Taiwan: Performance in the Programme for International Student Assessment

Su-Wei Lin, Huey-Ing Tzou, I-Chung Lu, and Pi-Hsia Hung

Abstract Taiwan has, from 2006, participated in five Programme for International Student Assessment (PISA) surveys. This chapter discusses Taiwan's performance in PISA and its implications. At first, the education system and the process of educational reform in Taiwan were described. Then Taiwan's performances for reading, math, and science in PISA were delineated. Taiwanese students have had consistently excellent performance for math and science; its reading performance, although not as outstanding as those for math and science, has improved significantly from 2009 to 2018. The gender gap in reading, in favour of female students, has narrowed, and the gender gap in math and science has been small. Educational equity, especially between rural and urban students, has also improved from 2006 to 2018. The proportion of high performers in reading and the proportion of low performers in reading, math, and science has increased from 2006 to 2018, while the proportions of top performers in math and science have decreased. These findings are interpreted from the perspectives of cultural beliefs, changes in the education system and national assessment, government investment in the related domains, and the nature of the PISA assessment.

1 Introduction

The Programme for International Student Assessment (PISA), organized by the Organisation for Economic Co-operation and Development (OECD), is a cross-national survey conducted once every 3 years. PISA assesses a country's performance profile with respect to the core competencies required for 15-year-old students to participate in future society.

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Specifically, through evaluating the performance of students in foundational competence domains and gathering information on students, teachers, and schools, PISA provides an overall score that describes how well a country's students are performing. This score aids countries in the adjustment of their educational policies, and educational decision makers attach great importance to PISA: the results allow such decision makers to compare their students' performance with those in other PISA-participating countries and economies, thus helping them better understand the future competitiveness of their students. Many participating countries publish their own PISA reports, and public discussions often cite PISA materials. Although the PISA survey cannot confirm that educational input has a causal relationship with the PISA results, these results are valuable because they allow educators, policymakers, and the general public to understand the similarities and differences between education systems. Furthermore, PISA attracts much attention from global media, indicating the PISA's impact. Some countries have also started to develop and implement PISA-related assessments as additional projects or as part of their national assessments.

Taiwan has participated in the PISA survey five times, beginning from PISA 2006. The PISA 2018 survey focused on reading—with science and mathematics as minor evaluation areas—where it specifically examined students' attitudes toward and motivation for reading.

This chapter is organized as follows: First, the education system and PISA-related educational policies in Taiwan are briefly reviewed. Subsequently, Taiwan's results in the five PISA surveys (2006–2018) are discussed, with regard to trends, gender difference, social equity in learning outcomes, and changes in top and low performers. It then concludes with implications and policy recommendations.

2 The Education System in Taiwan

The present-day education system in Taiwan has a 6-3-3-4 structure. It was established in 1949, then having only 6 years of compulsory primary school education. To reduce competitive pressure in middle school admissions and because a more highly skilled workforce was needed for Taiwan's national development, Taiwan's 9-year compulsory education system was implemented subsequently in 1968, which had 6 years of primary school followed by 3 years of junior high school. The compulsory education system was free of charge, and it was in place for more than four decades until 2014, where it was extended to the present-day 12-year basic education system. This extension was aimed at developing a more highly skilled workforce for future economic growth. Although early childhood education (i.e., preschool) is not part of Taiwan's compulsory education system, the government has actively invested resources targeted at reducing the burden of financially disadvantaged families from sending their (specifically, 5-year-old) children to preschool (Ministry of Education [MOE], nd).

Students in Taiwan's education system have two important choices. This first choice comes after graduation from junior high school, where students can either choose to go to a senior secondary school or a 5-year junior college, depending on their interests as well as performance in the required Comprehensive Assessment Program (CAP). In general, senior secondary education in Taiwan comprises four school types: general, skill-based, comprehensive, and specialized senior secondary schools. Thus, to aid students in making this decision, in addition to the regular curriculum, technical arts education is included in junior high schools to offer students a greater diversity of learning opportunities. Thus, students do have the opportunity to better understand what vocational education will look like and explore future career options.

The second choice comes after graduation from senior secondary school, where students choose which college to go to. Most of these graduates will have taken the General Scholastic Ability Test (GSAT), and they obtain admission into a college of their choice through two paths (personal application and school recommendation) based on their GSAT results. For students without a place in a college of their choice or with unsatisfactory GSAT results, they can still take the Advanced Subject Test (AST) and obtain college admission based on their AST results as well as their preference list. Meanwhile, graduates of skill-based senior secondary schools can take the Technological and Vocational Education Joint College Entrance Examination to get admission into technical colleges or technical universities.

Figure 1 presents educational statistics for 2018. In particular, the enrolment rates for preschool, elementary school, junior high school, senior high school, and university or college were 63%, 97%, 98%, 94%, and 77%, respectively. The gross enrolment ratio and average years of schooling were 94% and 12.2 years. In Taiwan, primary and secondary school teachers were relatively young, and the proportion of teachers older than 50 years was approximately 20%. The average class size, for both primary and secondary schools, was approximately 26 students, and the education expenditure per student was more than NT$203,000 (US$6700). Total education expenditure accounted for 5.08% of Taiwan's GDP. More than half (56%) of primary and secondary schools in Taiwan were public but only 31% of higher education institutions were public. A detailed description of Taiwan's education system can be found in the 2019 edition of Education Statistics of the Republic of China (MOE 2019) and on the website of the Department of Statistics, MOE (http://stats.moe.gov.tw/files/ebook/Education_Statistics/108/108edu_ODF.htm).

Since the 1990s, Taiwan's MOE has been steadily engaging in educational reform. Initial reforms focused on ensuring that all students have access to a high-quality education, whereas recent reforms have focused on developing teacher capacity to foster the critical thinking and literacy skills needed in a fast-changing global economy. These recent reforms are part of Taiwan's response to criticism that its education system, in focusing too heavily on standardized tests, rewards rote memorization rather than the creative application of knowledge. This section outlines the evolution of educational policy in Taiwan over the past 30 years.

On April 10, 1994, several nongovernmental organizations in Taiwan organized a march and formed the 410 Alliance of Education Reform. The alliance made

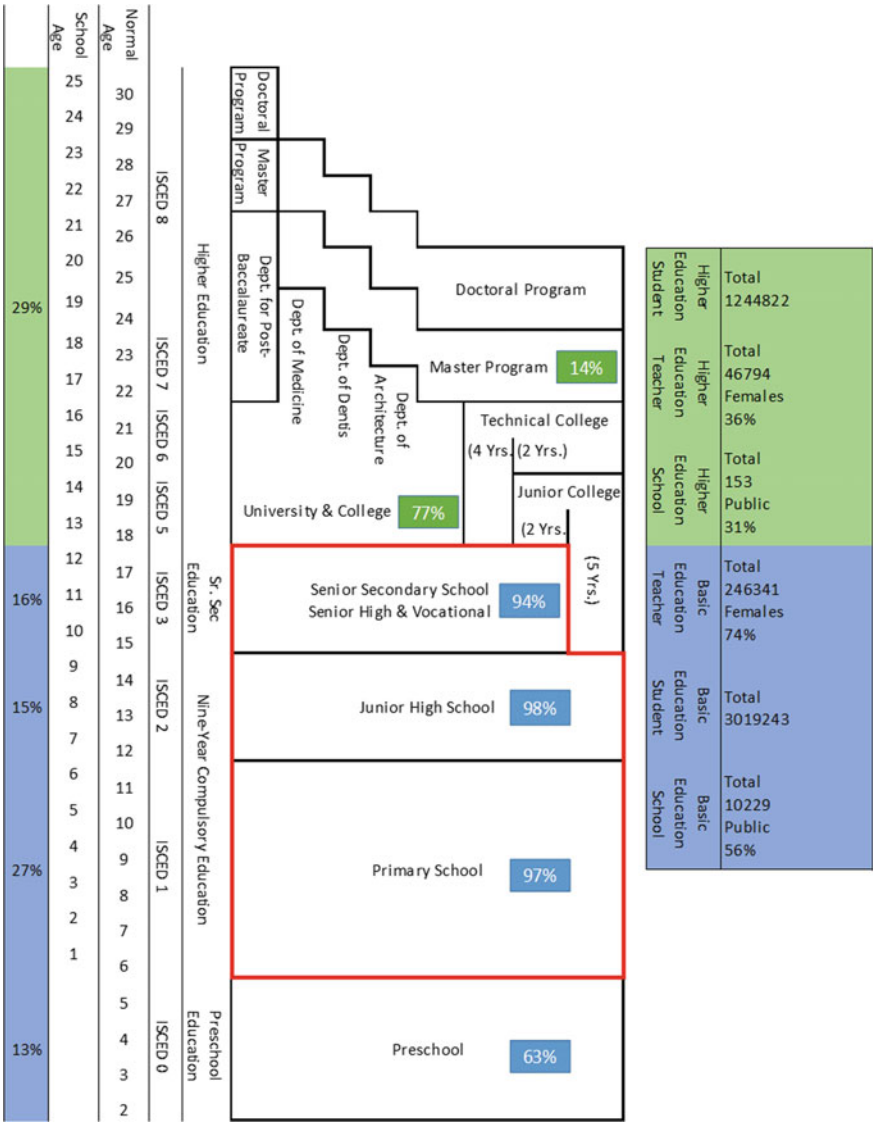

Fig. 1 Structure of the Taiwanese education system in 2018. *Data Source* MOE (2019)

four appeals for education reform: (1) to establish more senior high schools and universities, (2) to reduce the class- and school-size in primary and junior high schools, (3) to promote the modernization of education, and (4) to formulate the *Educational Fundamental Act*. This march was regarded as the birth of Taiwan's education reform, and the four appeals became the primary axis of education reform.

In response to the public's demand, the Executive Yuan pledged to set up the Consultation Committee of Education Reform. In December 1996, the Committee proposed the *Consultants' Concluding Report on Education Reform*, which sought to relax the limitations in the education system, to take good care of every student, to accelerate school entrance paths, to enhance teaching quality, and to build a lifelong learning society. To implement the aforementioned proposal, the MOE proposed the *Action Plan for Educational Reform*, which was designed to implement 12 policy items within 5 years with a budget of more than NT$157 billion. These policy items included increasing the education budget, strengthening education research, enhancing primary and junior high school education, universalizing early childhood education, improving preservice and in-service teacher education, promoting diversity and refinement in technical and vocational education, and making further education more accessible.

In 2010, the MOE published the *Education Report of the Republic of China*, which outlined the educational development blueprint for Taiwan over 2011–2020. This report proposed three visions (new era, new education, and new promise) and four goals (refinement, innovation, fairness, and sustainability). To fulfil these visions and goals, ten strategies were formulated: (1) promoting 12-year basic education and integrating kindergartens with nursery schools, (2) improving the education system and reinforcing education resources, (3) refining preservice teacher education and teachers' professional development, (4) promoting the transformation and development of higher education, (5) innovating the education industry and cultivating talent for the knowledge-based economy, (6) developing the literacies of diverse modern citizens, (7) promoting sports and a healthy lifestyle for all, (8) promoting respect for cultural diversity and the rights of disadvantaged groups as well as those who need special education, (9) expanding cross-strait, international, and overseas Chinese education, and (10) deepening lifelong learning and cultivating a learning society (MOE 2010).

Because humans are the most important resource and their talent is key to national development, *MOE Talent White Paper* was published in December 2013, which proposed a 10-year blueprint for cultivating talent over 2014–2023. The proposed blueprint is illustrated in Fig. 2. It included two visions of "cultivating excellent and creative people" and "improving Taiwan's international competitiveness," in addition to 12 themes of administration.

Beyond the *Action Plan*, *Education Report*, and *White Paper*, Taiwan's education underwent two significant innovations in the past two decades. The first was the 2001 replacement of the Joint High School Entrance Examination with the Basic Competence Test (BCtest) for junior high school students. The BCtest was a required test for all junior high graduates and evaluated competence in five subjects: Mandarin, Mathematics, English, Science, and social studies. All BCtest items were multiple choice except for the Writing Assessment, which was included in 2007. Students could take the BCtest twice in 1 year and use their better score for admission into a senior secondary school. However, as part of the implementation of Taiwan's 12-year basic education policy, the BCtest was replaced with the CAP in 2014. Unlike the BCtest, the CAP was only administered once a year, and a section evaluating English

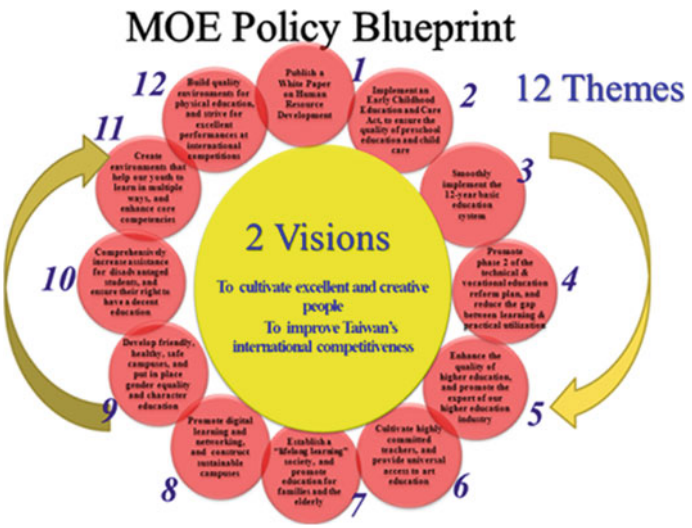

Fig. 2 MOE's 2014 policy blueprint

listening comprehension was added. Rather than a scaled score, the test results were reported in three levels—proficient, basic, and improvement needed.

In addition to changes in the examination system, curricular reform was another milestone in Taiwan's educational reform. In keeping with global 21st century trends of educational reform, the MOE initiated curricular and instructional reforms in primary and junior high school education based on the *Action Plan for Educational Reform*. Because the curriculum is foundational to schooling and instruction, the MOE prioritized the development and implementation of grade 1–9 curriculum. The *General Guidelines of Grade 1–9 Curriculum* was promulgated in 1998. Meanwhile, the MOE decided to introduce the Grade 1–9 Curriculum gradually, beginning from the 2001 academic year. At its core, the Grade 1–9 Curriculum was student-centred and focused on life experiences to cultivate students' 10 basic competencies. The new curriculum had five new features: (1) replacing knowledge with basic competency in students, (2) providing English instruction in primary education, (3) emphasizing the integration of learning areas, (4) focusing on school-based curriculum design, and (5) integrating instruction and assessment.

Subsequently, in response to the implementation of the 12-year basic education system, Taiwan's MOE released the *Curriculum Guidelines of 12-Year Basic Education—General Guidelines* in November, 2014. The Curriculum Guidelines were based on the newly adopted concepts of *taking initiative*, *engaging in interaction*, and *seeking the common good* to encourage students to become spontaneous and motivated learners. The visions of the new curriculum were to develop talent in every student—nurture by nature—and promote lifelong learning. To implement the ideas and goals of the 12-year basic education policy, core competencies were used as the basis of curriculum development to ensure continuity between educational stages

and encourage integration between domains as well as subjects. The concept of core competency underscores how learning should not be limited to the knowledge and skills taught in school, where learning should instead engage real-life scenarios and emphasize holistic development through action and self-development. The notion of lifelong learning constituted the heart of the core competencies in 12-year basic education. Figure 3 illustrates the aforementioned concept of core competencies.

Because the PISA survey is a low-stakes assessment for Taiwanese students, the PISA survey does not directly implicate education policy in Taiwan. Before the PISA survey, the 1999 *Third International Mathematics and Science Study-Repeat* (TIMSS-R) was the first international large-scale assessment (ILSA) taken up by Taiwan. Since then, Taiwan has been involved in many large-scale international assessments, such as the TIMSS (Trends in International Mathematics and Science Study), PIRLS (Progress in International Reading Literacy Study), PISA, ICCS (International Civic and Citizenship Education Study), and TALIS (Teaching and Learning International Study). Taiwanese students have had outstanding performances in both the 1999 TIMSS-R and 2003 TIMSS. However, there was a large gap between low- and high-performers in the 2003 TIMSS. To shorten the achievement gap and improve educational equity, the MOE promoted the *After-School Alternative Program* (ASAP) in 2006 (Lin et al. 2013).

As the performance of Taiwanese students in the PISA reading assessment was unsatisfactory, the MOE, National Science Council (present-day Ministry of Science

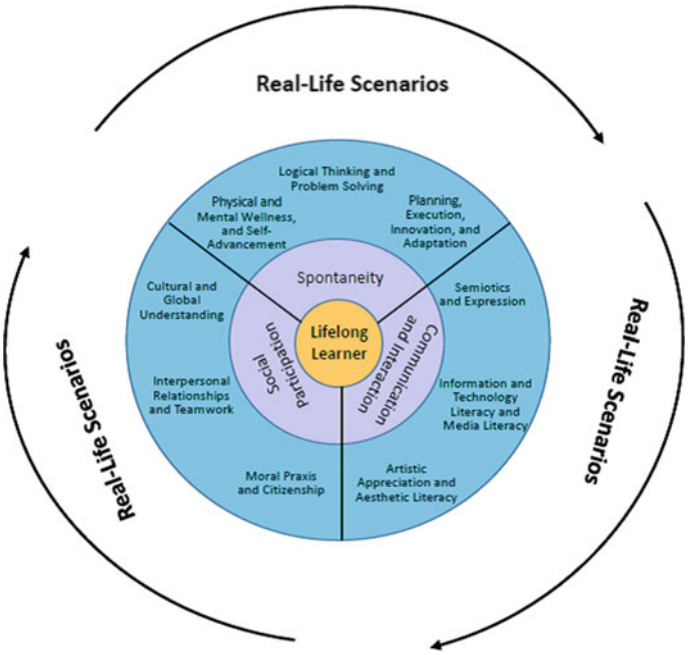

Fig. 3 Wheel-in-action diagram of core competencies. *Source* MOE (2014). Figure 1

and Technology), and local government education bureaus have allocated additional funds for reading instruction, hoping to improve reading performance. Research on effective reading instruction has been encouraged, and professional learning communities on reading instruction among teachers have also been promoted. The MOE also combined the ASAP and *Educational Priority Areas Project: Learning Guidance* into a new project called *Project for Implementation of Remedial Instruction* in 2013. Students who have not passed the remedial education screening test were the target students of this program.

3 Taiwan's PISA Performance

The first PISA survey joined by Taiwan was the 2006 PISA. Taiwanese students performed very well in mathematics (549 points) and science (532 points) in the 2006 PISA and have maintained such performance.

This impressive performance in mathematics and science can be explained by several factors. The first factor is cultural norms regarding learning. Influenced by Confucianism, Taiwanese society places a premium on education, holds teachers in high esteem, emphasizes student discipline and attention in the classroom, and prioritizes both repeated practice and a firm grasp on foundational knowledge (Tan 2015a, b, 2017). Furthermore, effort, instead of innate ability, is emphasized as the basis for achievement (Stevenson et al. 1993), and academic achievement is believed to be the key to future success (Wei and Eisenhart 2011). Parents, especially mothers, are also highly involved in their children's education, and they demand effort and good grades from their children (Fejgin 1995). As a result of these cultural beliefs toward education and parenting, relative to US students, Taiwanese students spend more time on homework, receive more help from family members with homework, and have more positive attitudes toward homework (Chen and Stevenson 1989). Meanwhile, because of this emphasis on effort, many Taiwanese students attend *buxiban*, which are private after-school programs that help students attain high grades in standardized tests. Mathematics and science are especially popular subjects focused on in *buxiban.* In addition to these cultural beliefs, a highly competitive education system contributes to Taiwanese students' excellent performance in mathematics and science. As mentioned earlier, grade 9 students are required to take the CAP in order to get into different types of senior secondary school. Taiwanese students are therefore under much pressure to perform well in the national examination.

Taiwanese students had unsatisfactory reading performance in the PISA 2006 (496 points). For all five PISA surveys Taiwan has participated in, Taiwan's mean readings scores were consistently and considerably lower than its mean scores in mathematics and science. This gap is unusual because reading is foundational to learning, regardless of the subject matter. Several reasons may explain this gap. First, the belief that mathematics and science are more important than language arts is prevalent in Taiwanese society, especially among parents and teachers. Students are encouraged to study further in science, technology, engineering, and mathematics (STEM)-related

areas and discouraged to pursue a career in arts and humanities areas. When students enrol in *buxiban* outside of school, they rarely enrol in classes on Chinese/Mandarin. Second, many in Taiwan, even school teachers, believe that mathematics and science are more difficult than Chinese/Mandarin. In addition to the focus on mathematics and science in *buxiban* classes, junior high schools are also more likely to offer remedial instruction in mathematics and science than in Chinese/Mandarin. Third, except for the writing test, the national assessment comprised only multiple-choice items before 2014. Thus, Taiwanese students have had little experience with constructed-response items, which constitute approximately 40% of items in the PISA reading assessment. All these factors may contribute to Taiwan's relatively poor performance in the PISA reading assessment.

In the PISA 2018, Taiwan's scores for reading, mathematics, and science were 503, 531 and 516, respectively. Comparing to the performance in PISA 2009, in which year the major domain was reading as well, the reading score of 503 constituted an 8-point improvement for Taiwanese students. Taiwan has also come to score better relative to the OECD average in reading: Taiwan scored 2 points higher in 2009 but 16 points higher in 2018, improving from the "not significantly different from the OECD average" group in 2009 to the "significantly higher than the OECD average" group in 2018. However, Taiwan's PISA performance in mathematics and science has decreased in 2018: Taiwan's mathematics and science scores were, respectively, 11 and 16 points lower than its corresponding scores in PISA 2015.

At present, Taiwan has had results from five PISA cycle surveys. Figure 4 displays the 12-year evolution in the three domains of reading, mathematics, and science for Taiwan and the OECD average. The evolutionary trends between the three domains differed for Taiwan. Reading performance had a hump-shaped trend, due to both Taiwan's outstanding performance in the PISA 2012 as well as similar performance among the other cycle surveys. Mathematics performance had a gradual downward trend, although it remained outstanding among the participating countries. Science

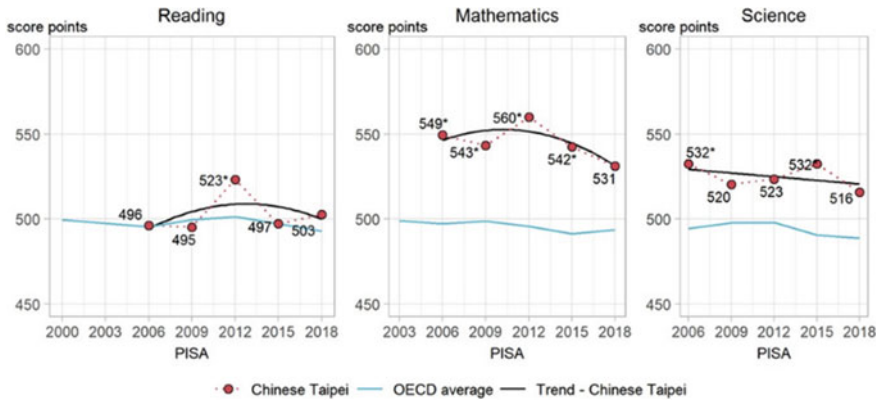

Fig. 4 Trends for Taiwan and the OECD average in reading, mathematics and scientific literacy. *Source* OECD (2019a), Chinese Taipei—Country Note—PISA 2018 Results, Fig. 2

performance remained stable, although the mean science performance in the latest PISA 2018 was the lowest ever.

The downward trend in Taiwan's mathematics performance is a worrying finding. The authors can't help but ask, has the mathematics competence of Taiwan students really declined? Taiwan has the CAP for grade 9 students, but the CAP does not employ a common scale and its testing results over the years can't be compared directly, nor can the results be used to construct an evolutionary trend. Furthermore, the CAP is a comprehensive exam that is closely related to Taiwan's national curriculum, which measures achievement in curricular knowledge that differs from those measured in the PISA assessment. Thus, the CAP provides only limited information for elucidating the downward trend in PISA mathematics performance in Taiwan.

We speculated that three reasons may explain this downward trend in Taiwanese students' PISA mathematics performance. The first is testing fatigue. In addition to PISA, Taiwan has participated in several international assessments, such as TIMSS, PIRLS, ICCS, and TALIS (see Fig. 5). Including field trials and main studies, since 2006, Taiwan has conducted one to two large-scale assessments almost every year. The Taiwanese public was initially interested in Taiwan's performance in these large-scale assessments, but frequent testing resulted in testing fatigue among schools, teachers, and students. Furthermore, these assessments were low-stakes tests for students, and they could not attract the sustained attention of the Taiwanese public. Teachers, students, and parents thus preferred to put their effort into high-stakes tests, such as the CAP, rather than these international assessments.

The second reason is student unfamiliarity with the PISA's computerized testing format. The computerized testing was adopted since the PISA 2015 survey. The emphasis was placed on the use of technological tools for solving mathematics literacy–related problems. The CAP, by contrast, is a paper-and-pencil test and focuses on assessing the student's acquisition of foundational knowledge. The proportion of improvement needed students (low performers) in the CAP math test has declined year by year, indicating that Taiwanese students' mathematical competence has improved. However, technology is not widely used in mathematics classrooms in Taiwan and students receive little instruction from teachers on how

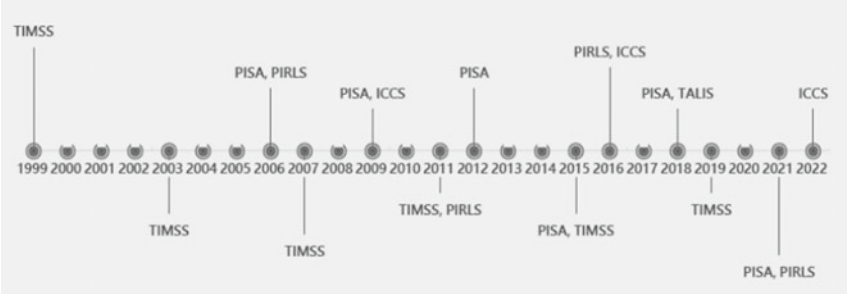

Fig. 5 Timeline of Taiwan's participation in large-scale international assessments

to use technology to solve mathematical problems. Therefore, the improvement of Taiwanese students in the CAP math test was unable to reflect on the performance in PISA math assessment.

A less competitive education system in Taiwan over time may be the third reason. Because Taiwan has had a low birth rate, the number of examinees in the CAP decreased from 285,295 in 2015 to 215,219 in 2018. This large decrease has meant that fewer students are competing for admission into any given high school, which decreases the incentive, especially among lower-performing students, to study hard. This potentially explains the increased number of low-performing students. Furthermore, because the results for the CAP, a criterion-referenced test introduced in 2014, are of only three levels—proficient, basic, and improvement needed, high-achieving students have little incentive to aim for a perfect score and to do their best effort. That is may be one of the reason why, in PISA 2018, the proportions of high-performing Taiwanese students in mathematics and science were lower relative to previous PISA surveys.

3.1 Top and Low Performers

To aid interpretation of student scores, PISA divides student performance into several proficiency levels, where levels 5 and 6 indicate high performance and below level 2 indicate low performance. In PISA 2018, 10.9% of Taiwanese students were at or above level 5, which was more than double the corresponding figure of 5.2% in PISA 2009 (Table 1). This revealed that Taiwan's number of top performers in reading has increased significantly over the past 9 years. However, in PISA 2018, 17.8% of Taiwanese students did not reach level 2, which although lower than the 2018 OECD average (22.7%), was higher than the corresponding figure for Taiwan in PISA 2009 (15.6%). Therefore, Taiwan's proportions of top performers and low performers in reading increased obviously between 2009 and 2018, explaining the

Table 1 Percentage of low and top performers in reading, mathematics, and science (2006–2018)

Year	Reading		Math		Science	
	Below level 2	Level 5 or above	Below level 2	Level 5 or above	Below level 2	Level 5 or above
	(<407.47)	(≥625.61)	(<420.07)	(≥606.99)	(<409.54)	(≥633.33)
2018	17.8	10.9	14	23.2	15.1	11.7
2015	17.2	6.9	12.7	28.1	12.4	15.4
2012	11.5	11.8	12.8	37.2	9.8	8.3
2009	15.6	5.2	12.8	28.6	11.1	8.8
2006	15.3	4.7	12	31.9	11.6	14.6

Source OECD (2019b, c), PISA 2018 Database, Table I.B1.7
OECD (2007a, b), PISA 2006 Database, Table 2.1a, 6.1.a and 6.2a

reason that Taiwan's mean performance in reading did not improve significantly during this time period.

This 2009–2018 increase in the proportion of top performing Taiwanese students in reading is consistent with expectations. This is because the MOE has invested much resources into reading education after Taiwan's poor reading performance in the 2006 PISA and 2006 PIRLS. Nevertheless, the increase in the proportion of low performers in reading also suggests that educational resources alone are insufficient to improve the reading abilities of low-performing students, who require individualized remedial instruction on how to read adaptively and strategically. Reading instruction in general should also be individualized and reading skills for the new information age should be cultivated; professional development programs that hone teachers' abilities to conduct such reading instruction are urgently needed.

As for mathematics performance, in PISA 2018, 23.2% of Taiwanese students (and 10.9% of OECD students) were at levels 5 or above, and 14% were below level 2. The proportion of low-performing Taiwanese students has been stable across the past five PISA surveys, although the 2018 figure of 14% was the highest ever. Conversely, the proportion of Taiwanese students who were top performers decreased from 37.2% in 2012 to 23.2% in 2018, which explains the reasons that Taiwan's mean scores for mathematics performance decreased from 2012 to 2018.

As for science performance, in PISA 2018, 11.7% of Taiwanese students (and 21.9% of OECD students) were at levels 5 or above and 15.1% were below level 2. The 2018 figure of 15.1% for low performers was the highest ever, and the proportion of top performers decreased by 3.7% from 2015 to 2018. This decrease in the proportion of top performers and increase in the proportion of low performers explain the reason that Taiwan's mean performance in science in PISA 2018 was the lowest ever.

The decreased proportion of top performers in mathematics and science between PISA 2018 and previous PISA surveys may be attributable to changes in the aforementioned scale of national assessment. In the BCtest, a national assessment that preceded the CAP, performance for each subject was scored at a maximum of 80 points. Because a single point increase for a subject may decide a student's admission into a more elite school, top performers tended to study diligently to attain a perfect score. By contrast, as mentioned earlier, the declining birth rate and three-tier scoring system for the CAP has made Taiwan's education system less competitive, which has decreased the incentives for low and top performers to study hard.

3.2 Gender Differences

The PISA results have consistently indicated that in reading, female students outperform male students in most countries. This has also been the case in Taiwan. As indicated in Table 2, In PISA 2018, the difference between average female and male reading scores (average female reading score – average male reading score) was 22 points, which was significantly lower than the OECD average of 30 points. This gender gap narrowed significantly from 37 points in 2009 to 22 points in 2018. This

Table 2 Gender differences for Taiwan and OECD average in reading performance (2006–2018)

Year	Taiwan			OECD average		
	Girls	Boys	Gender differences	Girls	Boys	Gender differences
2018	514	492	**22**	502	472	**30**
2015	510	485	**25**	504	477	**27**
2012	539	507	**32**	516	478	**38**
2009	514	477	**37**	511	472	**39**
2006	507	486	**21**	511	473	**38**

Note Statistically significant values are indicated in bold
Source OECD (2019b, c), PISA 2018 Database, Tables II.B1.7.27–II.B1.7.42. OECD (2007a, b), PISA 2006 Database, Tables 6.1C and 6.2C

decreased gender difference was due to improvements in male students' reading performance and female students' reading performance remaining the same.

The gender gap in PISA performance can be further elucidated by considering top and low performers (see Table 3). For Taiwanese students in PISA 2018, 9.8% of male students and 11.9% of female students read at levels 5 or above; these figures were greater than the corresponding figures of OECD average in PISA 2018. These figures were also significantly greater than those for Taiwanese students in PISA 2009, with the increase for male students being far greater than that for female students. Regarding low performers, for Taiwanese students in PISA 2018, 21.3% of male

Table 3 Percentage of girls and boys at each proficiency level in reading (2006–2018)

	Girls					Boys				
	2006[a]	2009[b]	2012[b]	2015[b]	2018	2006[a]	2009[b]	2012[b]	2015[b]	2018
Below level 1c	2.2	0.1	0.2	0.4	0	5.2	0.3	1	1.6	0.2
Level 1c					0.5					1.9
Level 1b		1.5	1.1	3.1	3		5.5	3.8	5.6	6
Level 1a	9.7	7.9	5.4	10	10.7	13.2	14.9	11.6	13.6	13.2
Level 2	23.2	22.2	16.9	21.1	21.1	25.4	27	19.4	23.8	22.5
Level 3	34.7	36.2	30.1	32.3	28.9	33.3	31	29.7	30.4	26
Level 4	24.1	24.9	31.5	24.6	23.8	19.3	17.2	25.8	19.6	20.3
Level 5	6.1	6.5	12.8	7.7	9.9	3.5	3.1	7.9	4.9	8.6
Level 6		0.6	1.9	0.8	2		0.2	0.9	0.4	1.2

Note [a]The lowest reading level of 2006 is only classified as level 1a, and the highest is only classified as level 5
[b]The lowest reading level for 2009, 2012 and 2015 is only classified as level 1b
Source OECD (2019b, c), PISA 2018 Database, Tables II.B1.7.2, II.B1.7.4 and II.B1.7.6
OECD (2016a, b), PISA 2015 Database, Tables B2.I.3, B2.I.7 and B2.I.11
OECD (2013, 2014), PISA 2012 Database, Tables I.2.2a, I.4.2a and I.5.2a
OECD (2010a, b), PISA 2009 Database, Tables I.2.2, I.3.2 and I.3.5
OECD (2007a, b), PISA 2006 Database, Tables 2.1b, 6.1b and 6.2b

students and 14.2% of female students read below level 2; these figures were lower than the corresponding 2018 OECD averages of 27.6% and 17.5%, respectively. However, these figures were also greater than those for low-performing Taiwanese students in PISA 2009: 20.7% of male students read below level 2 in 2009 compared with 21.3% in 2018, and 9.5% of female students read below level 2 in 2009 compared with a significant increase to 14.2% in 2018.

The greater improvement of male students in reading from 2009 to 2018 may be attributable to the new computerized format of PISA 2018. Previous studies have found that Taiwanese male students had lower motivation for printed reading than female students (e.g. Sung et al. 2003). The PISA 2018 survey also showed that Taiwanese male students had less interests in reading and spend considerably more leisure time on using ICT than their female counterparts. These findings seem to suggest that digital reading may be more attractive than printed reading for male students. They may have tended to be more interested and engaged in the PISA test when it was administered through a computer as opposed to through paper-and-pencil. If this explanation is correct, then teachers can use digital reading to encourage reading in male students.

In contrast to the large gender gap in reading performance, the gender gaps among Taiwanese students in mathematics and science were smaller. In PISA 2018, male students slightly outperformed female students by 4 points in mathematics and 1 point in science, albeit nonsignificantly so. Such non significance was also noted for previous PISA surveys, except for PISA 2006, where male students outperformed female students by 13 and 7 points in mathematics and science, respectively.

This small gender gap in mathematics and science performance among Taiwanese students may be attributable to the following reasons. First, the Taiwan government has adopted a policy of cultivating female talent in science and technology. To address the gender disparity in STEM fields and to attract more young women into STEM, Taiwan's Ministry of Science and Technology has consistently invested money into promoting female role models as well as hands-on STEM activities and research opportunities in university laboratories for female secondary school students who have an interest in STEM. Second, the stereotype of STEM being a male field has become less entrenched in Taiwanese society, particularly among parents and teachers; girls are encouraged to pursue any field they may be interested in. Consequently, more female high school students have expressed interest in pursuing further study in a STEM field.

3.3 Social Equity in Learning Outcomes

Interschool disparities due to social stratification may affect students' learning opportunities and, by implication, educational outcomes. Educational systems with low interschool variability typically have high education equity. For example, in Finland, interschool variability in reading performance constituted less than 10% of the total variability for the country (OECD 2019d). Figure 6 presents the trend for interschool

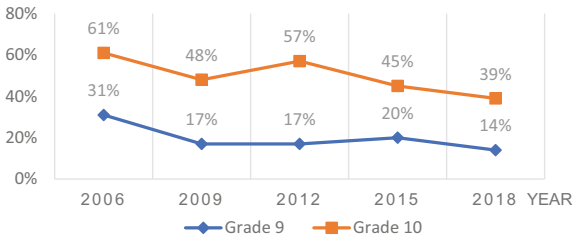

Fig. 6 Variation in reading among schools by grade (2006–2018)

variability in Taiwan with regard to PISA reading performance. In Taiwan, 15-year-old students are mainly in grade 9 or 10. Grade 9 students are mostly in junior high schools in their neighbourhood, whereas grade 10 students are in senior high schools or vocational high schools, as primarily determined through the aforementioned admission system. Therefore, interschool differences in grade 10 are affected by the CAP examination, resulting in higher variation in grade 10 than in grade 9. As indicated in Fig. 6, interschool variation for reading in 2018 were the lowest ever. The total variation for the grades 9 and 10 decreased respectively from 61 and 31% in 2006 to 14 and 39% in 2018. This result suggests an improvement in educational equity in Taiwan from 2006 to 2018.

High educational equity can also be indicated by a low correlation of socioeconomic status with educational attainment in general and literacy performance in particular. The PISA index of economic, social, and cultural status (ESCS) enables a comparison between students and schools of different socioeconomic profiles. The ESCS slope of Taiwan in 2018 was equal to the OECD average, where a one-unit increase in ESCS was associated with a 37-point increase in the PISA reading score. ESCS explained 11.4% of the variance in Taiwanese students' reading performance, which was slightly lower than the corresponding figure of 11.7% in 2009.

Due to the increase in the standard deviation of Taiwanese students' reading performance across the PISA surveys, the total variation (sum of between- and within-school variation, see Table 4) gradually increased. However, variation in reading performance among schools did not change considerably over the years, while the proportion of between-school variation decreased from 47% in 2006 to 29% in 2018. This indicated that the performance difference between schools in Taiwan has been decreasing and the equity in education has been improved. Conversely, from Year 2006 to Year 2018, a one-unit increase in student ESCS level was associated with an increase 14–18 score points in reading performance. This suggested that the relationship of student ESCS and reading performance remained relatively stable from 2006 to 2018. Meanwhile, if the school ESCS level increased one unit, the school reading performance could increase 84–96 score points. In other words, the relationship between school ESCS and school reading performance was stronger than that between student ESCS and student reading performance.

The variation between schools and variation within schools in reading performance could be further explained by student ESCS and school ESCS. For example, student ESCS level explained 8.1% (2015) to 10.8% (2012) of the variation in reading

Table 4 Gradient decomposition of the PISA index of ESCS into inter- and intra-school components in reading assessment (2006–2018)

Year	Total variation	Variation between schools (%)	Variation within schools (%)	Change in reading performance associated with a one-unit increase in student ESCS level	Change in school reading performance associated with a one-unit increase in school ESCS level	Explained variance in student ESCS level (%)			Explained variance in student and school level ESCS (%)		
						Total variation	Variation between schools	Variation within schools	Total variation	Variation between schools	Variation within schools
2018	10,370	3042 (29)	7328 (71)	17	90	8.7	23.1	2.7	23.0	72.1	2.7
2015	8668	2904 (34)	5764 (66)	15	95	8.1	19.8	2.2	24.6	69.0	2.2
2012	8214	3201 (39)	5013 (61)	18	94	10.8	22.4	3.4	29.5	70.4	3.4
2009	7357	2515 (34)	4842 (66)	17	84	9.1	20.4	3.2	23.5	62.4	3.2
2006	7060	3322 (47)	3738 (53)	14	96	8.2	14.7	2.5	28.5	57.7	2.6

Source OECD (2019b), PISA 2018 Database; OECD (2016a), PISA 2015 Database; OECD (2013), PISA 2012 Database; OECD (2010a), PISA 2009 Database; OECD (2007a) PISA 2006 Database

Table 5 Mean score and variation in reading performance by urbanization level

Year	Urban		Suburban		Rural	
	Mean	SD	Mean	SD	Mean	SD
2018	524	102	495	99	475	96
2009	510	85	484	82	454	86

Source OECD (2019b), PISA 2018 Database; OECD (2010a), PISA 2009 Database

performance. If it was coupled with school ESCS, the explained proportion of total variation increased to 23.0% (2018) to 29.5% (2012). Addition of school ESCS amplified the variation in reading performance between schools. As seen in Table 4, the explained variance ranging from 14.7% (2006) to 22.4% (2012) was increased to a range from 57.7% (2006) to 72.1% (2018). Apparently and not surprisingly, school ESCS can explain the reading performance variation between schools. To further understand the impact of school ESCS, we narrowed our focus on results of 2009 and 2018 as reading literacy was assessed in both years. The total variation in reading performance explained by student ESCS was 9.1% and 8.7%, respectively; together with school ESCS, the total variation explained was increased to 23.0% and 23.5%, respectively. The increase by school ESCS in explaining the total variation was about 14%, which was roughly the same in both years. In terms of the variation in reading performance between schools, however, the explained variance was increased from 20.4 to 62.4% in 2009 and from 23.1% to 72.1% in 2018, when school ESCS was added to the model after student ESCS was already in. The 42% increase in 2009 and the roughly 50% increase in 2018 indicated that school ESCS played a more dominant role in explaining school differences in reading performance, after nearly ten years. To sum up, the results above implied that ESCS was an essential factor to equity in Taiwan's education, especially school ESCS.

The urban–rural gap also implicates educational equity. Table 5 presents the 2009 and 2018 reading performance of students from regions of different urbanization levels in Taiwan. According to the research report about the classification of levels of urbanization by Academia Sinica (Hou et al. 2008), we classified Taiwan's PISA-participating schools into three urbanization levels: urban, suburban, and rural. The reading scores for all three urbanization levels improved significantly between 2009 and 2018, by 14, 11, and 21 points for urban, suburban, and rural areas, respectively, where the greatest increase was for students in rural areas. Furthermore, the urban–rural gap in reading performance narrowed from 56 to 49 points, both in favour of urban students, from 2009 to 2018.

The increasing mean reading scores for students from the three urbanization levels and the decreasing urban–rural gap in reading performance indicate the effectiveness of government investment into reading educational resources for the past 10 years. The MOE has, since 2001, implemented a series of reading education projects. For example, the 2006–2008 *Reading Promotion Project for Schools in Rural* Areas was aimed at providing library resources, teacher training on reading instruction, and reading promotion activities for schools in less wealthy rural areas. The 2008

Reading 101: Reading Promotion Project and 2017 *Promotion of Reading Education Project* were also focused on teachers' professional development in reading instruction, in addition to training teachers librarians, developing reading materials, improving schools' reading resources, improving the books and equipment of school libraries, providing funding to schools in rural areas for reading resources, and presenting awards to teachers with excellent performance in reading promotion.

4 Taiwan's Performance in TIMSS and PIRLS

Taiwan has also participated in other ILSAs. Tables 6 and 7 detail the performance of Taiwanese students in PIRLS and TIMSS, respectively. As indicated in Table 6, grade 4 students in Taiwan have improved consistently and significantly from PIRLS 2006 to PIRLS 2011 and 2016. In 2016, PIRLS implemented a computer-based assessment. The score of Taiwanese students in the computer-based assessment was 546 points, which was significantly lower than the 559 points in the paper-based assessment.

Table 6 Taiwanese students' performance in PIRLS and ePIRLS

Year	PIRLS	ePIRLS
	Mean (SE)	Mean (SE)
2006	535(2.0)	
2011	551(1.8) ▲	
2016	559(2.0) ▲	546(2.0) ■

Note ▲More recent year significantly higher, ■ Difference in PIRLS and ePIRLS statistically significant
Source Mullis et al. (2017)

Table 7 Taiwanese students' performance in TIMSS

Year	Mathematics		Science	
	Grade 4	Grade 8	Grade 4	Grade 8
	Mean(SE)	Mean(SE)	Mean(SE)	Mean(SE)
1999	–	585 (4.2)	–	569 (4.2)
2003	564 (1.8)	585 (4.6)	551 (1.8)	571 (3.5)
2007	576 (1.8) ▲	598 (4.6) ▲	557 (2.0) ▲	561 (3.6) ▼
2011	591 (2.0) ▲	609 (3.2) ▲	552 (2.2)	564 (2.3)
2015	597 (1.9) ▲	599 (2.4) ▼	555 (1.8)	569 (2.1)

Note – only eighth graders in TIMSS 1999 surveys, ▲More recent year significantly higher, ▼More recent year significantly lower
Source Mullis et al. (2016)

TIMSS did not implement a computer-based assessment until TIMSS 2019, and the present results are thus based on the results of the paper-based TIMSS assessment. As shown in Table 7, Taiwan's grade 4 students have continued to improve in mathematics and maintained their performance in science, and Taiwan's grade 8 students had the best mathematics performance in 2011, with a slight decline in 2015. Taiwanese students' performance in science have remained relatively stable, except for TIMSS 2007. Compared with the results in 2003, the grade 4 students' science scores in 2007 improved significantly, while the grade 8 students' scores decreased significantly.

Although the sampling targets are different in the three ILSAs, the target populations are all within the range of basic education in Taiwan. Also, Taiwan has accumulated 3 or 5 survey results in these ILSAs. Figure 7 attempts to present the evolutionary trend of Taiwanese students' performance on these three ILSAs. The evidence provided by PISA on students' performance does not seem to align with the results from PIRLS and TIMSS. As for reading, PISA has a hump-shaped trend and PIRLS has a positive, but flattening trend. The positive trend of the PIRLS results fails to replicate and extend to PISA. One important reason might be that the 15-year-old students in PISA put most of their effort into the high-stakes test— CAP and they did not try their best in PISA as the grade 4 students did in PIRLS.

As for math, PISA has a gradual downward trend and TIMSS has a hump-shaped trend in grade 8 but a positive trend in grade 4. The different trends between 8th and 4th graders in TIMSS-math are similar to those between PISA and PIRLS in reading performance. We do concern whether the trend of TIMSS-math of 8th grade

Fig. 7 Taiwanese students' performance in PISA, PIRLS, and TIMSS

is going to evolve into a downward trend, like in PISA math. More information will be obtained to examine this concern after the results of TIMSS 2019 come out. The evolutionary trends of science between PISA and TIMSS are roughly stable. At a closer check, it reveals that the PISA results show a flat but slight downward trend and the TIMSS results show a flat but slight upward trend.

The inconsistency between the trend found in the math and science performance in PISA and TIMSS was understandable. PISA aims to assess 15-year-olds' mathematic and scientific literacy, while TIMSS relates more to the curriculum and instruction. The trend of the TIMSS results indicated that Taiwanese students had acquired a great deal of what has been taught in their math and science classes.

5 Concluding Remarks

From 2009 to 2018, the percentage of top performers of reading in Taiwan doubled from 5 to 11%. However, the disparity in reading literacy among Taiwanese students has also increased (standard deviations were 84 for 2006 and 102 for 2018) due to the much greater proportion of top performers and slightly greater proportion of low performers.

The gender gap in Taiwan's PISA scores was significantly smaller than the OECD average. This gender gap also narrowed significantly from PISA 2009 to PISA 2018 because of improved reading performance among male students and constant reading performance among female students. However, PISA 2018 results indicated a significantly increased gap between Taiwan's high and low performers in reading; this gap was higher than 260 points, which is equivalent to 6–7 school years. Greater effort should thus be made to reduce this gap in reading performance. For instance, reading instruction in rural and suburban schools should be strengthened by providing teachers with professional development programs and instructional resources. Assistance programs should also target the students whose reading literacy are below level 2 in PISA. Instruction should be tailored to the student's reading levels so that every student can be nurtured by the scaffolding appropriate for them.

Since 2018, PISA has adopted computer-based adaptive testing and employed diverse materials and reading elements to simulate the conditions of reading on the Internet. Such testing requires students to evaluate the quality and credibility of information as well as to detect and resolve conflicts between pieces of information. These have rarely been the focus of traditional teaching and paper-and-pencil assessments in Taiwan. To enhance Taiwanese students' reading performance, in addition to encouraging students to be more proactive toward reading, digital reading instruction and assessment should be included in schools. Teachers should also instruct students on how to read strategically as well as formulate and clarify reading goals.

Although mathematics and science were not the main assessment domains in PISA 2018, several facets of trends in PISA scores for mathematics and science still allow countries to track student performance. Taiwan's outstanding performance

in mathematics and science education has been the cornerstone of its competitiveness. The mathematics and science scores in 2018 did not change considerably from the scores in the previous surveys, and Taiwan has maintained its excellent performance, remaining in the top group globally and having significantly higher scores relative to the OECD average. The proportion of top performers in mathematics and science declined moderately between 2015 and 2018, and the proportion of low performers increased. The difference between high and low performers in PISA scores for mathematics and science has decreased slightly over time.

The global demand for highly skilled technical human resources has been rapidly growing and the competition for talent has thus intensified across the globe. Examining students' performance in reading, mathematics, and science helps countries evaluate their future talent pool. The percentage of Taiwanese students who were top performers in all three domains was 6.7%, which was twice the OECD average. However, 9.0% of Taiwanese students were low performers in all three domains. This figure merits attention despite being lower than the OECD average, where low-performing students will face difficulties in their careers and further study. Educators must continue to provide high-quality and differentiated instruction to support these students.

PISA attaches great importance to educational equality, and its results serve as a reference indicator that allows for comparison across countries, in addition to elucidating interschool variation, gender gaps, and urban–rural gaps, and the relationship between student SES and educational performance. The correlation between ESCS and reading performance among Taiwanese students was similar to the OECD average. This correlation decreased slightly from 2009 to 2018. The proportion of interschool variation decreased from 32% in 2009 to 29% in 2018. As for the gender gap, the male–female gap in reading PISA scores decreased from 37 to 22 points from 2009 to 2018, both in favour of female students. The urban–rural gap in Taiwan's reading PISA scores narrowed slightly from 2009 to 2018. Overall, Taiwan's education parity indicator indicated a slight improvement in educational equity from 2009 to 2018.

After PISA 2000, educational policymakers in many countries have referred to PISA results in their initiation of educational reforms. Although Taiwanese education policymakers do not undertake educational reforms based on PISA results alone, participation in PISA helps Taiwanese policymakers and educators to not only familiarize themselves with the concepts of literacy but also track the literacy performance of Taiwan's 15-year-old students using a globally held framework. Therefore, the *Curriculum Guidelines of 12-Year Basic Education* focus on core competencies, which are used as the basis of curricular development to ensure continuity between educational stages and integration between domains and subjects. The concept of core competencies encompasses the information, skills, and attitudes that a person ought to possess in their daily life and in the face of future challenges. The concept of core competencies underscores how learning should not be limited to the knowledge and skills taught in school and should instead engage real-life scenarios and emphasize holistic development through action and self-development. The new curriculum

in Taiwan's 12-year basic education policy is undoubtedly consistent with the notion of literacy measured in PISA.

Based on Taiwanese students' performance in PISA 2018, we strongly recommend the provision of more assistance to students who read below level 2 proficiency. We also recommend a focus on problem-solving skills and self-regulation in learning among students as well as the promotion of teachers' professional skills in literacy-based instruction and assessment. These recommendations are likely to be realized through the implementation of Taiwan's 12-year basic education policy, which will likely result in better performance in future PISA assessments by Taiwanese students.

References

Chen, C., & Stevenson, H. W. (1989). Homework: A cross-cultural examination. *Child Development, 60*(3), 551–561.

Consultation Committee of Education Reform. (1996). *The consultants' concluding report on education reform.* Retrieved from https://www.naer.edu.tw/files/15-1000-7992,c1315-1.php?Lang=zh-tw.

Fejgin, N. (1995). Factors contributing to the academic excellence of American Jewish and Asian students. *Sociology of Education, 68*(1), 18–30. https://doi.org/10.2307/2112761.

Hou, P. C., Tu, S. H., Liao, P. S., Hung, Y. T., & Chang, Y. H. (2008). The typology of townships in Taiwan: The analysis of sampling stratification of the 2005–2006 "Taiwan Social Change Survey". *Survey Research—Method and Application, 23,* 7–32 https://doi.org/10.7014/tcycffyyy.200804.0007.

Lin, S. W., Hung, P. H., & Lin, F. L. (2013). *A remedial action based on Taiwanese students' results of TIMSS*. Paper presented in the 5th IEA international research conference, Nan-yang Technological University, Singapore.

MOE. (2010). *Education report of the Republic of China.* Retrieved from https://www.naer.edu.tw/files/15-1000-2976,c551-1.php.

MOE. (2013). *MOE talent white paper.* Retrieved from https://ws.moe.edu.tw/001/Upload/3/RelFile/6315/6919/%E6%95%99%E8%82%B2%E9%83%A8%E4%BA%BA%E6%89%8D%E5%9F%B9%E8%82%B2%E7%99%BD%E7%9A%AE%E6%9B%B8.pdf.

MOE. (2014). *The curriculum guidelines of 12-Year basic education: general guidelines.* Taipei, Taiwan: Department of Statistics of the Ministry of Education.

MOE. (2019). *The 2019 edition of "Education Statistics of the Republic of China"*. Taipei, Taiwan: Department of Statistics of the Ministry of Education. Retrieved from http://stats.moe.gov.tw/files/ebook/Education_Statistics/108/108edu_ODF.htm.

MOE. (n.d.). Educational reform. Retrieved from http://history.moe.gov.tw/policy.asp?id=7.

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 International Results in Mathematics.* Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/timss2015/international-results/.

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2017). *PIRLS 2016 International Results in Reading*. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/pirls2016/international-results/.

OECD. (2007a). Database-PISA 2006. Retrieved from https://www.oecd.org/pisa/data/database-pisa2006.htm.

OECD. (2007b). *PISA 2006: Science competencies for tomorrow's world*. Paris: OECD Publishing.

OECD. (2010a). Database-PISA 2009. Retrieved from https://www.oecd.org/pisa/pisaproducts/pisa2009database-downloadabledata.htm.

OECD. (2010b). *PISA 2009 results (Volume I): What students know and can do: Student performance in reading*. Mathematics and Science: OECD Publishing, Paris.
OECD. (2013), Database-PISA 2012. Retrieved from https://www.oecd.org/pisa/data/pisa2012database-downloadabledata.htm.
OECD. (2014). *PISA 2012 results (Volume I): What students know and can do: Student performance in Mathematics, reading and Science*. Paris: PISA, OECD Publishing.
OECD. (2016a), PISA 2015 Database. Retrieved from https://www.oecd.org/pisa/data/2015database/.
OECD. (2016b). *PISA 2015 results (Volume I): Excellence and equity in education*. Paris: PISA, OECD Publishing.
OECD. (2019a). *Chinese Taipei—Country Note—PISA 2018 Results*. Retrieved from http://www.oecd.org/pisa/publications/PISA2018_CN_TAP.pdf.
OECD. (2019b). 2018 database—PISA. Retrieved from https://www.oecd.org/pisa/data/2018database/.
OECD. (2019c). *PISA 2018 results (Volume I): What students know and can do*. Paris: PISA, OECD Publishing. Retrieved from. https://doi.org/10.1787/5f07c754-en.
OECD. (2019d). *PISA 2018 results (Volume II): Where all students can succeed*. Paris: PISA, OECD Publishing. Retrieved from. https://doi.org/10.1787/b5fd1b8f-en.
Sung, Y-T., Liu, P-Y., & Chien, H-Y. (2003). A report on the revision of the Motivations for Reading Questionnaire of the fifth- to seventh-grade students. *Psychological Testing, 50*(1), 47–71. https://doi.org/10.7108/PT.200306.0047.
Stevenson, H. W., Chen, C., & Lee, S. Y. (1993). Mathematics achievement of Chinese, Japanese, and American children: Ten years later. *Science, 259,* 53–58. https://doi.org/10.1126/science.8418494.
Tan, C. (2015a). Teacher-directed and learner-engaged: Exploring a Confucian conception of education. *Ethics and Education, 10*(3), 302–312.
Tan, C. (2015b). Education policy borrowing and cultural scripts for teaching in China. *Comparative Education, 51*(2), 196–211.
Tan, C. (2017). Confucianism and education. *Oxford Research Encyclopedia of Education.* Retrieved from https://oxfordre.com/education/view/10.1093/acrefore/9780190264093.001.0001/acrefore-9780190264093-e-226.
Wei, M. H., & Eisenhart, C. (2011). Why do Taiwanese children excel at math? *The Phi Delta. Kappan, 93*(1), 74–76.

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