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MOVING PISA RESULTS INTO THE POLICY ARENA: PERSPECTIVES ON KNOWLEDGE TRANSFER FOR FUTURE CONSIDERATIONS AND PREPARATIONS

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ABSTRACT. Evidence-based policies, decisions, and practices are highly valued and underachieved in the international mathematics and science education reforms. Many in the mathematics and science education research communities lament the lack of influence that research results have on the education profession, schools, and teaching. Academic research done in isolation of end-users—with the faint hope that teachers, politicians, and bureaucrats will access and utilise these results to inform curriculum, assessment, and instruction and to influence public policy—has not worked. Some funding agencies require dissemination of research and development results to the broader political and education communities; therefore, applicants agree to these requirements without fully realizing the breadth of these demands. However, to achieve such knowledge transfer requirements, researchers need to become more (a) aware of the needs, players, and processes of 'speaking truth to power'; (b) active in knowledge transfer and influencing public policy; and (c) alert to values and normative premises of the policy makers. This article outlines the essential principles, barriers within the academic community, international efforts, and future considerations for knowledge transfer regarding international assessments. Specific articles on PISA 2000, 2003, and 2006 included in this special issue are used to illustrate these insights into verification of curricular influences, educational opportunity and equality, regional comparisons, and direct influence on policy.

KEY WORDS: educational policy, evidence-based policies/decisions, knowledge transfer, Programme for International Student Assessment (PISA), speaking truth to power

Introduction

The processes of advocacy and influencing public policy are not well understood or enacted for mathematics and science education worldwide (Fensham, 2009; Shelley, 2009). Mathematics and science education constitute large and dynamic elements of schooling that are generally viewed as important to individual students in enhancing their understanding of the world and improving their chances of life success and also important at the larger societal level in today's knowledge economy where the capacities of the citizenry are directly linked to the well-being of the nation. However, the importance of mathematics and science education is a distant second compared to the importance ascribed to

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language and literacy education, especially reading. Some international mathematics and science education reforms have not had the level or speed of influence on public policy and professional practice anticipated (Anderson, Milford, Jagger & Yore, 2009). These well-intentioned reforms in Canada, the USA, and elsewhere are getting dated and run the likelihood of becoming passé; the once-promising opportunities may be wasted if the mathematics and science education communities do not become more collaborative and aware of and proactive in knowledge transfer (KT) that influences public policy and decision making at the federal, state/provincial, and local levels.

There are some interesting recent efforts in literacy and science education that provide a host of renewed opportunities, lessons learned about goals, processes, and results: *National Literacy Panel on Language–Minority Children and Youth* (USA; August & Shanahan, 2006), *Taking Science to School: K-8* (USA; United States National Research Council [NRC], 2009), *Science Education NOW: A Renewed Pedagogy for the Future of Europe* (European Union; Rocard, Csermely, Jorde, Lenzen, Walberg-Henriksson & Hemmo, 2007), *Science Education Policy-making: Eleven Emerging Issues* (UNESCO; Fensham, 2008), and *Science Education in Europe: Critical Reflections* (Nuffield; Osborne & Dillon, 2008). However, we believe that the 2nd cycle (2009, 2012, 2015) of the Programme for International Student Assessments (PISA) provides rich opportunities to influence reading, mathematics, and science education policy and practice worldwide, which can be leveraged by a 'second sober look' at the 1st cycle's (2000, 2003, 2006) results and influences and connecting mathematics and science literacies to reading and other language literacies.

Background

The potential influence of PISA on educational policy lies in its basic design features and their relationship to contemporary education reforms dealing with disciplinary literacies. An analysis of the English language arts (United States National Council of Teachers of English & International Reading Association, 1996), the mathematics (United States National Council of Teachers of Mathematics, 2000), and the science (American Association for the Advancement of Science, 1990, 1993; NRC, 1996) reform documents in the United States revealed common goals and pedagogy across these reforms—disciplinary literacy for all, constructivist approaches, and authentic assessment (Ford, Yore & Anthony, 1997). These commonalities are found in other nations' reform documents (Hand, Prain & Yore, 2001). However, many international and national assessments have not reflected these commonalities—until PISA uncoupled their underlying assumptions, assessment framework, and instrument design from prescribed curricula and completed a full cycle of administration across the dominant foci of reading (2000), mathematics (2003), and science (2006) while simultaneously collecting data on all three domains and school, student, and home characteristics. PISA has limitations in that it relies on self-reported data for the school, student, and home and does not collect data at the classroom level. However, the datasets have provided a much more complete picture of disciplinary literacies (Moje, 2008; Norris & Phillips, 2003; Shanahan & Shanahan, 2008) in terms of fundamental literacy based on informal text and disciplinary understandings and contextual applications needed for survival in twenty-first century economies. PISA's conception of disciplinary literacies closely approximates the interacting senses of mathematics and science literacy leading to fuller participation in the public debate of science, technology, society, and environment issues (Yore, Pimm & Tuan, 2007). The correlations amongst the PISA literacies are very high, showing 61–77% shared variance, suggesting associations amongst reading, mathematics, and science (Anderson, Chiu & Yore, 2010).

The Globe and Mail, Canada's most-read national newspaper, in an editorial entitled "Those who read well at 15 succeed" captured the relation between the PISA 2000 results and biannual Statistics Canada surveys of postsecondary education participation ("Those who read," 2010, p. A20). The findings of this longitudinal study revealed that parental education level and family income are strongly predictive of postsecondary education. However, time spent studying in secondary school and PISA reading performance, non-preordained attributes, are the most important determinants regarding postsecondary education. "Students who scored in PISA's top category for reading skills were an astounding 20 times more likely to be in university than their peers with poor reading skills. Those in the second and third highest levels for reading still showed very strong attainment levels. Reading matters, even for students in sciences and math[ematics]." (p. A20).

Media reports like this have real potential to influence parents, policy makers, and politicians. Unfortunately, *The Globe and Mail* editorial did not fully clarify what kind of reading literacy PISA 2000 attempted to measure (Organisation for Economic Co-operation and Development [OECD], 2003): “An individual’s capacity to understand, use and reflect on written texts, in order to achieve one’s goals, to develop one’s knowledge and potential and to participate in society.” (p. 15). PISA 2000 emphasised informational text, not narrative text, and reported three content dimensions: interpreting texts, reflecting and evaluating, and retrieving information (Anderson, Lin, Treagust, Ross & Yore, 2007). Editorials, media reports, video clips, and sound bites frequently tell only part of the story; they require focused and brief follow-up comments written for the audience in a nonconfrontational tone to clarify that it has to do with reading for information rather than pleasure. Duke (2010) provided an example of how this can be done by addressing (a) the gap between narrative and informational reading and writing performance, and (b) the need to more accurately reflect the real-world uses of language and text in schools. She stated, “The evidence is compelling: We should involve students in informational text early in school—not only through such commonly mentioned practices as teaching text structure and vocabulary, but also by enacting the triad of *reading real-world informational texts* for *real-world reasons* in *motivating contexts*.” (p. 70).

Mathematics and science education communities can mobilise their resources to speak truth to power more effectively through indirect and direct approaches (Shelley, 2009). Both the indirect approaches (e.g. news releases, opinion pieces, and media interviews) and direct approaches (e.g. political actions, testimony at official hearings, and service on taskforces and governmental panels) require having something worth saying; the evidence to support such claims; awareness of the political participants’ values and processes; and the willingness, communication skills, and effort to make a difference.

Brickhouse (2006) pointed out that education researchers need to be held to “a higher ethical standard ... [in] that research should have at least some potential to improve the quality of education and the lives of children.” (p. 4). Rees (2008) stated:

> Unfortunately, politics is among those domains of human activity least beholden to sound academic research. First politics—indeed, social relations of all kinds—is about power, ambition, social status, and personal prestige. Thus, while politicians will readily adopt research that supports their beliefs, many show little affinity for results that challenge their political survival. (p. 10)

Furthermore, he believed that "policy action is often propelled more by myth than science." (p. 10). Hess (2008) suggested that the politicians' impatience, desire for rapid and dramatic changes, and increased polarization "have made it *less* likely that research—even when it is rigorous and reliable—will influence policy." (p. 354). He continued:

> While researchers in both health care and education pursue advances with enormous personal stakes for individuals and for society, the health profession has won enough credibility that a substantial reservoir of support for basic research has developed, even though the benefits may not be visible for decades. However, lacking a similar history of successes, educational research has not earned similar trust or good will.... (p. 356)

This tendency of policy makers to formulate, announce, and implement policy then encourage research engagement that could retrospectively support the policy initiatives has been recognized in both the medical and financial fields and termed *policy-based evidence-making* (Giles, 2010; Marmot, 2004). Success in making the results of research useful as evidence for educational policy and reform relies on persistent efforts, realistic expectations, well-developed, practical, and documented claims disseminated to the appropriate end users, and continuous support.

Knowledge Transfer Process

Knowledge transfer involves intense, dynamic, recursive, and prolonged interactions among researchers, policy advisors, policy makers, and the public (Landry, Lamari & Amara, 2003). There are several steps in the KT process that need to be anticipated by academics if they are to inform and influence public policy successfully (Knott & Wildavsky, 1980). However, research results are necessary but not sufficient grounds for setting policy. Policy advocacy and briefs need to recognise and engage inherent values and normative principles held by the policy makers and society (Norris, Phillips & Macnab, 2009). Furthermore, researchers have to become advocates and address the constituents and influential players (e.g. politicians, policy advisors, bureaucrats, end users, etc.) involved in the policy area and then identify and respect the windows of opportunity open to influence policy (Yore, Shelley & Hand, 2009). What persuades some may not persuade others—abstract theoretical statements might be the discourse of the academy, but concrete examples that facilitate judgments and deliver reasonably immediate results are more likely to influence policy makers, decision makers, and other stakeholders.

Communicating with Public Policy

Persuasion means using appropriate language, stressing cooperation and collaboration rather than conflict, and recognising that extended arguments—evidence, claims, counterclaims, and rebuttals—need to be optimally nuanced with clear policy directions indicated. Academics need to provide informative policy briefs in ‘plain language’ that clearly describe the knowledge claim, underlying premises, and evidence as well as engaging and rebutting alternative claims. “Actions targeting those who shape public opinion, and the public itself, as well as those who shape the policy positions of corporations, associations, interest groups, and political parties, go beyond policy-making into the realm of politics” (Cohn, 2007, p. 16). Frequently, research discourse is not the discourse of the targets to be influenced. This means that terminology, data sources, and data analysis must be selected from those understood and valued or translated into the discourse of the targets—politicians, bureaucrats, citizens.

Funding Agencies’ Expectations and University Reward Systems

The calls for proposals and the associated terms of reference for some funding envelopes emphasise KT and dissemination of results to the policy and professional teaching communities. Grant applicants respond to funding agency requests for the inclusion of public access websites, portals, podcasts, social networks, and blogs; commitments to present practical implications to teachers and administrators; and plans to lobby teacher education program directors and ministries/departments of education. Many of these well-intended promises are made without full understanding of the process or the labour-intensive nature of KT. Furthermore, many university researchers discover in the context of KT projects that such efforts are not highly valued by the university rewards system. The politics of knowledge involving university promotion and merit reward systems that superficially assess research impact—rather than actual impact, practical applications, and influence on public policy for grant evaluations and personnel and salary decisions—appear to mitigate against such long-term, labour-intensive knowledge transfer.

Efforts in using the PISA 2000, 2003, and 2006 Results

The recent special issue of the *Journal of Research in Science Teaching* (Bybee, Fensham & Laurie, 2009) focused its attention on scientific literacy; it emphasised contextual applications of science knowledge and tangentially addressed policy issues. The article on science teaching practices and student attributes and performance in top-performing Finland provided rich insights into the congruency amongst policy, classroom practices, and scientific literacy (Lavonen & Laaksonen, 2009). Students' scientific literacy, self-efficacy, and self-concept toward science and their interest in physical sciences and future science-oriented careers are connected to the priority of science in a knowledge-based society, educational policy, equality, local control, and teachers' background and classroom practices (use of demonstrations, practical work, and student negotiations).

Many reports of the PISA results stop with OECD's technical and summary publications and media releases of the 'league tables' for participating countries/economies' rank-ordered standings. The rankings provide feedback for the competitively minded but do not fully analyse the effects and potential causes of these performances. Much like the Olympic metals that magnify minor differences in performance, these rankings reflect a host of factors leading to the final performances and overlook some of the critical influences that could inform public policy and debate and provide directions for improved practice.

Comparison of the 10 'top' and 'bottom' performing countries in the 2000, 2003, and 2006 league tables provides few surprises, consistent placements, and high correlations with the country's GDP and education spending and the students' socioeconomic and cultural status (Anderson et al., 2007; Milford, 2009; Ross, 2008). The PISA datasets provide opportunities for much deeper investigations than simple average performance in the focus domain by using the coordinated information on families, schools, and minor domain foci, by developing derived indices (e.g. school socioeconomic and cultural status from the average status of responding students from the school), and by exploring correlates amongst meaningful factors (e.g. reading and mathematics and reading and science) (Anderson et al., 2010; Anderson et al., 2007). The authors in this special issue provided such value-added analyses and insights using a variety of designs—secondary analyses and historical case studies that reprocessed the PISA datasets and other linked data sources. The articles contribute to four areas: Verification of curricular influences, educational opportunities and equality, regional comparisons of trading partners, and direct influence on policy.

Verification of Curricular Influences on PISA Performance

Coertjens, Boeve-de Pauw, De Maeyer & Van Petegem (2010) investigated environmental education and science literacy by exploring school influence on students' environmental attitudes and awareness in the Flemish schools of Belgium. They found that schools that had implemented science teaching with an environmental component had positive influences on students' environmental attitudes and awareness; however, this influence varied across gender, immigrant status, socioeconomic status, and educational track. Schools that used hands-on activities produced higher student environmental awareness, and environmental learning activities produced more pro-environmental attitudes among students across all levels of science literacy performance. These results appear to support the inclusion of environmental-based activities in the science curriculum.

Kubiatko & Vlckova (2010) investigated the uses and types of information communication technologies (ICT) activities on students' science knowledge in the Czech Republic. They conducted a secondary analysis of PISA 2006 scientific competencies embedded in thematic contexts (evolution, mouse pox, genetics, and acid rain) linked with a national-option-questionnaire that focused on different ICT activities. They found positive effects on science knowledge achievement for ICT activities connected with education rather than entertainment and gaming. Their results provided guidance for the inclusion of ICT in the school curriculum and for its influence on scientific literacy and, likely, mathematical literacy (Yore et al., 2007).

Educational Opportunity and Equality

Social justice and equity were central considerations of four articles in this special issue. These authors explored educational opportunity and equality of experience in relatively distinct high- or above-average-performing countries: Japan, Hong Kong-China, Australia, and Ireland. Each study used distinctive secondary analyses of the PISA 2003 and 2006 datasets.

Knipprath (2010) explored the quality and inequality for mathematics and science in the Japanese education system. She pointed out that the judged quality of the Japanese education system often differs for internal and external perspectives with international communities ascribing much higher regard than the internal community does. Advocates and detractors assume that students perform equally well or bad, teachers do not differ in their methods, and students are treated similarly across schools. Her results from secondary analyses of PISA 2003 and 2006 datasets revealed that students performed well but a decline in mathematics achievement was detected between these assessments, an achievement gap existed across types of school, and tracking led to differential experiences. Equity policies within differentiated education systems need to consider how unequal programs could lead to equality of learning opportunities and basic mathematics and science literacies.

Ho (2010) explored familial influences on science performance in Hong Kong-China, a traditionally high-performing participant in international assessments, using the PISA 2006 dataset. Multilevel analyses examined the relationship between parental involvement and investment and students' scientific literacy performance. She found that students' science achievement and self-efficacy toward science were significantly associated with certain types of parental investment and involvement even after controlling student and school background factors. Science learning enrichment activities provided at an early age (e.g. watching TV programs about science; reading books on scientific discovery; watching, reading, or listening to science fiction) were found to be highly effective in promoting children's science achievement and self-efficacy. These results appear to support many of the assertions about informal learning environments and science achievement and illustrate the need for society to provide these preschool opportunities. Although children's ideas and beliefs appear to be topic- or problem-specific rather than generalised understandings, early informal experiences and conversations with peers and family appear to nurture information-seeking, cause-seeking, and knowledge-building processes and enhance intuitive reasoning that parallels scientific thinking (NRC, 2009). Clearly, parents, early childhood educational systems, and the broader society need to ensure such opportunities and encouragements are equally available for children of both genders and all socioeconomic and cultural backgrounds such that financial and geographic dislocation do not mitigate against future mathematics and science literacies.

McConney & Perry (2010) investigated the role of socioeconomic composition on educational equality and effects on science and mathematics achievement in Australia. They explored socioeconomic status (SES), science and mathematics achievement, and student interest in science in the context of varying school socioeconomic composition in the PISA 2006 dataset and found that increases in school SES were consistently associated with increases in science and mathematics performance regardless of individual students' SES. However, they found that interest in science was not associated with school SES and only marginally and inconsistently associated with individual SES. These results have policy implications and strategies for mitigating the influence of school SES composition on science and mathematics performance and for the achievement of more equitable and effective schooling.

Gilleece, Cosgrove & Sofroniou (2010) explored a rarely considered issue of equity in mathematics and science across performance groups and the influences on group performance. They examined student and school characteristics associated with low and high achievement in mathematics and science on PISA 2006. The results of a multilevel, multinomial model of achievement for each domain indicated a greater number of the variables were associated with low performance than high performance. At the student level, home language, intention to leave school early, SES, grade level, cultural capital, and books in the home were significantly associated with achievement in mathematics and science. School average SES was the only statistically significant factor in the school-level models. Females were more likely to be low achievers and males were more likely to be high achievers in mathematics. However, males intending to leave school early were more likely to be in the low-achieving group than females intending to leave early in science. These results emphasised the need for policies, resources, and strategies aimed at promoting equity at both the student and school levels.

Regional Comparison of Sociocultural and Socioeconomic Effects and Schooling

Milford, Ross & Anderson (2010) attempted to better understand the influence of PISA 2006 results in North, Central, and South America regarding literacies in reading, mathematics, and science. The PISA participants from the Americas have increased over the 2000, 2003, 2006, and 2009 administrations. Milford et al. summarised the media reactions to PISA within North and South America and presented an Americas-specific example of the ways in which the PISA dataset can be used for exploratory policy and curriculum purposes rather than just league table comparisons. Multilevel modeling revealed the importance of student and school SES in predicting scientific literacy across all nations in the study while other school-level significant predictors were more nation-specific. The internationally comparative nature of the PISA dataset facilitates analyses, which leads to better understandings of schooling, revealing common and country-specific elements in statistical models.

Direct Influences on Policy

Neumann, Fischer & Kauertz (2010) provided a historical case study of the impact of PISA results in Germany that led to educational policy, national standards, and competence models. This case appears to be a positive example of research influencing policy and practise for an education system that did not traditionally rely on standardised testing and placed high value on *Bildung*, the general-liberal education of students, and in *Didactics*, which places sole responsibility for the enactment of educational goals and assessment on professional teachers. However, when the PISA results revealed unexpected low performance and disparities amongst the 16 federal states, policy makers enacted a major reform that introduced National Education Standards, which in science were influenced by PISA's underlying framework. The shift moved away from Bildung toward *literacy*. Furthermore, the introduction of standards stimulated the development of a new field of empirical educational research on models of scientific literacy or competency models as a basis of benchmarking the standards. The policy change and the resulting changes in educational research and practices were smooth, indicating an acceptance by educators and other stakeholders.

Dolin & Krogh (2010) reported on a historical case study addressing the relevance and consequences of the PISA results on Denmark. They described and analysed the changes in the Danish school culture induced and encouraged by the PISA results that, unlike the German case study, appear to have been a negative experience. The policy changes and reforms were temporally connected with the publication of the PISA 2000 results, but the political initiative more likely was based in socioeconomic and sociopolitical influences of the political party in power. They outlined how PISA's assumptions and assessment framework and the resulting policy and implied practices did not align with the fundamental goals of Danish education and the traditions, like Germany, of Bildung and Didactics. The results of this inquiry into the PISA definitions of literacies and assessment framework and the Danish educational goals and instructional practices revealed areas of correspondence and fundamental differences related to values underlying the Danish school system and formative assessment practices. This example illustrates what can happen when stakeholders are not consulted and local values and traditions are not considered while establishing public policy.

In Closing

The PISA project has certainly had effect during its 1st cycle. Most notable are the shock reactions to low standings in the country rankings leading to broad-scale reform in educational systems; the league tables effects are clearly evident in the Danish and German responses to PISA results that are reported in this issue and elsewhere (e.g. Fuchs & Wößmann, 2007). However, there has also been substantial research conducted on the PISA datasets to better understand the nature and effects of schooling for both research and policy purposes—again, well illustrated in this special issue of the *International Journal of Science and Mathematics Education* and in conferences such as the PISA 2009 Research Conference organized by Leibniz Institute for Science Education at the University of Kiel (http://www.pisaresconf09.org/_call/). These more complex analyses—investigating relationships among achievement and student, home, and school characteristics—are directly aligned with the more simplistic policy initiatives motivated by low national standings. This alignment could lead to better functional relationships between research and policy communities since the same data underlie the analyses, interpretations, and decisions of both fields—perhaps even some common language is under development as a result.

The open access to the data generated by each administration of PISA has stimulated the field of secondary data analysis for both the policy and research communities. As illustrated in the articles in this special issue, school reforms can be monitored in terms of change utilising the longitudinal character of the PISA datasets; multilevel models can be used to predict the effects of educational modifications; and international comparisons can provide perspective on targeting reform initiatives. Educational policy is a complex field that can be well served by research; however, it would be unrealistic to assume that research will provide a complete understanding of a complex social system such as education (Gist, 1998). Research can have an important role in serving policy formulation by building understandings of the nature, limitations, variations, and changes that are characteristics of an educational system.

These understandings can provide an empirical knowledge base that should be central to decision making. This role for research can be considered to be an enlightening function (Kennedy, 1999) to influence perceptions and concepts that lead to better grounded policy and practice.

Although the PISA project does provide open access to a significant dataset—and since it is likely to have high value for policy and research for years to come, some improvements should be considered. The PISA assessment frameworks for reading, mathematics, and science literacies should be enhanced to improve and expand its definitions of these literacies to assess the specific types of authentic mathematical and scientific texts subsumed under the interacting senses of mathematics and scientific literacy. The current definitions emphasise application of knowledge in real-world contexts, which is fine, but they lack explicit connections to discipline-specific language with these disciplinary literacies (Moje, 2008; Norris & Phillips, 2003; Shanahan & Shanahan, 2008; Yore et al., 2007). These contemporary definitions of mathematical and scientific literacies specify linguistic functions in which language plays a role in constructing knowledge as well as in communicating and applying knowledge. It would be possible to select text that includes text structures/genres (procedures, cause-effect, problem-solution, argument, etc.), features (heading, symbols, signs, etc.), representations (visual, mathematical, metaphorical, etc.), and plausible reasoning (inductive, deductive, hypothetico-deductive, abductive) commonly found in authentic mathematical and scientific work (academic reports, media releases, journalistic version reports, primary adapted reports, etc.).

Participating nation states should lobby for classroom-level questionnaires and take advantage of adding local options that will allow them to link the PISA results to other national/federal or provincial/state assessment and information databases. Current models of reading, mathematics, and science literacies lack insights into classroom climate, resources, and instructional practices (teaching and assessment) because reliable information is not acquired by the PISA data collection protocols. Furthermore, many jurisdictions have underutilised information stores that, if linked to current mathematics and science assessment datasets, could allow more complex models to inform policies and decision about schools, instruction, and learning. Some systems have historical records for students from 5–15 years of age that could provide insights into performance progressions and changes in curriculum and instruction.

It is our hope that this special issue of the *International Journal of Science and Mathematics Education* will foster further research investigating educational performance and stimulate stronger links between research and policy, which will lead to better education in terms of enhanced performance levels with equity for all students. International assessments need to go beyond who is first or what nation outperformed other nations.

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