

THE ROLE OF COGNITIVE SKILLS ACCUMULATION ON EDUCATIONAL QUALITY AND ECONOMIC GROWTH

BİLİMSSEL YETENEK FORMASYONUNUN EĞİTİM KALİTESİ VE EKONOMİK BÜYÜMEDEKİ ROLÜ

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Abstract

This paper inquires ‘outcomes’ in education quality by focusing on issues related to cognitive skill development. Cognitive skills, which include literacy and numeracy, are defined as the “ability to understand complex ideas, adapt effectively to the environment, learn from experience, and reason” (The World Bank, 2017). UNESCO (2005, p.2) mentions the importance of cognitive development as “the major explicit objective of all education systems” and as one of the principles of defining quality in education. The first section of this paper will elaborate on the role of cognitive skills within the purpose and quality of education, followed by a section on teacher quality, and early childhood education since an amalgam of research states both factors having a significant statistical impact on cognitive skill formation (HW, 2015; Cunha& Heckman, 2017; Dahmann, 2015). The paper will conclude by touching issues regarding measurement and research gaps. There are several factors which enhance cognitive skill formation, and the aim of this research is not about assessing importance/relevance weights on specific factors; instead, it is an inquiry on the lack of cognitive skills within education quality.

Keywords: Educational Quality, Economic Growth, Cognitive Skills

JEL Codes: A12, A20, I25

Öz

Bu makale biliřsel beceri geliřimi ile ilgili konulara odaklanarak eğitim kalitesindeki “ıktıları” arařtırmaktadır. Okuryazarlık ve sayısal bilgiyi içeren biliřsel beceriler, “karmařık fikirleri anlama, çevreye etkili bir şekilde uyum saęlama, deneyimden ve akıldan öğrenme” řeklinde tanımlanmaktadır (The World Bank, 2017). UNESCO (2005, s.2) biliřsel geliřimin “tüm eğitim sistemlerinin temel açık hedefi” ve eğitimde

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kaliteyi tanımlamanın ilkelerinden biri olduğunu vurgulamaktadır. UNESCO (2005, s.2) bilişsel gelişimin “tüm eğitim sistemlerinin temel açık hedefi” ve eğitimde kaliteyi tanımlamanın ilkelerinden biri olduğunu vurgulamaktadır. Bu makalenin ilk bölümü, bilişsel becerilerin eğitimin amacı ve kalitesi içindeki rolü üzerinedir. Araştırmalar, bilişsel beceri formasyonu üzerinde bir istatistiksel etkiye sahip faktörleri belirttiğinden (HW, 2015; Cunha ve Heckman, 2017; Dahmann, 2015) sonraki bölümler öğrenci kalitesi ve erken eğitim üzerinde tartışacaktır. Rapor, ölçme ve araştırma boşlukları ile ilgili konulara dokunarak sonuçlandırılacaktır. Bilişsel beceri oluşumunu geliştiren birkaç faktör vardır ve bu yazının amacı belirli faktörler üzerindeki önem ağırlıklarını değerlendirmek değildir; bunun yerine, eğitim kalitesi dahilinde bilişsel becerilerin eksikliğine dair bir soruşturmadır.

Anahtar Kelimeler: Eğitimin kalitesi, ekonomik büyüme, bilişsel beceriler

Jel Kodları: A12, A20, I25

1. Introduction

“Education is pre-eminently a matter of quality, not amount.”

(Ford, 1922, p.2)

What does quality mean in the context of education? Given “education is a normative field” with various quality judgments (Besley, 2009, p. 214), several definitions of education quality exist (UNICEF, 2000; UNESCO 2005; Jain & Prasad, 2017). Within those definitions, terminologies such as efficiency, effectiveness, and equity are used interchangeably (Adams, 1993), revealing the multifaceted nature of this concept. In layman terms, quality of education can be viewed as “the investment and consumption value of the education” (Ladd & Loeb, 2013, p.5). While the investment part of it indicates better earnings and health, democratic participation, and other outcomes due to education, the consumption part captures the enhancement of the lives of children and their families (Ladd & Loeb, 2013).

UNESCO (2005, p.7)’s framework based education quality on four interwoven pillars: “learner characteristics, enabling inputs, context, and outcomes.” This paper inquires ‘outcomes’ in education quality by focusing on issues related to cognitive skill development. Cognitive skills, which include literacy and numeracy, are defined as the “ability to understand complex ideas, adapt effectively to the environment, learn from experience, and reason” (The World Bank, 2017). UNESCO (2005, p.2) mentions the importance of cognitive development as “the major explicit objective of all education systems” and as one of the principles of defining quality in education. The first section of this paper will elaborate on the role of cognitive skills within the purpose and quality of education, followed by a section on teacher quality, and early childhood education since an amalgam of research states both factors having a significant statistical impact on cognitive skill formation (HW, 2015; Cunha & Heckman, 2017; Dahmann, 2015). The paper concludes by elaborating on issues regarding measurement and research gaps. There are several factors which enhance cognitive skill formation, and the aim of this research is not about assessing importance/relevance weights on specific factors; instead, it is an inquiry on the importance of cognitive skills within education quality.

2. Role of Cognitive Skills within the Purpose and Quality of Education

Quality education refers to “the investment and consumption value of the education” (Ladd &Loeb, 2013, p.5), and returns such as economic growth and human well-being (Altınok & Aydemir, 2017). There is not a unified definition of the purpose of education given the plurality of ontological positions and epistemological worldviews held by scientists (Ammons, 1964; Dewey, 1934; Foshay, 1991), along with different political ambitions of governments (Yiannouka & Mouhyi, 2018). Bitesta (2008) however brings an amalgamated approach and states that the purpose of education is a function of “qualification, socialization, and subjectification” (p.39-40). Through education, qualification part refers to the knowledge and skills accumulated; socialization is on citizens being a part of “social, cultural, and political orders” (p. 40); and subjectification is about characteristics which make individuals distinct amongst others in society.

Hanushek& Woessmann (2007) (hereafter HW) state that cognitive skill development is a significant notion within the purpose of education and its quality. Main reason issues of low cognitive skills have been omnipresent for long is due to both policymakers and scholarship viewing school attendance as a mere variable to measure the value, quality and the impact of education (Mincer,1974; Barro & Sala-i-Martin, 2004). Hence, education systems with a mere focus on participation and a lack of emphasis on institutional, curricula and teacher quality brought an exogenous negative impact to the outcomes of the education provided, that being lack of cognitive skills (HW, 2007; 2008; 2015). Hanushek and Kinko (2000) were the first ones to incorporate international student achievement exams testing students’ numeracy and literacy skills, thus their cognitive abilities, such as PISA, TIMMS, and PIRLS (See Table 1), as an education quality measure to test its impact on the widely-acclaimed benefits of education such as inclusive income per capita growth and increase in living standards. These results were further corroborated in HW’s (2008; 2012a; 2015) studies where results show that education quality, hence cognitive skills measured by PISA, TIMMS, and, PIRLS account for 78% of the variation in per-capita income growth. One major reason on why HW (2008)’s work has resonated well within academia was that their bi-variate regression framework suggests that school attainment does not explain the variation in per-capita income growth. This finding has resulted in vociferous debates within academia given the wide-spread usage of school attainment figures to explain the impact of education on income and human-wellbeing (Jackson, Johnson, & Persico, 2017; Bretton, 2011). Although discussions on the impact on school attainment on economic growth remain vigorous, there seems to be consensus behind the notion that cognitive skills accumulation of a nation explains the per-capita income variations across countries (Bretton, 2011).

Table 1. International Student Achievement Tests Comparison Table

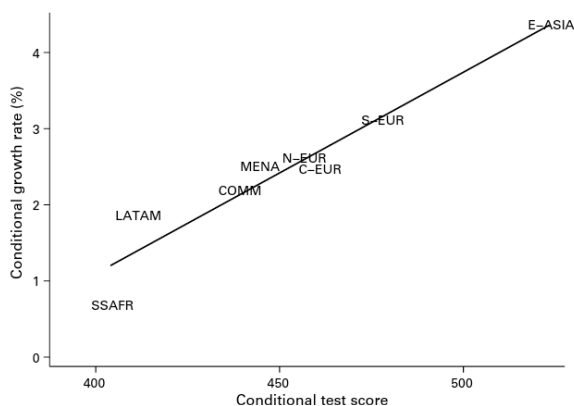
	PISA (OECD, 2016)	TIMMS (Mullis et al., 2012)	PIRLS (Mullis, 2012; Martin et al., 2017)
Name	Program for International Student Assessment	Trends in International Mathematics & Science Study	Progress in International Reading Literacy Study

Organization	Organization for Economic Co-operation and Development (OECD)	International Association for the Evaluation of Educational Achievement (IEA)	International Association for the Evaluation of Educational Achievement (IEA)
Assessment	Reading, mathematics, science, problem-solving	Mathematics & science	Reading
Age	15	10 and 14	10
Purpose	Evaluates education systems on what extent students at can apply their knowledge to real-life situations and be equipped for society.	Measures trends in mathematics and science. Describes educational context, students' attitudes, curriculum, teachers' training.	Measures trends in reading comprehension. Investigates the experiences young children have at home and school.
Focus	Skills-based	Curriculum-based	Curriculum-based
Countries	72	57	50

Source: Watts, A. (2017). International surveys TIMSS, PISA, PIRLS (pp. 1-5, Issue Brief No. 692.056.5690). Cambridge Assessment International Education, p.2

The main reason behind HW (2008)'s contention on school attainment's impact on achievement is that a year of education in low-performing countries in international assessments would not yield the same returns in juxtaposition to the high-performing countries. In their recent book, HW (2015) make an extensive review on the plight of Latin American (hereafter LATAM) countries, particularly Mexico and the rise of East Asian countries such as Singapore, South Korea, and Japan. Authors state that in 1960, LATAM countries had higher school attainment figures and per capita income than both East Asian and the Middle East and North African (hereafter MENA) countries. Today, East Asian countries moved significantly ahead of LATAM countries concerning economic growth and per-capita income; LATAM countries fell even behind of MENA countries, sharing the bottom ranking with sub-Saharan African countries. As shown in Figure 1, low level of cognitive skills appears to explain the poor per-capita growth rates of Latin America and the high-performance levels of East Asian countries.

Figure 1. Cognitive Skills and Economic Growth Rates Across the World³



Source: Hanushek, E., Woessmann, L., (2015). The Knowledge Capital of Nations. Education and The Economics of Growth. The MIT Press, Cambridge, MA, p.4

3 Y variable: Real GDP per capita between 1960-2009. X variable: Average test scores on international student achievement tests

The plight of LATAM countries, with a significant focus on Mexico, is a subject that is highly inquired in social sciences (HW, 2012b). In their famous book *Why Nations Fail*, Acemoglu & Robinson (2013) (hereafter AR) highlight a town called Nogales in which the territory is shared between the United States and Mexico, divided with nothing but a mere fence. While Nogales, Arizona benefits from high per-capita income, stable infrastructure, efficient health care services, Nogales, Sonora in Mexico averages 1/8th of the income of the other side of the fence and battles with corruption and crime issues. AR state the reasoning of this perplexing issue with their renowned term of ‘inclusive institutions,’ defined as “those that allow and encourage participation by the great mass of people in economic activities that make best use of their talents and skills and that enable individuals to make the choices they wish” (Acemoglu& Robinson, 2013, p. 74).

To test both HW (2015) and AR (2013)’s claims, GDP growth rates of Mexico and the US between 1950-2014 were analyzed using data from version 9.0 of Penn World Tables (Feenstra, 2015; Zeileis, 2017). Calculations were made based on Solow (1956)’s Growth Model using Brumm (1956)’s derivations to account for human capital augmentation. As seen in Table 2, a significant share of US’ economic growth (40.16%) came from their human capital, which is the accumulated cognitive skills of a nation (HW, 2015), and total factor productivity, which simply put is growth from technological progress, also caused by education (Mankiw et al., 1992). On the other hand, Mexico heavily relied on growth from physical capital — tangible and fixed goods such as machinery and buildings (Samuelson & Nordhaus, 2010) — and labor force participation with a high rate of 83.90%. Henceforward, differences in where economic growth came from provide further statistical reasoning on the stark contrast between these countries regarding income, living conditions, innovation creation, and educational quality. Even though Mexico’s economy grew 1.21% more on average per annum, it is still behind of the US in almost every indicator of economic and human well-being (OECD, 2018). From thereof, countries that do not base their growth trajectories on the cognitive skills accumulation of their citizens seem to fall behind of countries that do as seen in cross-country analyses of HW and AR and results shown below. This is why the existence, importance, and preeminence of issues regarding low cognitive skills have also been recognized by international bodies such as the United Nations (2015) as they have made quality education a goal, and cognitive skills formation a target of their Sustainable Development Goals 2030.

Table 2. Mexico and the US’ Economic Growth Accounting: Human Capital Augmented Model

	Mexico	United States
GDP Growth Rate	4.32 %	3.11 %
Labor Input Contribution	1.38 %	0.73 %
Total Factor Productivity(TFP) Contribution	0.27 %	0.90 %
Human Capital Contribution	0.42 %	0.36 %
Physical Capital Contribution	2.25 %	1.12 %
Growth from Labor& Physical Capital	83.90%	59.37%
Growth from Human Capital & TFP	16.10%	40.63 %

Equation ¹: $Y(t) = K(t)^\alpha H(t)^\beta [A(t) L(t)]^{1-\alpha-\beta}$

Source: Solow, R. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70(1), 65-94. and Brumm, H. J. (1996). “The Human Capital Augmented Solow Model Revisited.” *Applied Economics Letters* 3(11): 711-14.

1 Total Factor Productivity (A); Physical capital (K); Human capital (H); Labor Force Participation (L); and Productivity-Augmented Labor (AL)

3. Teacher Quality and Early Childhood Education

One possible explanation for the existence of issues regarding low cognitive skills in education quality is the lack of attention to teacher quality, which is key to student achievement (Hanushek, 2005). Pont et al. (2008) highlight “supporting, evaluating and developing teacher quality” (p. 4) as one of the four main responsibilities of school leadership. Barber and Mourshed (2007) on the other hand state that ‘the quality of an education system cannot exceed the quality of its teachers’ (p. 13), and that top-performing countries hire teachers from the top third of the graduating class. Teacher quality is mentioned to have the greatest effect in cognitive skill accumulation and student performance (Seidel & Shavelson, 2007; HW, 2015). Regarding cognitive skills, the magnitude of learning produced by a teacher can vary from 0.5 years of gain to 1.5 years of gain per academic year; in lifetime earnings, one standard deviation increase in teacher quality can generate gains of \$400,000 or more (Hanushek, 2010). Likewise, at a national level, if for instance the US were to replace “the bottom 5–8% of teachers with average teachers,” it could move “near the top of international math and science rankings with a present value of \$100 trillion” (Hanushek, 2010, p. 466). Furthermore, cognitive skills are crucial not only in education quality but also in teacher quality as Piopiunik et al. (2018) state teacher cognitive skills are heavily related to student performance, and “that differences in teacher cognitive skills across countries are strongly associated with international differences in student performance” (p. 33).

Early childhood education (hereafter ECE) as well has a direct impact in cognitive skill formation (Cunha& Heckman, 2017), and “evidence suggests learning in the formative years before formal schooling is important for ultimate academic achievement” (HW, 2015, p. 198). In their work, Cunha and Heckman (2007) famously stated that “skills beget skills and abilities beget abilities” (p. 8), suggesting that skills and learnings developed at early ages form into greater skills and learnings with a higher multiplier effect. They argue that an individual’s future skills arsenal is based on the following model (as cited in Dahmann, 2015):

$$(1) \quad \theta_{t+1} = f_t(h, \theta_t, I_t)$$

where skills at age $t+1$, θ_{t+1} , is a function of initial skills θ_t , “parental investments in child skill when the child is t years-old” (p. 9), I_t , and, on parental and environmental skills, h . According to this model, skills are multiplied during two stages, that being dynamic complementary and self-productivity. Dynamic complementary arises when $\partial^2 f_t(h, \theta_t, I_t) / \partial \theta_t \partial I_t > 0$, indicating that “skills produced at one stage raise the productivity of investment at subsequent stages” (p.8). According to the authors, dynamic complementary explains “returns to educational investments are higher at later stages of the child’s life cycle for more able children (those with higher θ_t)” (p.9). Self – productivity takes place when $\partial f_t(h, \theta_t, I_t) / \partial \theta_t > 0$, which then shows that “that skills acquired in one period persist into future periods” (p. 7). In their later work where they test the validity of this theory, Cunha and Heckman (2008) find out that investments, I_t , bring the highest returns in early stages of life, suggesting that childhood and especially ECE is a vital component in skill formation. Dahmann (2015) also suggest that “skills may be malleable through educational interventions, especially at an early stage in life” (p. 3), pointing at the importance of establishing a functioning ECE system to enhance skill accumulation.

4. Research and Measurement Gaps

The brain is a complex organ where science has yet to reveal out all its secrets (National Institutes of Health, 2018), making elusive concepts such as cognitive skills arduous to measure. Baron & Treiman (1980) state that given abilities are measured with “an experimental task” (p.313) which is sensitive to the interest of the examinee, this causes many issues to research related to cognitive skill development such as biased data. Examinee initiative is also a ubiquitous problem in international tests (Evans, 2018). As cited in Evans (2018), Gneezy et al. (2017) estimate that increasing American students’ motivation on the PISA would result in an increase of 22—24 points in mathematics, “equivalent to moving the U.S. from 36th to 19th in the 2012 mathematics rankings” (p. 4). Besides student motivation, political ambition also is a factor which skews PISA results given the results receive mass public attention and governments are likely to take measures to avoid bad publicity. For instance, Gruber (2017) reports that Israel does not include Arab-Israelis in the PISA exam and that there is a considerable learning gap between Jews and Arabs in Israel. There are also copious claims that countries make great efforts to skew their results (Jerrim, 2017) as China and Argentina “were allowed to take their sample from their most educated cities or regions” (Sands & Roy, 2017, para. 4), and 30% of PISA participants in Malaysia in 2015 came from a group that represents less than 3% of the 15-year-old students (Jaya, 2016). Furthermore, Rao et al. (2014) state tools to measure cognitive skills development in very young children remain lackluster, which may hinder further research in ECE.

In terms of data analysis, a commonly phrased issue among education research in cognitive skills is data limitations as many authors state the impact of data limitations on topics ranging from identifying effective teachers (Hanushek, 2010) to conducting panel estimation to question “what extent the increase of cognitive skills within a given country induces economic growth” (Altınok & Aydemir, 2017, p. 189). Researchers are tied down to the initiatives of countries and schools to college and share data, which hinders them to draw macro-level conclusions as In addition, many studies related to this field are heavily reliant on survey data, such as Piopiunik et al. (2018)’s measurement for teachers’ cognitive skills, and PISA’s measurement for student socio-demographics and expectations (OECD, 2016). Research with survey data itself posits an influx of problems as issues from social desirability, and anchoring bias might cause respondents to report unfaithfully, leading to biased and skewed data (Moy & Murphy, 2016).

UNESCO (2005) framework for quality education identifies not only cognitive skills as a part of its outcomes component but also “creative and emotional skills” (p. 7), which make up non-cognitive skills (Heckman, Stixrud & Urzua, 2006). The impact of non-cognitive skills on quality education and human-wellbeing is an essential research gap that should be addressed since automation is causing significant shifts in the labor market, and raising the importance of non-cognitive skills (Kattan, 2017). Alas, tools to measure the impact of non-cognitive skills are limited since Skills Towards Employability and Productivity (STEP) Survey (World Bank, 2014) is one of the few datasets available to research this topic, which besides being a survey, is limited to few countries. Other studies in non-cognitive skills measure micro-level impact given data limitations, which is not enough to draw macro-level conclusions (García, 2014).

5. Conclusion

Cognitive skills accumulation is a vital component of education quality. It dovetails well with the purpose of education defined by Bitesta (2008) since it increases knowledge and skills accumulated and makes individuals distinct amongst society by providing grounds for them to pursue sui generis interests. Research discussed above delineates the significant role it plays in explaining the per-capita income variations across countries (Bretton, 2011). Studies conducted by HW (2015) and AR (2013), along with the data analysis in Table 2 show how cognitive skills accumulation impacted some countries to fall behind, and others to thrive. The global effort carried out by PISA and the United Nations for cognitive skills accumulation is another indicator of this issue's presence and eminence. Teacher quality and ECE directly impact the formation of these skills and student performance by considerable amounts (Seidel & Shavelson, 2007; Cunha& Heckman, 2017).

Measurement and research gaps exist; however, this paper, by drawing from various disciplines and fields, ultimately suggests that cognitive skills help shape educational quality, and per HW (2015), the overall prosperity and well-being of a nation is linked its society's cognitive skills.

BİBLİOGRAPHY

- ACEMOGLU, D., & ROBINSON, J. A. (2013). *Why nations fail: The origins of power, prosperity, and poverty*. New York: Crown.
- ADAMS, D. (1993). Defining Educational Quality. *Educational Planning*, 9(3), 3-18. Retrieved December 27, 2018, from <https://eric.ed.gov/?id=EJ487855>.
- ALTINOK, N., & AYDEMİR, A. (2017). Does one size fit all? The impact of cognitive skills on economic growth. *Journal of Macroeconomics*, 53, 176-190. doi:10.1016/j.jmacro.2017.06.007
- AMMONS, M. (1964). Purpose and Program: How Does Commitment Today Differ from That in Other Periods. *Association for Supervision and Curriculum Development*, 15-20. Retrieved December 28, 2018.
- BARBER, M. & MOURSHED, M. (2007) *How the World's Best Performing Schools Come Out on Top*. London: McKinsey and Company.
- BARON, J., & TREIMAN, R. (1980). Some problems in the study of differences in cognitive processes. *Memory & Cognition*, 8(4), 313-321. doi:10.3758/bf03198270
- BARRO, R. J., & SALA-I-MARTIN, X. (2004). *Economic growth*. Cambridge (Mass.): MIT Press.
- BESLEY, T. (2009). *Assessing the quality of educational research in higher education: International perspectives*. Rotterdam, Netherlands: Sense.
- BRETON, T. R. (2011). "The Quality vs. the Quantity of Schooling: What Drives Economic Growth?" *Economics of Education Review* 30(4): 765–73.
- BRUMM, H. J. (1996). "The Human Capital Augmented Solow Model Revisited." *Applied Economics Letters* 3(11): 711–14.
- CUNHA, F., & HECKMAN, J. (2007). The Technology of Skill Formation. *American Economic Review*, 97(2), 31-47. doi:10.1257/aer.97.2.31
- CUNHA, F., & HECKMAN, J. J. (2008). Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation. *Journal of Human Resources*, 43(4), 738-782. doi:10.3368/jhr.43.4.738
- DAHMAN, S. (2015). How Does Education Improve Cognitive Skills? Instructional Time versus Timing of Instruction. *SSRN Electronic Journal*, 1-55. doi:10.2139/ssrn.2630179

- DEWEY, John (1934). Individual psychology and education. *The Philosopher* 12 (1):1-6.
- EVANS, D. (2018, January 31). The World Bank What's new in education research? Impact evaluations and measurement – January 2018 round-up [Web log post]. Retrieved January 4, 2019, from <http://blogs.worldbank.org/impactevaluations/what-s-new-education-research-impact-evaluations-and-measurement-january-2018-round>
- FEENSTRA, Robert C., ROBERT Inklaar and MARCEL P. Timmer (2015), “The Next Generation of the Penn World Table” *American Economic Review*, 105(10), 3150-3182
- FORD, H. (1922, December 1). Ford News, Volume 3, 1922. *Ford Motor Company*, p. 2. Retrieved December 27, 2018, from https://openlibrary.org/works/OL17621497W/Ford_News.
- FOSHAY, A. (1991). The Curriculum Matrix: Transcendence and Mathematics,” *Journal of Curriculum and Supervision*, 6(4), 277-293. Retrieved December 28, 2018, from http://www.ascd.org/ASCD/pdf/journals/jcs/jcs_1991summer_foshay.pdf
- GARCIA, E. (2014, December 2). The Need to Address Noncognitive Skills in the Education Policy Agenda. Retrieved January 4, 2019, from <https://www.epi.org/publication/the-need-to-address-noncognitive-skills-in-the-education-policy-agenda/>
- GNEEZY, U., LIST, J., LIVINGSTON, J., SADOFF, S., QIN, X., & XU, Y. (2017). Measuring Success in Education: The Role of Effort on the Test Itself. 1-64. doi:10.3386/w24004
- GRUBER, N. (2017). Why Israel does poorly in the PISA exams – perceptions versus reality. *Institute for Socio-economic Research | SHORESH*, 1-44. Retrieved January 4, 2019.
- HANUSHEK, E. A., & KIMKO, D. D. (2000). Schooling, Labor-Force Quality, and the Growth of Nations. *American Economic Review*, 90(5), 1184-1208. doi:10.1257/aer.90.5.1184
- HANUSHEK, E., 2002. Publicly provided education. In: Auerbach, A.J., Feldstein, M. (Eds.), *Handbook of Public Economics*. Elsevier, Amsterdam, pp. 2045–2141.
- HANUSHEK, E. (2005). The Economics of School Quality. *German Economic Review*, 6(3), 269-286.
- HANUSHEK, E., & WOESSMANN, L. (2007). The Role of Education Quality for Economic Growth World Bank Policy Research Working Paper No. 4122. Available at SSRN: <https://ssrn.com/abstract=96037>
- HANUSHEK, E., & WOESSMANN, L. (2008). The Role of Cognitive Skills in Economic Development. *Journal of Economic Literature*, 46(3), 607-668. doi:10.1257/jel.46.3.607
- HANUSHEK, E., & WOESSMANN, L., (2012a). Do Better schools lead to more growth? Cognitive skills, economic outcomes, and causation. *J. Economic Growth* 17 (4), 267–321.
- HANUSHEK, E., & WOESSMANN, L., (2012b). Schooling, educational achievement, and the Latin American growth puzzle. *J. Development Economics* 99 (2), 497–512.
- HANUSHEK, E., WOESSMANN, L., (2015). The Knowledge Capital of Nations. Education and the Economics of Growth. *The MIT Press*, Cambridge, MA.
- HECK, R., (2009). Teacher effectiveness and student achievement: Investigating a multilevel cross-classified model. *Journal of Educational Administration*, 47 (2), 227-249. Heckman, J. J., Stixrud, J., & Urzua, S. (2006). The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. *Journal of Labor Economics*, 24(3), 411–482
- JACKSON, K., JOHNSON, R., & PERSICO, C. (2017, November 02). Money Does Matter After All. Retrieved December 29, 2018, from <https://www.educationnext.org/money-matter/>
- JAIN, C., & PRASAD, N. (2017). Quality in Education—Concept, Origin, and Approaches. *Quality of Secondary Education in India*, 9-16. doi:10.1007/978-981-10-4929-3_2

- JAYA, P. (2016, December 08). Ong: Did ministry try to rig results for Pisa 2015 report? Retrieved January 4, 2019, from <https://www.freemalaysiatoday.com/category/nation/2016/12/08/ong-did-ministry-try-to-rig-results-for-pisa-2015-report/>
- JERRIM, J. (2017, July 19). Why does Vietnam do so well in PISA? An example of why naive interpretation of international rankings is such a bad idea [Web log post]. Retrieved January 4, 2019, from <https://ffteducationdatalab.org.uk/2017/07/why-does-vietnam-do-so-well-in-pisa-an-example-of-why-naive-interpretation-of-international-rankings-is-such-a-bad-idea/>
- KATTAN, R. B. (2017, August 5). The World Bank: Non-cognitive skills: What are they and why should we care? [Web log post]. Retrieved January 4, 2019, from <http://blogs.worldbank.org/education/non-cognitive-skills-what-are-they-and-why-should-we-care>
- LADD, H., & LOEB, S. (2013). The challenges of measuring school quality: Implications for educational equity. In D. Allen, & R. Reich (Eds), *Education, Justice, and Democracy*. Chicago, IL: University of Chicago Press.
- MINCER, J. (1974). Schooling, experience, and earnings. New York: *National Bureau of Economic Research*.
- MANKIW, G., DAVID R., & DAVID W., (1992). A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics*, vol. 107: 407 – 438.
- MARTIN, M. O., MULLIS, I. V. S., & HOOPER, M. (Eds.). (2017). *Methods and Procedures in PIRLS 2016*. Retrieved from Boston College, *TIMSS & PIRLS International Study Center*
- MONTT, G. (2012). Pisa in Focus: Does Money Buy Strong Performance in PISA? *PISA in Focus*. doi:10.1787/5k9fhmfzc4xx-en
- MORTIMORE, P., & STONE, C. (1991). Measuring Educational Quality. *British Journal of Educational Studies*, 39(1), 69-82. doi:10.2307/3120871
- MOY, P., & MURPHY, J. (2016). Problems and Prospects in Survey Research. *Journalism & Mass Communication Quarterly*, 93(1), 16-37. doi:10.1177/107.769.9016631108
- MULLIS, I. V. (2012). *PIRLS 2011: International results in reading*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center.
- MULLIS, I.V., Martin, M.O., Foy, P., & Arora, A. (2012). Chestnut Hill, MA: *TIMSS & PIRLS International Study Center*, Boston College
- National Institutes of Health. (2018, December 12). Brain Basics: Know Your Brain. Retrieved January 3, 2019, from <https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Know-Your-Brain>
- OECD (2012), *Equity and Quality in Education: Supporting Disadvantaged Students and Schools*, OECD Publishing. <http://dx.doi.org/10.1787/978.926.4130852-en>
- OECD. (2016). *PISA 2015 Results (Volume II) Policies and Practices for Successful Schools*. PISA, OECD Publishing, Paris. doi:10.1787/978.926.4267510-en
- OECD (2018), *OECD Economic Outlook, Volume 2018 Issue 2*. OECD Publishing, Paris, https://doi.org/10.1787/eco_outlook-v2018-2-en.
- OECD. (n.d.). Mexico – OECD Data. Retrieved December 31, 2018, from <https://data.oecd.org/mexico.htm>
- PIOPIUNIK, M., WIEDERHOLD, S., & HANUSHEK, E. (2018). The Value of Smarter Teachers: International Evidence on Teacher Cognitive Skills and Student Performance*. *Journal of Human Resources*. Retrieved January 2, 2019.
- RAO, N., SUN, J., WONG, JMS., WEEKES B.P., SHAEFFER, S., YOUNG, M., BRAY, M., CHEN, E., LEE, D. (2014), *Early childhood development and cognitive development in developing countries: A rigorous literature review*. Department for International Development.

- RIVKIN, S., HANUSHEK, E., & KAIN, J. F. (2005). Teachers, Schools, And Academic Achievement. *Econometrica*, 73(2), 417-458.
- SAMUELSON, P. A., & NORDHAUS, W. D. (2010). *Economics*. Boston: McGraw-Hill.
- SANDS, G., & ROY, A. (2017, January 04). Are the PISA Education Results Rigged? Retrieved January 4, 2019, from <https://www.forbes.com/sites/realspin/2017/01/04/are-the-pisa-education-results-rigged/#2d867.963.1561>
- SEIDEL, T., & SHAVELSON, R.J. (2007), “Teaching effectiveness research in the past decade: the role of theory and research design in disentangling meta-analysis results”, *Review of Educational Research*, 77 (4), 454-499.
- SOLOW, R. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70(1), 65-94.
- The Global Goals for Sustainable Development. (n.d.). Goal 4: Quality Education. Retrieved December 31, 2018, from <https://www.globalgoals.org/4-quality-education>
- UNESCO. (2005). EFA global monitoring report: The quality imperative. Regional Overview. United Nations Educational, Scientific and Cultural Organization.
- UNICEF. (2000). Defining quality in education (Defining Quality in Education A paper presented by UNICEF at the meeting of The International Working Group on Education Florence, Italy June 2000). Retrieved from <http://www.unicef.org/education/files/QualityEducation.PDF>
- United Nations. (2015). *Transforming Our World: The 2030 Agenda For Sustainable Development*. New York: UN Publishing, Print.
- United Nations Development Programme. (n.d.). Goal 4: Quality education. Retrieved December 31, 2018, from <http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-4-quality-education.html>
- WATTS, A. (2017). *International surveys TIMSS, PISA, PIRLS* (pp. 1-5, Issue Brief No. 692.056.5690). Cambridge Assessment International Education.
- World Bank. (2014). STEP skills measurement surveys: innovative tools for assessing skills (English). Social protection and labor discussion paper. Washington, DC: World Bank
- World Bank. (2017, October 10). Skills Development. Retrieved from <http://www.worldbank.org/en/topic/skillsdevelopment>
- YIANNOUKA, S., & MOUHYI, Z. (2018, April 03). There is no one-size-fits-all school model: Developing a flexible and innovative education ecosystem. Retrieved December 28, 2018, from <https://www.brookings.edu/blog/education-plus-development/2018/04/03/there-is-no-one-size-fits-all-school-model-developing-a-flexible-and-innovative-education-ecosystem/>
- ZEILEIS, A., (2017). pwt9: Penn World Table (Version 9.x). R package version 9.0-0.