

PISA as a Challenge for Science Education: Inherent Problems and Problematic Results from a Global Assessment Regime¹

PISA como um Desafio para a Educação em Ciências: Problemas Inerentes e resultados Problemáticos de uma Avaliação Global

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We experience the emergence of a global educational reform movement, where the OECD (Organization for Economic Cooperation and Development) through its project PISA (Programme for International Student Assessment) has become the key driver. PISA and its focus on league tables and rankings influence educational debates and educational policy world-wide. The OECD is, with PISA as the main instrument, emerging as a kind of global ministry of education, promoting their own standardized curriculum and system of quality assessment. PISA is designed to be used by the 30+ modern, highly developed countries in the OECD, but is also used by some 40 less developed non-OECD countries as a benchmark for their education system. This influence of OECD will be further widened by a version of PISA that will target developing countries, “PISA for development”. This instrument has the same underlying assumptions and ideals as PISA: the main concern is the national economy, not the personal development of the learner. There is also the underlying assumption that competition is always good, and that a free-market economy always promotes quality. The increasing role taken by the OECD is pushing aside the influence of international organization with different agendas and ideals, like UNESCO and UNICEF. Since studies like PISA by design cannot identify causal relationships behind neither success nor failure, the educational consequences of the studies are not clear. In many countries, PISA results are used to legitimize market-driven reforms, control of the teachers, payment by test results for teachers and principals, erosion of the public school system, privatization and the introduction of more testing regimes. In this development, the OECD now operates in close contact with the world’s largest commercial company in the education sector, Pearson Inc. The success of PISA as an instrument of governance is currently expanded also to target schools and their teaching in a more direct way: a PISA-like instrument, “PISA for Schools” is developed for local use, for schools and school districts, enabling them to compare their own schools to “PISA winners”. This development may also create anxiety and concern not only at the national or federal level, but also at the local level.

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This test is also a commercial product, opening up a large and untapped market.

Keywords: Comparative studies; science education; educational policy; globalization; standardization; OECD; PISA.

Estamos vivenciando o surgimento de um movimento global de reforma educacional conduzido principalmente pela OECD (Organização para Cooperação e Desenvolvimento Econômicos), através do seu projeto PISA (Programa de Avaliação Internacional de Estudantes). PISA e seus focos em tabelas e rankings têm influenciado debates e políticas educacionais em todo o mundo. Assim, tendo o PISA como seu principal instrumento, a OECD tem emergido como um tipo de ministério global da educação, promovendo seus próprios currículos e sistemas de qualidade de avaliação padronizados. PISA é feito para ser usado pelos 30 países mais desenvolvidos da OECD, mas também é usado por outros 40 países menos desenvolvidos, não membros da OECD, como um ponto de referência para seus sistemas educacionais. Esta influência da OECD será estreitada por uma versão do PISA feita exclusivamente para países em desenvolvimento, o “PISA para Desenvolvimento”. Este instrumento se baseia nos mesmos princípios básicos do PISA: a preocupação principal é com a economia nacional, não com o desenvolvimento pessoal do aprendiz. Existem também os pressupostos implícitos de que competição é sempre boa, e de que uma economia de livre mercado sempre promove qualidade. O papel crescente assumido pela OECD tem deixado de lado a influência de organizações internacionais com diferentes planos e ideais, como a UNESCO e a UNICEF. Considerando que estudos como o PISA, por seu próprio design, não podem identificar relações causais por detrás do sucesso ou do fracasso, as consequências educacionais de tais estudos não são claras. Em muitos países, os resultados do PISA são usados para legitimar reformas controladas pelo mercado, controle sobre professores, pagamento por bons resultados para professores e diretores de escolas, destruição do sistema educacional público, privatização e introdução de testes adicionais. Nessa linha, a OECD opera agora conjuntamente com a maior companhia comercial do setor de educação do mundo, a Pearson Inc. O sucesso do PISA como um instrumento de poder também está se expandindo no sentido de atingir escolas e professores de uma maneira mais direta: um instrumento do tipo PISA, “PISA para Escolas” é elaborado para uso local, por escolas de regiões específicas, possibilitando a comparação dessas escolas com os “Países Vencedores do PISA”. Isto pode também criar inquietação, não só nos níveis nacionais e de estados, mas também no nível local. Tal teste também é um produto comercial, aberto a um amplo e, até então, intocável mercado.

Palavras-chave: estudos comparativos; educação em ciência; política educacional; globalização; padronização; OECD; PISA.

Introduction

From the mid 1990's, the OECD started the planning of Program for International Student Assessment, now well known as PISA (see figure 1 for general information). Since the first publication of PISA results in 2001, based on the testing in 2000, the results have become a kind of global "gold standard" for educational quality. Although the political and educational importance of PISA varies from one country to another, the results often set the scene for public debates on the quality of education. PISA league tables are widely published in mass media, and also used by politicians and educational authorities. In many countries, educational reforms are launched as direct responses to the PISA results. The testing takes place every three years, and when results from PISA2015testing were published in December 2016 (OECD, 2016b & 2016c), we now have data from six rounds of PISA. Brazil is not a member of the OECD, but has taken part in all these rounds.

PISA: Program for International Student Assessment
Organized by the OECD (Organization for Economic Cooperation and Development)
Designed for the (now 34) member countries of OECD
Also 35 non-OECD countries and economies take part
Three main domains: reading, mathematics and science
Testing every 3 years. Started in 2000, now 6 rounds
Brazil (not in OECD) has participated in all PISA rounds
Testing national samples (app. 5000) of 15 year olds *in schools*
Data also from students' and principals' questionnaire
Testing based on a framework ("curriculum") developed by appointed experts
Test items not "school science"
The test is digital/electronic from 2015
Results from PISA 2015 published in December 2016

Figure 1. PISA general information

The intentions of PISA are, not surprisingly, related to the overall political aims OECD and the underlying commitment to a competitive global free market economy. PISA was constructed and intended for the 30+ industrialized and wealthy OECD countries, but has later been joined by a similar number of countries and "economies". When PISA is presented, its importance is stated like this: "PISA has participation from 80% of the global economy" (OECD 2014a, p. 3). For educators, this may seem a surprising way of counting pupils, but it indicates the focus of the PISA-project: economy. This may also account for the extreme political importance that is now attributed to PISA results: it seems "common sense" that high scores on reading, mathematics and science are predictors for the country's future economic competitiveness. Bad rankings on PISA are thought to be bad signals for the future prosperity of the country. We will

return to this crucial point towards the end of this article.

Tables of country rankings on PISA scores are often taken at face value, not only in the media, but also by policymakers and politicians. The PISA undertaking is a well-funded multinational “techno-scientific” machinery, undoubtedly the world’s largest empirical study of schools and education. Estimates suggest that the annual cost is around 80 million USD (PISA-leader Schleicher in interview, Sydney Morning Herald, Nov 29, 2013). This sum does, however, *not* include the costs of involving half a million of students, tens of thousands of schools and their teachers, let alone the pupils. Given the size and importance, PISA has to be understood not just as a study of student learning, it has to be understood as a “social phenomenon” in a wider political, social and cultural context (Lundgren, 2011).

PISA rankings create panic and discomfort in practically all countries, also in high-scoring countries (Alexander, 2012). This produces an urge for politicians and bureaucrats to do “something” to rectify the situation. But since PISA by its research design does not say anything about cause and effect, the creativity blooms, and educational reforms that are not at all empirically founded are introduced, often overnight.

This article presents critical points of two categories. The first category relates to the PISA project as such. Some problems are inherent in the PISA undertaking, and hence cannot be “fixed”. It will be argued that it is impossible to construct a test that in a fair and objective way can be used across countries and cultures to assess the quality of learning in “real-life” situations with “authentic texts” as they claim PISA does. Problems also arise when the brave intentions of the PISA framework are translated to concrete test items to be used in a great variety of languages, cultures and countries. The requirement of “fair testing” implies by necessity that local, current and topical issues must be excluded. This runs against most current thinking in science education, where “science in context” and “localized curricula” are ideals promoted by e.g. UNESCO, educators as well as in national curricula, in particular for the compulsory years of schooling.

The second category of critical points relates to some of the rather intriguing results that emerge from analysis of PISA data: It seems that pupils in high-scoring countries also develop the most negative attitudes to the subject. It also seems that PISA scores are unrelated to educational resources, funding, class size, time allocated to science teaching etc. PISA scores also seem to be negatively related to the use of active teaching methods, inquiry based instruction, doing experiments and the use of ICT. Whether one believes in PISA or not, such intriguing results need to be discussed.

A positive aspect of PISA that it has brought schools and education to the forefront in the media and in political debates internationally, but even more so nationally. Scientists and science educators may, of course, also celebrate the fact that our subjects are given high priority through these studies.

However, the PISA results seem to be accepted at face value, they may have counterproductive consequences and there are few critical voices. Therefore, the focus of this article is on the more problematic sides of the PISA testing.

PISA scores seem to function like a kind of IQ-test on school systems. A most complex issue is reduced to simple numbers that may be ranked with high accuracy. But, as for IQ-scores, there are serious concerns about the validity of the PISA-scores. What does PISA claim to measure and how does it live up these claims? The first point, then, is to look into what PISA claims to measure.

What does PISA claim to measure?

The emerging picture is in many ways confusing. In some places, PISA claims that they do *not* measure school knowledge or competencies acquired at schools, in other places they state that they actually do measure the overall quality the nations' school system. Let us consider some details. The overall aims of PISA were stated already in 1999, before the first PISA testing took place in 2000:

How well are young adults prepared to meet the challenges of the future? Are they able to analyse, reason and communicate their ideas effectively? Do they have the capacity to continue learning throughout life? Parents, students, the public and those who run education systems need to know. (OECD, 1999, p. 7)

These exact words have been repeated in practically all PISA reports from OECD during the 17 years since then. One can hardly object ambitions like this. It would be great if PISA really “answers these questions and more”, as they also state at the same place.

In other parts of their reports, they are more modest. They stress that PISA scores do not actually provide measures the quality of *education systems*, but the collective results of school, home and social environment.

PISA is rather explicit that they do *not* measure according to national school curricula, but based the definitions and the framework made by the OECD-appointed PISA experts (OECD, 2006a). The PISA Technical Reports clearly state that the knowledge and skills tested on PISA “are defined not primarily in terms of a common denominator of national school curricula but in terms of what skills are deemed to be essential for future life.”(OECD, 2009). The same report also states that items that are close to the curriculum and items with “school science” are excluded.

So, although PISA states that it does not test school knowledge, and that it does not test according to national curricula or testing school knowledge, the PISA results are interpreted, also in OECD reports, as valid measures of the quality of national schools systems, and the PISA reports are full of policy recommendations regarding schools (Loveless, 2009). More on this later.

The politics of the OECD PISA project

OECD is the organization for the highly industrialized and economically developed nations, and the mandate of the organization lies in the name: Organization for Economic Cooperation and Development. The home site (<http://www.oecd.org/>) is

explicit about the mission of OECD. Its aim is, above all, to promote policies and set standards for economic development in a global, competitive free market economy. One should remember that the E in OECD stands for Economy, not Education. But education is certainly a driving force in economic development and national competitiveness, and has over time become an important element of the OECD's concerns and policy advice.

The mandate of the OECD also explains why the "PISA subjects" are reading, mathematics and science. These subjects are seen to be key elements for the competitiveness in a world economy driven by science and technological development. But this selection of subjects also carries an implicit message about what is considered to be important in schools and in the development of young people. One should note the domains that are *not* included when PISA measures the quality of schools: the humanities, social sciences, ethics, foreign languages, history, geography, physical education etc. One might also note that the PISA does not address aspects that are central in many countries' official purposes of education, like personal and social development, equity, empathy, solidarity, curiosity and engagement, care for the environment, etc. In the public and political debates, these statements about the agreed (and legally binding) purposes of the school system are often forgotten or ignored when discussions about the quality of the school is based on PISA scores and rankings.

It is interesting to note that in the PISA 2012 testing, a new component was added: "financial literacy" (OECD, 2013a), of course also a consequence of the mandate and priorities of the OECD. This module was included in the testing by some 40 countries. OECD is often very clear about the economical purpose of PISA and the competitive, international nature of the PISA rankings:

In a global economy, the yardstick for success is no longer improvement by national standards alone, but how education systems perform internationally. The OECD has taken up that challenge by developing PISA, the Programme for International Student Assessment, which evaluates the quality, equity and efficiency of school systems in some 70 countries that, together, make up 90 percent of the world economy. (OECD, 2010a, Foreword)

There seems to be a contradiction here. On the one hand OECD/PISA state that they do not measure according to school curricula, and not even the knowledge acquired at school. On the other hand they claim that they do evaluate "the quality, equity and efficiency of *school systems*." As mentioned, it is also interesting to note that the importance of PISA is defined in terms of the fraction of the world *economy*, not in terms of the fraction of the world's young people or *population*.

The competitive economical perspective is also at the forefront when PISA results are presented to the public. At the PISA 2006 Release Conference in Washington DC, the invitation reads as follows.

Losing Our Edge: Are American Students Unprepared for the Global Economy? The lessons learned from PISA results ... can, and should, be used to inform U.S. education policy so that our students graduate ... ready to compete, thrive, and lead in

the global economy of the twenty-first century. (Extracts only, full quotes and videos on <http://www.all4ed.org/events/losingedge>)

The political, economic and indeed normative use of PISA by the OECD is also very clear. The OECD makes regular economic reports to many countries with advice on future policy. My own country, Norway, is an example. In the Economic Survey report to Norway in 2008, OECD experts gave the following general advice: Norway ought to increase differences in salaries, reduce public spending, increase the rate of unemployment (sic!), reduce the level of sick leave salaries and reduce pensions for disabilities (OECD, 2008). (This advice was given just before the financial crisis.)

This particular OECD report to Norway had the education system as the focus. With PISA data as input for calculations, OECD gave advice on how to make Norwegian schools better. The operational definition of a “better school” was a school that is “cost-effective”, i.e. could give more PISA points per dollar spent on education. The very definition of a good school is thereby ignoring the national priorities set for our school system. The OECD educational advice was that Norwegian schools can become better by: *Closing smaller schools, increasing class size, introducing more testing, publishing results at school (and teacher) level, and basing teacher payments on achieved test results.* The report ended with a clear warning: “Higher spending on schools will have no effect.”(OECD, 2008, p. 8).

The essence of this “expert advice” is in fact that Norway should become a different kind of country, hardly an objective, neutral, “scientific” advice.

National policies based on PISA: examples

The attention given to PISA results in national media varies between countries, but in most countries it is formidable, and it has increased after several rounds of PISA testing (Breakspear, 2012).

In Norway, the results from PISA 2000 as well as from PISA 2003 provided war-like headings in most national newspapers. The headlines in all the newspapers told us, with war-like headlines, that “Norway is a school loser”. In fact, even the headings were misleading: Norway was close to the OECD average in the three test domains in PISA 2000 and PISA 2003, but this was translated to be “a loser”.

The results from PISA shaped the public image of the quality of our school system, not only for the aspects that had in fact been studied, but for more or less all other aspects of school. It became “common wisdom” that Norwegian schools in general had low quality. It seemed that the public as well as politicians accepted these versions as objective scientific truths about our education system. There was little critical public debate, and the researchers behind the PISA study did nothing to modify this false impression and remind the public about the limitations of the study and the fact that Norway was in fact among in the middle of the OECD countries. In sum, PISA created a public image of the quality of the Norwegian school that was not justified. Surveys among Norwegian teachers have shown that they consider the effects of the PISA project

as a serious cause of trouble in their daily work. The status and the professional pride of the teachers had been hurt.

But PISA did not only shape the public image of Norwegian schools, it also served as legitimization of school reforms. Under Kristin Clemet as Minister of Education for the conservative party (2001–2005), a series of educational reforms were introduced in Norway. Most of these reforms were legitimized by reference to international testing, mainly to PISA. In 2005, there was a change in government, and Clemet's Secretary of State, Helge Ole Bergesen, shortly afterwards published a book in which he presented the "inside story" on the reforms made while they were in power. A key feature of the book is the many references to large-scale achievement studies. He explicitly states that these studies provided the main arguments and rationale for curricular as well as other school reforms. Under the heading "The PISA Shock", he confirms the key role of PISA:

With the [publication of the] PISA results, the scene was set for a national battle over knowledge in our schools. [...] For those of us who had just taken over the political power in the Ministry of Education and Research, the PISA results provided a "flying start". (Bergesen, 2006, p. 41–42, author's translation)

In these memoirs, Bergesen (2006) also describes how the Ministry deliberately created an atmosphere of panic and urgency, and how all resistance was successfully marginalized and characterized as unscientific. When the next PISA-round showed a small fall in the test-scores of Norway, the ground was prepared for a major school reform, to be called The Knowledge Promotion. The other political parties followed suit.

Later, in the parliamentary election campaign in 2009, the prime minister candidate, and from 2013 our Prime Minister for the same party, had the following main message, even with a personal signature in the leading Norwegian newspaper:

I, Erna Solberg, herewith guarantee that if we (i.e. Høyre, the moderate/conservative party) form the Government after the election, we can promise more PISA points. (Aftenposten, March 27, 2009, authors' translation)

It is most interesting that this statement was made shortly after the Norwegian Parliament unanimously had passed a new law stating the value foundation for Norwegian schools. No reference was made to the key words in this law (like equity, solidarity, empathy, concern for environment etc.) in the elections campaign. It is also notable that the red/green Labour-dominated Norwegian government that took office in 2005 has followed more or less the same policy.

In the many White Papers on Schools that have been presented from the government to the Parliament in the years 2001 to 2016, the reference to the PISA project and "OECD experts" steadily increased. There is no doubt that the major reforms of Norwegian schools in the last decade has been strongly influenced by the OECD, with PISA as the main instrument. These reforms are also characterized as examples of New Public Management (Møller & Skedsmo, 2013). We have, among many reforms, established a high-stakes national testing system, where the categories are more or

less adapted from the PISA framework. The new national curriculum is also strongly influenced by the language and categories in the PISA framework.

In sum: international rankings, in particular PISA, are seen as the ultimate measure of the total quality of the Norwegian schools system, and new reforms were introduced as attempts to meet the perceived challenge. Most reforms on curriculum, national testing, accountability, transparency etc. also follow the policy advice that emerges from the PISA-study: more private schooling, free choice of schools and the growth of private consultancies for testing and reporting are also current trends that follow in the wake of the PISA rankings.

In the autumn of 2014 Norwegian teachers went on strike. Not for higher salaries, but as a reaction to stricter external control of their working hours and other working conditions. The underlying cause of the conflict was the growing demand for more testing, reporting and control of teachers' work. It is evident that this development had been triggered by the "PISA-shock".

Similar developments have occurred in other countries, also our neighbouring countries Denmark and Sweden. It is interesting to note, however, that all these "solutions" to solve the perceived crisis are more or less the opposite of what our Nordic neighbour and declared "PISA-winner", Finland, is doing.

Many other countries had similar PISA-shocks. Germany was one of them. The results from the first PISA round placed Germany below the middle. German newspaper had alarming coverage about the scandalous results (see figure 2 below). This became an important issue in the German election the following year, and the perceived bad results also led to major initiatives to promote the quality of science and mathematics education. The German national Institute for science education, IPN (Intitut für die Pädagogik der Naturwissenschaften) received large grants to improve the quality of science education. IPN also had the contract to run PISA in Germany. From the perspective of science education, one may say argue that "bad results are good news", very much the same way that the "Sputnik-shock" was "good news" for science and mathematics educators in the Western world when the Soviet Union launched their Sputnik in 1957.

The influence of PISA in Germany went even further. "Germany finally introduced national standards for science education as one reaction following the results of the PISA studies" (Steffen, & Hößle, 2014, p. 351).



BILDUNG UND ERZIEHUNG IN DER KRISE

Schule macht dumm

VON REINHARD KAHL
Ein inländischer Kioskbestzer in Frankfurt: Höchstbeschwärmt: Kommen Sie mit nach Gießen! Schauen Sie sich unsere Kin-

Vernachlässigte Kinder, miserable Leistungen:

DIE WOCHE zeigt Auswege – und wie die Schule der Zukunft aussehen muss



fangern am jeweiligen Jahrgang fast zu erreichen. Wenn am 4. Dezember weltweit die ersten Ergebnisse des zwei-

Figure 2. “Schule macht dumm”. (The schools make you stupid) The first PISA-results created a crisis in Germany, and led to large investments in science and mathematics education (Bad results may be good news for science and mathematics educators).

The OECD is not hesitant to tell about the influence of PISA. The *OECD Education Working Papers*, N^o. 71 (Breakspear, 2012) reviews the policy impacts and the normative effects of PISA. With obvious pride, the report states that

PISA has been adopted as an almost global standard, and is now used in over 65 countries and economies. [...] PISA has become accepted as a reliable instrument for benchmarking student performance worldwide, and PISA results have had an influence on policy reform in the majority of participating countries/economies. (Breakspear, 2012, p. 5).

In this report, they review literature as well as results from their own questionnaires, and provide a ranking (!) of the impact that PISA has had on all OECD countries. The report notes that even “high-performing countries such as Korea and Japan have enacted reforms in response to a large range of PISA results”.

It may be interesting to note the USA is number 28 on this listing based on the scoring on “Informing policy-making process”. This influence is classified as “moderate”. Rutkowski (2014) argues that this rather limited impact of PISA on American schools may be the main reason why the federal government and OECD are eager to introduce the newly developed “PISA for schools” in the US. With this move, PISA will get closer to the decision makers in the US education system and the normative power will increase.

PISA, market thinking and globalization

The point so far has been to argue that PISA should be seen and understood in a wider political context. The two key elements here are market thinking and globalization.

As for the *market thinking*, the PISA project, organized by the OECD, can be seen as part of a current international policy trend, where concepts and ideas from the market economy are used in the education sector. The term New Public Management is used to describe this market driven philosophy which is supposed to make the public sector more efficient. Terms like quality, efficiency, transparency, accountability and “value for money” are among the (often positively laden) terms that are used in these policy reforms in many public sectors. Public services like schools and higher education, culture, health and care are all being invaded by market terms. Other (previously) public sectors experience the same trend: police, security, postal services, transport, water supply, handling of household garbage, sewage and waste water cleaning etc. Traditional public services are increasingly subjected to competitive bids where they compete with private actors. Out-sourcing of key public services is increasing internationally, often to multinational companies, a process that is eased by new regulations on international trade. This trend towards marketization and privatization characterize the development in several countries. The education sector is in forefront in this development, with OECD as actor and with PISA project as an efficient tool (Meyer & Benavot, 2013).

The other, and related, political/economical perspective is that of *globalization*. The economy is getting globalized, large multinationals are important, and the workforce has to be flexible and moveable. Nations and multinationals compete on a common, global market. Hence, there is a need for common standards in education, common systems for exams, degrees and qualifications. Such tendencies operate within units like the European Union, where an example is the Bologna process and its introduction of a common degree system in higher education in Europe. In key areas, the OECD is playing an increasingly important role by developing and monitoring common standards, indicators and measures (Grek, 2009).

This PISA-inspired process represents a political pressure to standardize, harmonize and universalize national institutions like a country's school system and to promote competition on the global educational scene. While most educators argue for context-based teaching and localized curricula, at least in the obligatory school age, the pressure from the PISA project is in the opposite direction. A driving force behind these reforms is often the use of indicators; quantifiable and measurable standards that can be used for calculations (Popkewitch, 2011). PISA test scores and rankings are ideal for this purpose, whether the researchers behind the projects like it or not.

Andreas Schleicher (2013), director of PISA and recently also of Directorate of Education and Skills in OECD, in a TED talk, starts his presentation by stating that PISA is “really a story of how international comparisons have globalized the field of education that we usually treat as an affair of domestic policy”(figure 3).

PISA-leader Andreas Schleicher in TED-talk 615,228 views

PISA is:

"really a story of how international comparisons have **globalized the field of education** that we usually treat as an affair of domestic policy"



http://www.ted.com/talks/andreas_schleicher_use_data_to_build_better_schools?language=en

Figure 3. First words on PISA leader Andreas Schleicher's TED-talk on PISA.

Universally valid "real life" indicators?

The basic problem in PISA lays its own statements about what they want PISA to be, as documented above. A fundamental premise for the PISA project is that it is indeed possible to "measure" the quality of a country's education by indicators that are common, i.e. universal, independent of school systems, social structure, traditions, culture, natural conditions, ways of living, modes of production etc.

As noted, PISA claims that they measure "how well the young generation is prepared to meet the challenges of tomorrow's world". Such an ambition assumes that the challenges of tomorrow's world are already known and more or less identical for young people across countries and cultures. Although life in many countries do have some similar traits, one can hardly assume that the 15-year olds in e.g. USA, Japan, Turkey, Mexico and Norway are preparing for the same challenges and that they need identical life skills and competencies. It is also important to remind ourselves that the PISA framework and its test are meant for the relatively rich and modernized OECD-countries. When this instrument is used as a "benchmark" standard in the 30+ non-OECD countries that take part in PISA, among these Brazil, the mismatch between the PISA test and the needs of the nation and its youth is even more obvious.

One should also remember that the target population of the PISA testing is the not the *whole* age cohort, but all the 15-year olds that are *in school*. For most OECD countries, the 15-year olds are still in school, and close to the end of the compulsory

school. But they may be in different grades, depending on the school system and the system for repeating grades. In other, non-OECD countries, the whole cohort of 15-year olds may not be attending schools. If such a country shows high scores on PISA, it may simply reflect that only 50% of the 15-year olds attend schools.

In PISA 2012 sixteen participating educational systems (including top performing Shanghai) captured less than 80% of all 15-year-olds in their country. Albania and Vietnam covered 55% and 56%, respectively (OECD, 2014a, p. 268). If the country score lower on the next PISA, it may simply be a consequence of increasing school attendance, and not of falling quality (Rutkowski & Rutkowski, 2016).

Most 15-year olds have to face realities that are local and national in their future life. Only a minority of these young people, even the most advanced OECD nations, will operate in a global, international market.

All countries have their own school and education systems based on national decisions, most often by democratically elected governments and institutions. National traditions and deliberations have resulted in foundational legal statements about the overall purposes of the school as well as more concrete details like time allocations for school subjects, aims, objectives and curricula, exam structure etc. These traditions are often at the heart of the nation's identity, and the set of such laws and regulations is the mandate that society has given to the schools, the teachers and all who work to improve the quality of a nation's school.

PISA, however, makes it explicit that they do *not* relate to any national school system, what their measure does *not* fit any country's school. In reality, it is a kind of universal, presumably culture-free, curriculum as decided by the OECD and its experts. The rather explicit goal of OECD with its PISA project is to be an agent of change in the education system in the participating countries. In this respect one may say that PISA is a success story (Lawn & Grek, 2012). The international test movement, in particular PISA, leads to policy convergence across nations. This is detrimental to the expression of educational values within countries and to cultural identity and diversity in general.

Steps towards the PISA test

The process from the PISA overall ambitions to the actual tests that the students get has several stages, each of them with serious obstacles where many decisions have to be taken. The first step from intention to test is of course the selection of the knowledge domains (or school subjects) that should be included. OECD chose three domains ("literacies") for the PISA testing: reading (in mother tongue), mathematics and science. These are important and basic subjects, of course, but one should keep in mind that most school domains are *not* included, as alluded to earlier in this article.

Of course, a test like PISA cannot embrace all possible school subjects, but by selecting some and ignoring other, they implicitly pass a message to the public as well as politicians about what is important for schools and for future life. The actual choice of reading, science and mathematics also, of course, reflects the basic purpose of OECD;

the concern for economic competitiveness in a global, high-tech market economy. As mentioned, when PISA in 2012 extended its repertoire, the domain was “financial literacy” (OECD, 2013a).

The PISA Assessment Framework

The next important step in the process towards the actual PISA test is to make a testing framework, in reality a curriculum. Here the experts come in. The key institutions (who win the bid) and the selected subject matter specialists are in charge of a lengthy process to develop this framework. The persons selected for this purpose are well known international experts in their fields, often among the most respected and merited in the world. But, of course, they work within the frames decided by PISA as a project, and they must all be fluent in English, which is the dominating language in all deliberations and working documents. In addition to the subject matter specialists, the psychometricians play a key role in the whole process.

The PISA Assessment Framework constitutes the basis for PISA-testing. Science was the core subject for the first time in PISA 2006. In PISA 2015, when science for the second time was the core subject, the definition of science literacy from PISA 2006 was revised (Revising a definition of course makes comparisons over time problematic, but we do not dwell on this here.). The definition of science literacy in PISA2015 is the following:

Science literacy is defined as the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically.” (OECD, 2016a, p. 28)

This definition version is expanded, explained and well anchored in research literature (OECD, 2016a). Most science educators are likely to find the definition and its wider clarification useful, fruitful and even progressive. The framework could be used as a source for inspiration to stimulate the debate over educational priorities. The problem is, however, that this framework now serves as a normative international, universal curriculum and a framework for an international testing regime.

As one can see, the above definition of science literacy also includes affective dimensions and stresses aspect that today are known as inquiry-based science education (IBSE), argumentation and socio-scientific issues (SSI). They also use the term “epistemic beliefs” about aspects that are similar to what is often termed “Nature of Science” (NOS). Epistemic beliefs play an important role in the framework.

One might then assume that the PISA science literacy *score* should include these aspects of the science literacy *definition*. But, although they are part of the definition, they are not addressed by the test items. The published PISA science score is based solely on results from the test items.

Attitudinal aspects and questions related to teaching and learning experiences,

epistemic beliefs etc. are, however, addressed in the PISA student background questionnaire. On the basis of the questionnaire, certain constructs that are part of the above science literacy definition are calculated. PISA reports provide the details, and also how these constructs relate to the PISA test score (OECD, 2016c). We return to this important point further down.

Item selection and test construction

Given the assessment framework, the next step is to “operationalize” the framework, i.e. to use this framework for the development and selection of test items, and for the construction of the PISA test as a whole. There is no place here to go in detail on the technicalities in this complicated process, which is well described in the more than 400 page technical reports. See, e.g. OECD (2009) for the PISA 2006 testing, when science was the core subject for the first time.

Some of the elements in the process are the following. Each PISA country (OECD countries only) is invited to submit test items that fit the framework and are based on “authentic texts” addressing “real life situations”. Through a complicated process with initial screening and selection, national and international piloting, pre-field trials, main field trial round and psychometric analysis that involve many actors and subcommittees and many meeting for negotiations and debate, the final series of test items is decided. The complication of (just one of the many stages in) the process is apparent from the following extract from the Technical report.

These analyses [...] included the standard ConQuest® item analysis (item fit, item discrimination, item difficulty, distracter analysis, mean ability and point-biserial correlations by coding category, item omission rates, and so on), as well as analyses of gender-by-item interactions and item-by-country interactions. On the basis of these critical measurement statistics, about 40 new items were removed from the pool of items that would be considered for the main study. (OECD 2009, p. 41)

A logical consequence of wanting to make a fair international test is that an item cannot be used if it behaves in an “unfair” fashion. While this is a sensible argument from a statistical, psychometric point of view, it also means that items that are too close to real life contexts of some countries, but not in others, have to be removed. The principles for exclusions are described as follows.

The main reasons for assessing units as unsuitable were lack of context, inappropriate context, cultural bias, curriculum dependence, just school science and including content that was deemed to be too advanced. (OECD 2009, p. 34)

This clearly states that units (items) that relate to issues that are considered “inappropriate” (controversial in a particular country), has a “cultural bias” (be it positive or negative), or is close to the school curriculum (in some countries but not in others) were excluded. The statement also explicitly states that “just school science” should be excluded. This is, again, a clear statement that PISA does *not* measure school knowledge

or issues related to school curricula. From the above it seems somewhat strange that such a test is used to judge the quality of science taught at school in each country.

For example, in the final test, Norwegian students will find nothing about the key elements of the Norwegian economy. They will not find questions about oil and gas in arctic conditions on the continental shelf, aqua-culture and fish farming, hydroelectric power plants etc. Neither will they find anything about current topical issues and conflicts regarding conservation of our polar nature, nothing about current political conflicts between nature conservation (i.e. wild wolves) and sheep farming, nothing about snow, skiing or skating, nothing about the Northern light (which was the foundation of the University in Tromsø) or about the challenges of an arctic climate etc. Students in Brazil are, of course, not likely to find questions relating to their own culture, nature, history or current national challenges.

In reality, the test items in the final test are decontextualized, or the context is contrived or historical. Not by the intentions in the testing framework, but from statistical necessity and concern for “fairness”. This runs contrary to all recommendations by science educators as well as by many national curricula of promoting a science curriculum that is relevant, interesting and context-based, at least for the compulsory school level.

Item texts, language and translations

A further set of complications arise relating to item texts, language and translation. Most PISA items are based on rather lengthy texts that constitute the stem, called “stimulus”. The intention is positive, namely to present real, authentic texts and real-life situations. But this format, in particular the length and complication of the stimulus text, also make the PISA items rather different from most tests that are commonly used in school mathematics and science.

It is often claimed that many PISA items to large degree are testing reading skills rather than science and mathematics competencies. A strong correlation between the test result on the reading, mathematics and science lends support to such a claim. The fact that PISA items in later PISA versions have become shorter may indicate that this critique has been taken seriously in order to reduce the heavy load on reading skills.

A robust finding in PISA (as well as other kinds of reading tests, like PIRLS (International Reading Literacy Study)) is that girls outperform boys in reading in all countries. More surprising is that the gender difference in the PISA science and mathematics scores are more in favour of girls than in most other kinds of tests. This unusual gender pattern may, at least partially, be explained by the heavy reading load in many PISA items. PISA tests scores show a gender pattern in science and mathematics that is rather different from e.g. TIMSS (Trends in Mathematics and Science Study) results in many of the same countries, as well as other tests, like national exams. It is also interesting to note that the PISA gender pattern becomes rather different when the students answer questions on a computer-based questionnaire, as they do in the so-called Computer-Based Assessment in Science (CBAS) version. In this test, the boys

actually outperformed the girls in science (OECD, 2010b). This is an indication that also the context and the mode of data collection influence the results to a significant degree. From PISA2015, the whole test was digital, and most countries used this version.

The “authentic texts” which constitute the stimulus in each item have originated in a certain situation in one of the OECD countries, and, of course, in the language of that country. This text is then, as mentioned, translated into the two official PISA languages before submission to PISA. The item is then translated into the language of each of the participating PISA countries. This translation process follows very strict rules that are laid down in detailed instructions (see, e.g. OECD, 2009).

Item translation raises many questions. Thorough work on the PISA reading test items has been done by Arffman, in her PhD (2007) as well as in journal papers (2010). She provides a detailed text-analytical study of the translation from English to Finnish of three PISA items. Her study reveals many critical dimensions in this process. One of her conclusions is that one can never arrive at what may be called “equivalence of translation”. She also notes the scarcity of research on this most important issue. Neither poetry nor good prose can be translated according to a formalised set of rules, a fact that all good translators will acknowledge.

But even where the quality rules should have been followed, strange translations do appear. There seems to be a lack of empirical studies to look into this very important aspect of PISA (and TIMSS, PIRLS, etc.) testing. The key role played by these texts in PISA makes such a scrutiny very important. A thorough cross-national check of translation requires a cooperation of researchers from many countries, and with considerable linguistic skills as well subject matter knowledge.

But some languages lend themselves to rather easy comparisons, even for non-linguists. The three Scandinavian languages provide good examples. Swedish, Danish and Norwegian are very similar languages, in fact more like dialects, in part with a common literary tradition. Below follows a simple comparison, based on one single item.

Item translations: an example

The item about the cloning of the sheep Dolly is probably the best known PISA item, since it was released in 2006. The stem text of the original, in English, is reproduced in Figure 4.

S128: Cloning

Read the newspaper article and answer the questions that follow.

A copying machine for living beings?

Without any doubt, if there had been elections for the animal of the year 1997, Dolly would have been the winner! Dolly is a Scottish sheep that you see in the photo. But Dolly is not just a simple sheep. She is a clone of another sheep. A clone means: a copy. Cloning means copying 'from a single master copy'. Scientists succeeded in creating a sheep (Dolly) that is identical to a sheep that functioned as a 'master copy'. It was the Scottish scientist Ian Wilmut who designed the 'copying machine' for sheep. He took a very small piece from the udder of an adult sheep (sheep 1).

From that small piece he removed the nucleus, then he transferred the nucleus into the egg-cell of another (female) sheep (sheep 2). But first he removed from that egg-cell all the material that would have determined sheep 2 characteristics in a lamb produced from that egg-cell. Ian Wilmut implanted the manipulated egg-cell of sheep 2 into yet another (female) sheep (sheep 3). Sheep 3 became pregnant and had a lamb: Dolly. Some scientists think that within a few years it will be possible to clone people as well. But many governments have already decided to forbid cloning of people by law.

Question 1: CLONING

Which sheep is Dolly identical to?

- A Sheep 1
- B Sheep 2
- C Sheep 3
- D Dolly's father

Question 2: CLONING

S128Q02

In line 14 the part of the udder that was used is described as "a very small piece". From the article text you can work out what is meant by "a very small piece".

That "very small piece" is

- A a cell.
- B a gene.
- C a cell nucleus.
- D a chromosome.

Figure 4. The English original text and two questions for the item "Cloning". Reproduced exactly as it appeared in the student's questionnaire. (http://pisa.nutn.edu.tw/download/sample_papers/PISA_RelItems_Sc_en.pdf), retrieved March 10th 2017)

Based on this English (and the French) original, the three Scandinavian texts (available from the national PISA web sites) were translated, presumably according to the detailed rules and instructions given by PISA. The most striking and immediate

observation is that the three Scandinavian texts become strange and clumsy. In fact, they cannot be called “authentic texts” as they appear in the test. Equally important is that the resulting 3 versions are rather different from each other, and they have all changed the original in rather dramatic ways. In brief:

- The Swedish, Danish and Norwegian texts changed the word “nucleus” to become “cell nucleus”, and thereby providing the hint to that the “small piece” in question 2 is indeed a cell.
- While the English (and Swedish) texts states that he removed “the material that would have determined sheep 2 characteristics...”, the Danish texts states that “he removes the *genetic* material”, thereby changing the meaning in the sentence as well as introducing a science concept that does not appear in the original.
- In the Norwegian version “*all material* is removed from the egg-cell”, which makes the sentence more or less meaningless.
- The Danish text altered Question 1, and asks “Which sheep in Dolly a *copy* of?” (Probably because they find the word *identical* problematic, which is, indeed true.) The Danish version is also more in line with the title of heading in the text. “A copying machine for living things”. (This way of talking and writing about cloning is actually never used in any Nordic language, probably not in other languages either?)

PISA reports assert the readers that it has top quality in translation processes as well as in all other aspects of its work:

As in PISA 2003, one of the most important quality control procedures implemented to ensure high quality standards in the translated assessment materials consisted in having an independent team of expert verifiers, appointed and trained by the consortium, verify each national version against the English and French source versions. (OECD 2009, p. 91)

The procedures for this translation control is then described in detail. The “translation equivalence across PISA countries” is also thoroughly discussed in Grisay et al (2007). In the light of this, it is rather surprising that big blunders can be discovered by just a cursory look at published items.

Even a hasty reading by non-experts show that the translated texts are put in a strange and awkward prose that one cannot find published in any Scandinavian publications. Such texts cannot possibly be called “authentic”. Arffman (2010) notes that bad translations may also cause the readers to lose interest and motivation to get engaged with the text, and that this may severely have a negative effect on the tests results. This effect is likely to be higher in countries where students are critical, independent and unwilling to obey the authority of schools and the teachers. This point about students’ motivation and willingness to engage in the whole exercise is elaborated elsewhere (Sjøberg, 2007).

The PISA test as a “real life” situation?

As noted, the basic claims of PISA is that they test how well young people are “prepared for future challenges”, whether “they can analyze, reason and communicate effectively”, whether they have “the capacity to continue learning throughout life? And to what extent they have acquired some of the knowledge and skills essential for full participation in society”.

These ambitions are great, but are directly contradicted by the very format of the testing: The PISA test is a pen-and-paper test, where students sit for 2½ hours to answer written questions, in solitude and without access to sources of information. (From PISA2015, the test is digital in most countries.) How “real life” is this test situation? How does it relate to the challenges that young people may face in their future life as citizens, as participants in tomorrow’s democracy and as skilled workforce? Put in this form, the above questions are rhetorical: the PISA test situation does *not* resemble any real life situations. The only place where you sit in solitude with a test is in fact in exams at schools and universities. The only places where you are not allowed to communicate or allowed to use modern web-information technologies are similar test situations.

Real life, in private, at leisure as well at the workplace, is more or less the opposite of the PISA test situation. While one should expect that an organization like OECD should stress the competencies needed by the big international actors on a competitive global market, the PISA test situation is different. Therefore, PISA does hardly live up to serve the political/economical goals of OECD.

Test scores and economic prosperity

It may sound “common sense” that high scores on science and math tests at school are good predictors of future economic prosperity. The assumed strong connection between scores on tests like TIMSS and PISA and the economic competitiveness of the country is a core assumption behind these studies. As noted earlier in this article, bad rankings on PISA are thought to be bad signals for the future of the country. This assumption is probably the main reason for the extreme importance that is given to PISA results and rankings. PISA is in fact, “sold”, presented and understood in this perspective, as also noted earlier.

But this “common sense” assumption may now be studied empirically. In January 2013 *New Scientist* brought an article with the heading *West vs Asia education rankings are misleading*.

For developed nations, there is scant evidence that TIMSS rankings correlate with measures of prosperity or future success. The same holds for a similar test, the Program for International Student Achievement (PISA). [...]An analysis of 23 countries found a significant **negative** relationship between 2009 PISA scores and ranking on the Global Entrepreneurship Monitor’s measure of perceived entrepreneurial capabilities. (MacGregor Campbell, *New Scientist Magazine* 07 January 2013)

Among the references in the above article is a study by Tienken (2008), who has used a series of indicators for a countries' economic competitiveness and prosperity and seen how these correlate with scores on international tests of TIMSS (data since early 1960's) and PISA (since 2000).

Such studies are most interesting, since they undermine the fundamental premise behind PISA. Further studies of the connections between national test scores and economic prosperity are likely to shed more light on this important issue. Such statistical studies may be supplemented with studies undertaken by the actors on the market. Two examples are given below.

Competencies for the future: the voice of employers

There are many sources that provide qualified accounts of the skills and competencies that large employers in the high-tech sector require from its workforce. At the Official Bologna Seminar in 2008 on "Employability: the Employers' Perspective and its Implications" Dr. Frank Stephan Becker, head of Human Resources in Siemens, gave a presentation of his company's view on what competences they need from their employees. He presented the following list:

Professional competence – Vital skills for today's employees:

- Thorough knowledge of one's subject
- Ability to judge analytically, structure one's work, make "plausibility checks", carry out research, evaluate information and identify problems
- Ability to look beyond one's own area of competence and take other factors into account
- Independence, initiative, independent learning, work techniques, discipline, frustration tolerance, ability to set priorities
- Interpersonal skills: communication, feedback, a feeling for situations, capacity for teamwork, fluent English

Siemens AG is the largest Europe-based electronics and electrical engineering company. Siemens and its subsidiaries employ approximately 360 000 people across nearly 190 countries. One may easily see that most of the competencies on the above list are not addressed by the PISA test.

The second example is an investigation done by the Abelia, the Business Association of Norwegian knowledge and technology based enterprises. Based on a survey among 500 leaders in the most competitive sector of the Norwegian economy, they ended up with the following ranking of competencies for future leaders and key personnel.

Competencies for future leaders and key personnel:

- Good communication skills
- Sense for strategic thinking
- Ability to motivate

- Concern for staff and co-workers
- Self-confidence and self-efficacy
- Solid educational background
- Visionary
- Understanding numbers and quantities

As one can readily see, the two examples stress similar competencies, but they are hardly addressed in the PISA testing. It is interesting to note, however, that the perspectives expressed from high-tech industry in many ways coincide with the purposes and aims of schooling in many modern democracies, and they are also in line with many aspects of “progressive pedagogy”. Advice based on PISA results may, in fact be counterproductive even for companies that operate on the competitive global market.

Problematic statistics and lack of transparency

The PISA project is a large undertaking. It has many of the characteristics of what is called “Big science” and “techno-science”: it is costly; it involves the cooperation of teams from around 70 countries. The logistics of the project is complicated, and there are piles of documents with detailed instructions to the national groups who are responsible in the participating countries. Hundreds of experts from several fields of expertise are involved, contracts with subcontractors are given by bids, thousands of schools and teachers, nearly half a million of students spend 2½ hours answering the test and the questionnaire, data are carefully coded by thousands of specially trained markers etc. etc.

Some of the many problematic issues in the process from intentions to test items have been raised in above. But there are more issues that are problematic. The final test consists of items that are selected in the process previously described. These items constitute around 10 hours testing time in order to provide sufficient coverage of all dimensions of the assessment framework.

The booklets that are answered by the students are not identical. A system of “rotation” of items means that the students answer several different booklets. In this way, PISA can include a larger number of items in their test. After the time-consuming and tedious coding and data entry process, the data are submitted to the international testing agent and undergo complicated statistical analysis. The statistical process that lead from actual responses to these numbers is based on Item response theory (IRT) and Rasch modeling. Moreover, the final overall scores are normalized to provide an international mean score of 500 with a standard deviation of 100 for the OECD as a whole. These standards were established in the first phases of PISA, and through so called “bridge items” that are repeated from one round to the next, one can calculate absolute scores that may be compared over time. The OECD mean score for science in PISA 2015 was actually 493, down from 500, which was set as the standard in PISA 2006, when science

was the core subject for the first time (OECD, 2007). It is important to understand that the research design implies that results can only be given at the population (or sub-population) level. Results for the individual student or school are not, and cannot, be given. PISA is therefore “high-stakes” testing only at the national level.

The road from the actual responses to the final numbers in the publicly available tables is long and not very transparent, even for statisticians and well informed readers. The methods have also been criticized by well qualified statisticians, also among those who actually work on PISA data. Svend Kreiner, professor of biomedical statistics at Copenhagen University, argue that he can get Denmark up to a PISA rank number 2 or down to rank 42 by changing some of the parameters in the complicated statistical analysis. He also notes that the PISA methods of statistical calculations only are published in a very general form, making detailed critique difficult (Kreiner & Christensen, 2013).

When looking at the actual country mean scores on PISA, one may notice that the majority of the OECD countries are in middle group, with rather small and not even statistically significant differences in means. If it was a bike race, one would have said most countries came in the “peleton”, and got the same time. In fact, rather small changes in total PISA score can shift the country’s ranking considerably, as also Kreiner and Christensen (2013) demonstrated.

Moreover, the uncertainty in mean PISA-score is substantial. Some of this is, of course, the measurement sampling error. Additional uncertainties are related to the calculations of the published PISA scores that are based on the test results. As mentioned, the total PISA test consists of some 10 hours testing time, and each student gets about two hours test from this pool. The national PISA score and other population parameters are calculated by using a rather elaborate technique, using Rasch analysis and Item Response Theory (IRT). The assumptions about the properties of data that underlie the use of these techniques are clearly defined. Many psychometrics experts argue that the PISA data do not satisfy these conditions. The calculation method was actually strongly modified in the last round of PISA, causing dramatic changes in scores for some countries.

These uncertainties and possible sources for others errors are not well communicated in the PISA reports. Experts on statistics and psychometry criticise PISA for downplaying the problematic nature of the calculations and the lack of openness regarding sources of error and methodological uncertainties. Experts also criticise PISA reports for drawing unwarranted conclusions, and urge OECD to have “a more measured approach to reporting and interpreting PISA Results” (Rutkowski & Rutkowski, 2016). Some scholars use even stronger words, arguing that PISA is a “tale of flaws and hubris” (Meyer, 2013).

Problematic and intriguing results

The main concern in this article, as apparent from the above, is a critical view on the cultural, political and economic aspects of PISA, and on the overall, basic weaknesses

with the project. But there are also serious concerns that should be addressed, especially by those who embrace PISA and who believe that PISA provides valid data on educational quality and student achievement. The following is an overview of some of these concerns.

Resources and finance has no influence?

Already from the first PISA round, OECD produced graphs and indicators that showed small or negligible correlations between a country's PISA scores and its spending on education (OECD, 2001). This, of course, has led to the OECD advice that more spending on education will not improve the quality.

It is interesting to note that between the five Nordic countries, the relationship between public spending and PISA scores is actually strongly negative. Finland, for instance, is highest in PISA score, but lowest in spending. This finding is used in political debate: Finnish teachers have difficulties in asking for higher salaries and more funding, since they already are on top of the PISA rank. Norway, on the other hand, is lower on the PISA ranking, but with higher public spending per capita on schools. Based on PISA, Norwegian politicians have argued that it has been proved that more spending would not increase the quality of schools. As noted earlier, the OECD (2008) Economic Report to Norway actually warns Norway to increase spending on schools, stressing that "this will not improve the quality". The evidence is PISA-points per dollar spent.

PISA findings on cost and funding, like the above, are frequently used in influential OECD publications, like the annual *Education at a Glance*. They conclude that "averaged across OECD countries, there is potential for reducing inputs by 30.7 % while maintaining outputs constant" (OECD, 2007b, p. 266).

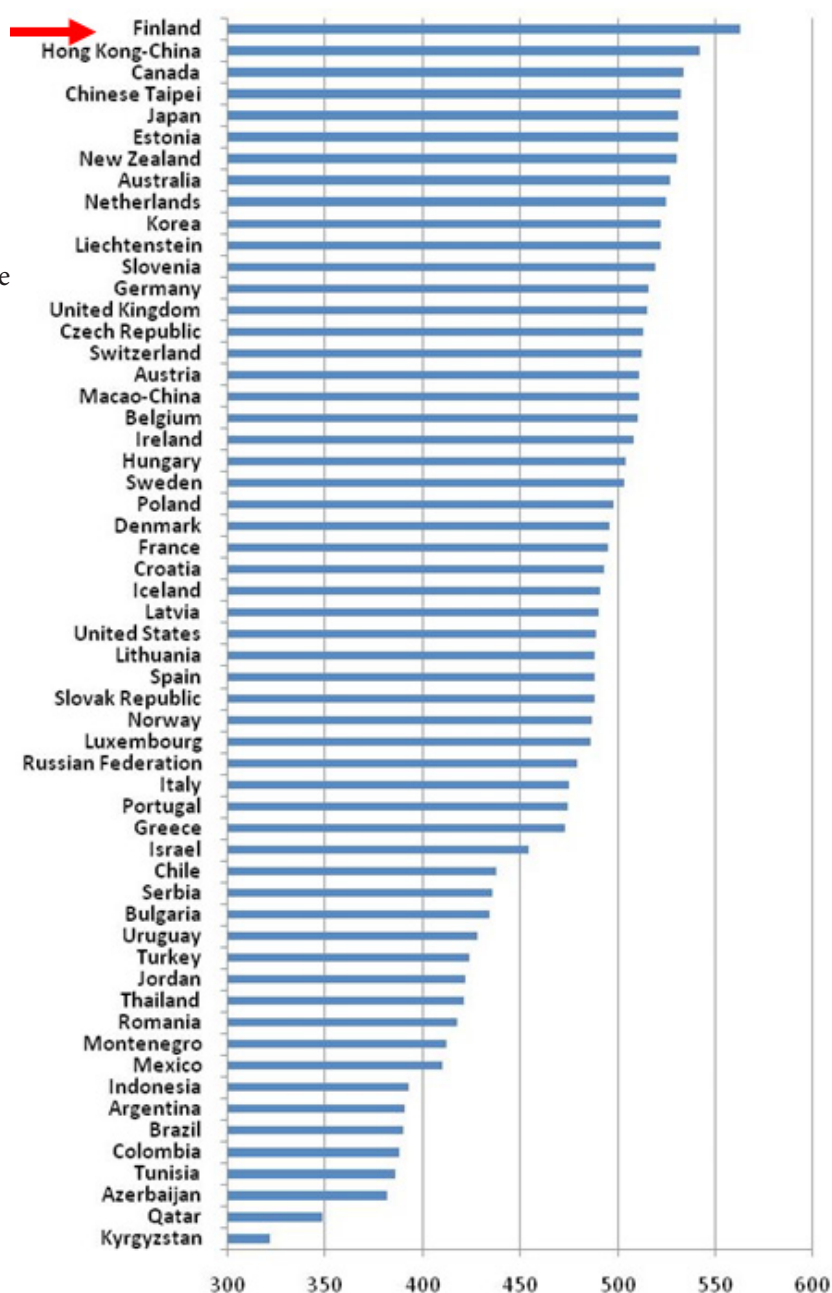
PISA science scores correlate negatively with interest and attitudes

PISA scores are often presented as league rankings between countries, with the winners on top and the losers at the bottom. But PISA also has many questions about attitudinal aspects of how young people relate to science. This was an important element of the PISA 2006 study, when science was the core subject. The definition of science literacy in PISA 2006 actually included "willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen" (OECD, 2006a). The indices and constructs that were developed for this broad attitudinal category were, however, *not* included in the PISA scores that were used for rankings etc. A special issue of *International Journal of Science Education*, (2011), 33(1), presents several interesting results from analysis based on these data.

The simplest and possibly most surprising finding is that many countries with the highest mean PISA science score were at the bottom of the list of students' interest in science (Bybee, & McRae, 2011). Finland is a prime example: at the top on PISA science score, and at the very bottom on constructs like "interest in science", "future-oriented motivation to learn science" as well as on "future science job", i.e. inclination to see themselves as scientists in future studies and careers (see figure 5). In fact, the PISA

science score correlates negatively² with *Future science orientation* ($r = -0.83$) and with *Future science job* ($r = -0.53$) (Kjærnsli & Lie, 2011).

Finland:
Highest science
score



² It should be noted that the above negative relationships are when *countries* are the units of analysis. When *individual students* within each country are the units, some of the correlations are positive. The unjust statistical inference from differences between groups to individual differences is actually labeled “ecological fallacy”.

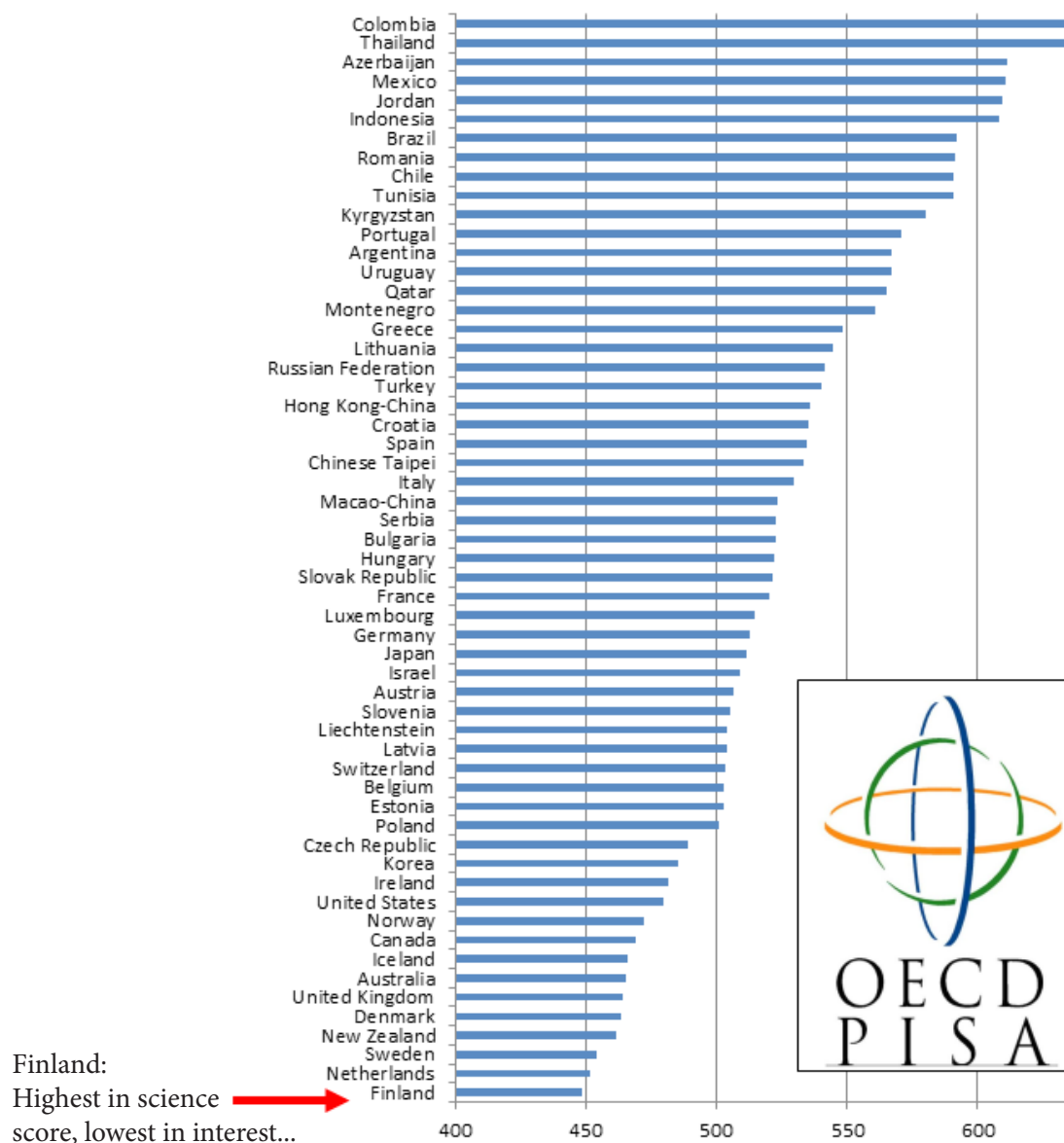


Figure 5. Finland came out on top of the PISA test score in 2006, when science was the core subject. The same students came out at the very bottom on the “Interest in science” score.

Such findings are most disturbing. If the students in PISA top ranking countries leave compulsory school with strong negative orientations towards science, one need to step back and think about the reasons for this as well as the possible consequences. Of course care should be taken not to interpret correlation with cause and effect, but one should at least think twice before using these countries as educational models and ideals to be copied.

In an analysis of the recent PISA2015-data Zhao (2017) points out that students in the so-called PISA-winners in East-Asia (e.g. Japan, Korea, Hong Kong, Singapore) seem to suffer from what he calls “side-effects” of the struggle to get good marks and

tests-scores. He presents the PISA-data that show that students in these countries have very low self-confidence and self-efficacy related to science and mathematics. He points out that

There is a significant negative correlation between students' self-efficacy in science and their scores in the subject across education systems in the 2015 PISA results. Additionally, PISA scores have been found to have a significant negative correlation with entrepreneurial confidence and intentions. (Zhao, 2017, p.13)

It is also interesting to note that many of the winners in the PISA science score also have the largest gender differences in PISA score. Finland is again a prime example, where girls outperform boys on all three subjects in PISA subjects. In reading literacy, the difference in means is about 50% of a standard deviation. Again, such findings from PISA should call for some caution against trying to copy the "PISA winners".

PISA and Inquiry-based science education (IBSE)

The concept of science as inquiry has a long history (Flick & Lederman, 2006). In recent years it has again been lifted as if it was a newcomer. IBSE is now an acronym and a slogan, and inquiry-based science education is the key recommendation in the influential EU-document "Science Education Now", the Rocard-report (EU, 2007). The term IBSE has been adopted as the key concept in calls for EU-funding in FP7 as well as for the current Horizon 2020-programme. It also plays a major role in the recommendations in the International Council for Science reports to the Science Unions world-wide (ICSU, 2006).

In PISA 2015, nine statements in the student questionnaire are combined to an *Index of inquiry-based teaching*. Some of the statements are these: "Students spend time in the laboratory doing practical experiments"; "Students are required to argue about science questions"; "Students are asked to draw conclusions from a experiments they have conducted"; "Students are allowed to design their own experiments" and "Students are asked to do an investigation to test ideas"(OECD, 2016c, p. 69).

Among the interesting findings is that in most of the "PISA-winners" (Japan, Korea, Taiwan, Shanghai, Finland) students report very little use of inquiry-based teaching.

For the variation within the same country, the PISA finding is that "*in no education system do students who reported that they are frequently exposed to enquiry based instruction [...] score higher in science.*" (OECD, 2016c, p. 36).

But, although the relationship between IBSE and PISA test score is negative, IBSE relates positively to interest in science, epistemic beliefs and motivation for science-oriented future careers:

However, across OECD countries, more frequent enquiry-based teaching is positively related to students holding stronger epistemic beliefs and being more likely to expect to work in science-related occupations when they are 30. (OECD, 2016c, p. 36)

One of the questions in the Inquiry Index may be of special interest for science educators. Experiments play a crucial role in science, and have always played an important role in science teaching at all levels. But when it comes to PISA, the report states that: *“activities related to experiments and laboratory work show the strongest negative relationship with science performance”* (PISA, 2016c, p. 71).

Current science education trends and reforms are reviewed by Jenkins (2009). Key concepts and acronyms in current thinking in science education are well known: science in context, inquiry-based science education (IBSE), hands on-science, active learning, NOS (nature of science), SSI (socio-scientific issues), argumentation, STS (Science, Technology and Society). There seems to be no evidence from PISA to back up such advice. PISA rather provides counter-evidence. This possible contradiction should at least be seen as problematic.

PISA score correlate negatively with the use of ICT

PISA has several questions regarding the use of Information and Communication Technology (ICT) in schools, and has made two constructs based on this. One construct or index is related to the use of internet at schools, the other is related to the use of software and educational programs. In a detailed study of the 5 Nordic countries, Kjærnsli et al (2007) document clear negative relationship between the use of ICT and PISA score. It is also interesting to note that the PISA winner, Finland, is by far the Nordic country with the least use of ICT, actually below the OECD average. In contrast, Norway is on top in the OECD in all indicators on the use of ICT in schools, but with only average PISA scores. Nevertheless, the policy advice in Norway is to increase the use of ICT in schools in order to achieve higher.

In a special OECD/PISA report on the use of computers in teaching and learning (OECD, 2015), the highlighted conclusions are strikingly clear (figure 6):

What the data tell us

- Resources invested in ICT for education are not linked to improved student achievement in reading, mathematics or science.
- In countries where it is less common for students to use the Internet at school for schoolwork, students' performance in reading improved more rapidly than in countries where such use is more common, on average.
- Overall, the relationship between computer use at school and performance is graphically illustrated by a hill shape, which suggests that limited use of computers at school may be better than no use at all, but levels of computer use above the current OECD average are associated with significantly poorer results.

Figure 6. The Information Box with highlighted findings from the OECD (2015) report on Students, Computers and Learning.

Intriguing PISA results: Concluding remark

Some of the above problematic results are not difficult to understand. If the final test of quality is score on a test (written or digital), it is no surprise that teaching will be more “cost-effective” if students do not spend time on excursions, experimental work or discussion of socio-scientific issues.

A written test like PISA can hardly measure the skills and knowledge acquired in experimental work in a lab or on an excursion; neither can it capture the kind of interest, curiosity and enthusiasm that may be the result of argumentation, inquiry, and the search for solutions to questions that the students have formulated themselves.

The use of PISA data for policy recommendations is, at best, very selective. If one believes in PISA, one has to take all the results seriously, also those which are counterintuitive and at odds with other research findings and policies that are recommended by scientists as well as science educators.

Critique from academics

In parallel with the increasing global influence of PISA on educational debate and policy, there is growing critique in the academic world. Several anthologies have been published (Hopman et al., 2007; Pereyra et al., 2011; Meyer, & Benavot 2013). The authors come from many countries and many academic fields and include well-known philosophers, sociologists, economist and educators.

In May 2014, a group of these and other academics sent an open letter to Andreas Schleicher, head of PISA and Director for Education and Skills in OECD. In the letter (Meyer et al. 2014) they voice a series of concerns about the growing influence of PISA. They argue that PISA is killing the joy of learning and lead to the detriment of basic values that schools should strive for. This initiative received public attention, also through coverage in *The Guardian* and other news media worldwide. The open letter was later signed by more than 2000 academics from about 40 countries. Behind the initiative are leading educators like Stephen Ball, David Berliner ad Robin Alexander. Noam Chomsky is also behind this initiative, likewise Diane Ravitch, who was previously U.S. Assistant Secretary of Education, appointed to public office by Presidents George H. W. Bush and Bill Clinton. She is now, as distinguished professor of history and philosophy of education, the most influential critic of market-driven education policies she earlier had a strong belief in. She is the author of several publications, among these the influential book *The Death and Life of the Great American School System* (Ravitch, 2011) with the telling subtitle *How Testing and Choice Are Undermining Education*.

It seems fair to say that the criticism of the uses and misuses of PISA now is rather common among most academics concerned about schooling and education. This critique has been fuelled in the past few years, also because PISA is extending its scope and influence in several ways. A further analysis of this development lies outside the scope of this article, but here are some aspects of the development.

PISA, Pearson and the market

PISA has recently established a close cooperation with *Pearson Inc.*, the owner of Financial Times, The Economist, Penguin Group and Dorling Kindersley. Pearson has expanded its activities into the education sector and has become the world's largest company for testing and education programs, with 40,000 employees in more than 80 countries. 80 % of Pearson's revenues now come from education, maybe the world's fastest growing market sector. Pearson won the bid for important parts of the PISA 2015 testing and has developed strong links with OECD. Pearson has, of course, a vested interest in creating a market for its services and products. Through its close partnership with OECD it has come in a good position to expand its market as well as its influence. Diane Ravitch, mentioned above, is concerned about this influence, and expresses it this way: "Are we prepared to hand over our children, our teachers, and our definition of knowledge to Pearson?" (Ravitch, The Washington Post, 7. May 2012).

For the coming PISA 2018, Pearson has got an even stronger grip on PISA. They won the bid for key elements of the whole undertaking. A joint press release from OECD and Pearson proudly announces that

Pearson, the world's leading learning company, today announces that it has won a competitive tender by the OECD to develop the Frameworks for PISA 2018. [...] The frameworks define what will be measured in PISA 2018, how this will be reported and which approach will be chosen for the development of tests and questionnaires." (Joint Press release PISA/OECD and Pearson, Dec 10th 2014)

This key role in PISA does, of course, not mean that Pearson's staff will do the work. But they will organize and administer the process. Pearson will continue to forge personal links with countless academics in key positions and the numerous representatives for national educational authorities. This contract is of course a most valuable investment for Pearson. The cooperation is already in place for several bi-products, like a video series about "Strong Performers and Successful Reformers in Education" (<http://www.oecd.org/pisa/pisaproducts/>).

It should also be noted that Andreas Schleicher, Director of the OECD Directorate for Education and Skills and head of PISA is also on the Advisory Board of Pearson. He is, among several things, also strongly involved in the Pearson initiative called *The Learning Curve*, where the main "product" is a ranking of the quality of educational systems, based on several data sources (PISA, TIMSS, PIRLS, PIAAC etc.). This ranking, often published well timed between the PISA reports, gets a lot of attention by the media, and also by politicians, who often get alarmed when their country is lower than they expect or when they move down on the rankings. Pearson is also involved in Brazil, as an article from Financial Times explains (see figure 7).

Pearson buys Brazilian school chain

- Pearson ... currently receives more than four-fifths of its sales and operating profits from Europe and North America, and is **aiming to increase its presence in emerging markets.**
- Pearson’s involvement in the country at a time when many multinationals are nervous about Latin America’s biggest economy’s stalling economic growth and **interventionist centre-left government.**
- <http://www.ft.com/cms/s/0/3a9a601a-5bf2-11e3-931e-00144feabdc0.html#axzz4lu2x3yPY>



Figure 7. Financial Times article about Pearson’s actions in Brazil.

PISA itself is also widening its repertoire. With a new product, the “**PISA-based Test for Schools**”, individual schools or school districts may get “*information and analyses [...] comparable to existing PISA scales.*” (<http://www.oecd.org/pisa/aboutpisa/pisa-basedtestforschools.htm>, accessed 13 March 2017). This, of course, may create an enormous market, and also bring competition, testing and rankings even closer to the daily activities in schools. The PISA influence on local education policy will also be stronger. The PISA-based test for schools is a commercial product.

As mentioned, PISA is constructed to be used by the highly industrialized OECD countries, but has already some 30+ non-OECD participants. But OECD wants an even further development of PISA, and has launched a “PISA for Development” version. This is presented as “*PISA survey instruments that are more relevant for the contexts found in developing countries but which produce scores that are on the same scales as the main PISA assessment.*” (<http://www.oecd.org/pisa/aboutpisa/pisafordevelopment.htm>, accessed 13 March 2017). Many countries have already shown interest for this project, and many are already launching their version.

With its PISA for Development, OECD is widening its influence over education in developing countries. Such a test will provide standardized definitions of worthwhile skills and knowledge that are measurable and common for developing countries, independent of their culture, traditions and natural resources and local challenges. Such scores will be seen as “benchmarks” and objective measures of quality by both development aid donors and national authorities. OECD may thereby push aside the influence of UN-

organizations like UNESCO and UNICEF, which may have rather different priorities than those of OECD. It is interesting to note that PISA for Development has close links with these organizations as well as with The World Bank.

While PISA has 15-year olds as target population, an emerging OECD project has been labeled “PISA for adults”: Programme for the International Assessment of Adult Competencies (PIAAC). Results from the first full-scale data collection in 24 countries were published in 2013 (OECD, 2013c), and the programme is likely to increase its importance, also for the sector of higher education and training. (<http://www.oecd.org/site/piaac/>, accessed 13 March 2017).

Winding up

International comparisons in education are important; they can open for new perspectives, and they can provide inspirations and ideas for educators, researchers and policymakers.

However, international comparisons have a kind of Janus face; they can be understood and used in two opposite ways. Such studies may be eye-openers to acknowledge and celebrate the great variety between youth, nations and cultures on aspects of education, and as such serve as a source of inspiration. But such studies can also be used normatively, providing a pressure to oblige and fit to allegedly universal and common standards set from the authority of external specialists. We experience what is seen as a prime example of New Public Management (Møller & Skedsmo, 2013) as well as a kind of global governance and standardization of education, as also noted by key educational experts (Ball, 2012; Rinne, 2008). As indicated above, academics from several disciplines have raised concerns about various sides of the PISA undertaking, and OECD acting like a global ministry of education. The open letter, signed by a large number of leading academics and school leaders is also a sign of a growing concern about how PISA is used to overrule national and local priorities in education.

The official intentions of PISA, as cited earlier in this article, can easily be endorsed. No one can disagree with the need to ascertain that young people develop the knowledge, skills and competencies needed to face the challenges as citizens of the future. But the underlying economic and political ambitions behind the OECD-driven PISA project are often ignored or under-communicated. Even researchers in the PISA project seem not to realize (or accept) the overall political/economic aspects of the project.

The inherent difficulties in measuring what PISA asserts that it measures are seldom realized. The road from the brave intentions to an actual test instrument and valid data is long and murky. This article has pointed to some of the problematic issues in this process. This relates to the selection of subjects, (and of ignoring other subjects). Fundamental problems are also inherent in the development of an international, fair test, which by necessity leads to context-free items. Further complications arise when items are to be translated to other languages. In this article and elsewhere (Sjøberg,

2007) I argue that it is not just problematic to live up to the intentions laid down in the overall statements of PISA. I argue that it is in fact “mission impossible”.

The public, media and policy makers, however, often take the PISA numbers and rankings as given facts. They trust that the experts know what they do, and that the numbers are objective and neutral measures. They trust that PISA scores measure what the intention has been.

No test is better than the items it consists of. The secrecy over most PISA items makes critique and scrutiny from the academic community and even the public difficult. Many of the published PISA items have met serious critique, both for its contents and for its language and relevance. Translations into the many different languages have only to a limited degree been examined, but it is easy to find flaws and even substantive changes and mistranslations. More research is needed here.

The problematic use of statistics should also be examined. Similarly, there seems to be little attention to the fact that many of the results of PISA are at odds with what educators recommend as well with what politicians propose as medicine to improve the quality of schools. Many politicians want to copy the PISA winners, but to do so, they often prescribe measures that are the opposite of what these winners actually do. There is a need to address seriously these paradoxical results. If one really believes in PISA, one has to accept and to address also some of these intriguing findings.

PISA has a profound influence on educational policy in many countries, and this indeed the intention behind the project. It is, however, obvious that PISA results are used selectively, misused and even distorted for political purposes in many countries. The reference to PISA to justify and legitimize educational reforms is widespread. This influence ought to be better researched and scrutinized. PISA is in essence a political project, a perspective that often falls outside the agenda of the educational research community.

The recent expansion of PISA into schools and school districts, adult education and education in developing countries needs to be followed with great concern, likewise the close connection between PISA/OECD and global, commercial actors like Pearson.

Large resources are used to run the PISA project and to produce their reports and publications, but critical research is scarce and not well funded. A key aspect of the academic ethos is to provide a critical voice, and to question and challenge conventional wisdom. Given the great political and educational importance of PISA, there is a strong need for critical and independent research.

In many countries, increasing the PISA-score has been officially stated as a prime goal for the nation and its schools. This is also the way OECD uses PISA data as indicator and standard for quality. Given the above examples, the obvious way to increase test scores will be to abandon the kind of teaching that the science community as well as the science education community recommends. Not only because it mirrors “authentic science”, what it means to do science, but also because it promotes motivation, recruitment and lasting interest in science.

The alternative to strive for higher PISA-score is to warn against the current celebration of PISA scores and rankings as valid measures for the quality of the school in general and school science in particular. This rejection should be based on a thorough knowledge of the details and limitations of PISA. In any case, scientists and educators should address the problematic findings of PISA in an informed and critical way.

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