners, the task of application does not end there. In general, science is about an abstract and general world, as opposed to the context of use, which is always concrete and particular. The main job of application is to take those abstractions and generalizations and use them in situations that are concrete and specific. Scientific knowledge is never directly applicable, and, no matter how complete and warranted, cannot yield prescriptions for teaching. Thus, not only must practitioners be able to interpret well the science of learning, they must have a grasp of when, where, and how it can be applied. General and abstract knowledge can be applied only through the use of situational knowledge. Application requires practitioners to make connections between the abstract and general world of science and the concrete and particular world of educational settings by filling in where the science leaves off, by making plausible assumptions about their situations, and by combining ideas from various areas of the science of learning that might never be combined in research. As they stand, the news reports on the OECD PISA Study provide suggested applications that are themselves general and detached from any given application setting, as if the same approach will work in all settings.

Continued on page 43

vated by parental concerns for its age-appropriateness or its "morality-appropriateness", is unlawful without, really, any concrete evidence that the failure to approve the books would foster discrimination or intolerance in the public school system, and in the face of evidence that suggests the same subject-matter could be addressed a year or a few years later in the curriculum. The conclusion that there should be one standard for assessing the suitability of teachers and a different standard for assessing teaching materials is unsettling – made all the more so by the curious failure of the majority in *Chamberlain* to address at all its reasoning in the *Trinity Western* case the year previous (except for a single passing reference, and even that on a procedural point). I may not know much about the science of learning, but I do know that trying to understand seemingly inconsistent decisions would be a whole lot easier if the Court would at least talk about them.

1 *Chamberlain v. Surrey School District No. 36*, 2002 SCC 86 (released December 20, 2002). Chief Justice McLachlin wrote the judgment for the majority, concurred in by L'Heureux-Dubé, Iacobucci, Major, Binnie and Arbour JJ. Mr. Justice LeBel wrote a separate judgment concurring in the result. Messrs. Justice Gonthier and Bastarache dissented.

2 *Trinity Western University v. British Columbia College of Teachers*, [2001] 1 S.C.R. 772. The majority judgment was written, jointly, by Messrs. Justice Iacobucci and Bastarache, with whom McLachlin C.J.C. and Gonthier, Major, Binnie, Arbour and LeBel JJ. concurred. Mme. Justice L'Heureux-Dubé delivered a dissenting judgment.

3 J. Paul R. Howard, "The Long Arm of Human Rights Law: Can We Legislate Beliefs?" *Education Canada 41* (Fall 2001), no. 3: 36-37.

Paul Howard is a lawyer practising with the firm of Shibley Righton LLP in Toronto, Ontario, and a Special Lecturer in Education Law at the Faculty of Law, University of Windsor. Paul's civil litigation practice is devoted almost exclusively to education law and other public law matters, including human rights, constitutional law and administrative law.

paul.howard@shibleyrighton.com
www.shibleyrighton.com

Public Understanding *Continued from page 27*

Implications

Practitioners should never expect or look for formulae and pat answers in the findings of the science of learning. Even when researchers have extreme confidence in their findings, research, as we have said, is always conducted in abstract and general contexts that inhibit direct and mechanical application. Very often, however, the results of science are less than certain. Thus, in addition to dealing with abstractions and generalities, practitioners must also deal with doubt and with results that are hedged in varieties of ways. Often such nuance is not made evident in the secondary sources of science translators, and, even when it is, it is not always accurately interpreted by readers and listeners.

We have an abiding concern that there remains in education a widespread hope for quick fixes and the expectation that educational research will provide certainty of results and directness of applicability. Such hopes and expectations are in vain. It is not just that there is not enough research funding, or that researchers are too far removed from practice. These might both be legitimate complaints. Yet, even if they were addressed adequately, there would still remain the inevitability of scientific results that are less than certain and always circumscribed, and the difficult tasks of interpreting those results for use in particular situations. If it chose, the media could play a significant role in the public understanding of scientific information. Such a role would require a communication of scientific results that promotes their accurate interpretation and useful application.

1 OECD, *Measuring Student Knowledge and Skills: The PISA 2000 Assessment of Reading, Mathematical and Scientific Literacy* (Paris: OECD Publication Service, 2000).

2 "Mind the Literacy Gap: In Survey after Survey, Girls Surpass Boys in Reading and Writing. Experts Blame Classrooms that are Out of Touch with Male Interests," *The Montreal Gazette*, 15 August 2002, August, F2.

3 "How to Get Johnny to Read: In Survey after Survey, Girls Outperform Boys in Reading and Writing," *The Ottawa Citizen,* 15 August 2002, F1.

4 M.G. Pellechia, Trends in Science Coverage: A Content Analysis of Three US Newspapers," *Public Understanding of Science* 6 (1997): 49-68.

5 J.W. Tankard, Jr. and M. Ryan,, "News Source Perceptions of Accuracy of Science Coverage," *Journalism Quarterly 51* (1974): 219-225, 334.

6 W.A. Evans, M. Krippendorf,, J.H. Yoon, P. Posluszny, and S. Thomas, "Science in the Prestige and National Tabloid Presses," *Social Science Quarterly 71* (1990): 105-117; J. Ryder, "Identifying Science Understanding for Functional Scientific Literacy," Studies in Science Education 36 (2001):1-44.

7 K. Penney, S.P. Norris, L.M. Phillips, and G. Clark, "The Anatomy of Junior High School Science Textbooks: An Analysis of Textual Characteristics and a Comparison to Media Reports of Science," *Canadian Journal of Science, Mathematics and Technology Education* (manuscript under review).

8 P. Bussière, F. Cartwright, R. Crocker, X. Ma, J. Oderkirk, and Y. Zhang,. *Measuring Up: The Performance of Canada's Youth in Reading, Mathematics and Science* (Ottawa: Minister of Industry, 2001).

9 e.g., L.M. Phillips, S.P. Norris, W.C. Osmond, and A.M. Maynard, "Relative Reading Achievement: A Longitudinal Study of 187 Children from First through Sixth Grades," *Journal of Educational Psychology 94* (2002):3-13.

10 P.J. Tichenor, C.N. Olien, A. Harrison, and G. Donohue, "Mass Communication Systems and Communication Accuracy in Science News Reporting, *Journalism Quarterly 47* (1970): 673-683.

11 S.P. Norris and L.M. Phillips, "Interpreting Pragmatic Meaning when Reading Popular Reports of Science, *Journal of Research in Science Teaching 3* (1994): 947-967.

12 S.P. Norris, L.M. Phillips, and C.A. Korpan, "University Students' Interpretation of Media Reports of Science and its Relationship to Background Knowledge, Interest, and Reading Difficulty, *Public Understanding of Science: An International Journal of Research in the Public Dimensions of Science and Technology* (in press).

13 C. Zimmerman, G. Bisanz, and J. Bisanz, "Everyday Scientific Literacy: Do Students Use Information about the Social Context and Methods of Research to Evaluate News Briefs about Science?" *Alberta Journal of Educational Research 44*, (1999): 188-207.

14 S. Gaon and S.P. Norris, "The Undecidable Grounds of Scientific Expertise: Science Education and the Limits of Intellectual Independence. *Journal of Philosophy of Education 35* (2001): 187-201.

Linda M. Phillips is Professor and Director, Centre for Research on Literacy, University of Alberta. She is the literacy theme leader for the Canadian Language and Literacy Research Network, a National Centre of Excellence.

Stephen P. Norris is Professor and Chair, Department of Educational Policy Studies, University of Alberta. He conducts research in science education policy and the public understanding of science.