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PISA-Scientific Literacy and Regional Socio-Demographics: A Causal-Comparative Study

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Abstract

This study determined the relationship between regional PISA-scientific literacy and socio-demographics in the Philippines, specifically in terms of household-related socio-demographics, school-related socio-demographics, regional competitiveness, and regional budget allocation on education. Utilizing quantitative descriptive causal-comparative research to explore the association between 2018 PISA scientific literacy scores and socio-demographic profiles of each region in the Philippines. The data were obtained from various government agencies such as the Department of Education, the Philippine Statistics Authority, the Department of Budget and Management, and the Department of Trade and Industry. It was revealed that certain regions in the Philippines had higher or lower scores in PISA-scientific literacy and that these scores were associated with various socio-demographics. Specifically, socio-demographics related to household conveniences, showed a significant correlation with PISA-scientific literacy score. It was also found a moderate positive correlation between PISA-scientific literacy score and school-student ratio, as well as in the regional budget allocation on education. In conclusion, this study provided valuable insights into the factors that influence PISA-scientific literacy in the Philippines and highlighted the need for concerted efforts to address the challenges faced by the education sector in the country. As suggested that interventions should be implemented to address poverty incidence among families, promote equitable access to technologies that aid learning and socialization, and enhance the school environment experience that fosters better learner socialization and interaction during growing diversity of learners. It was recommended to emphasize the importance of allocating equitable budget on education across regions and redirecting education intervention efforts to least performing regions in terms of PISA-scientific literacy.

Introduction

The Programme for International Student Assessment (PISA) was designed and developed by the Organisation for Economic Co-operation and Development (OECD) in the late 1990s as an ongoing, periodic international comparative study that primarily gathers indicators of student characteristics and proficiencies (OECD, 2020).

PISA-participating countries benefit from reports that assess students' readiness, based on public policy issues and the ability of students to apply their knowledge and skills (OECD, 2020). Scientific literacy, one of the domains measured by PISA, is useful for measuring and comparing the extent to which students are knowledgeable and skilled in applying scientific knowledge in various contexts.

The importance of applying scientific knowledge and skills in real-life situations necessitates an intensive promotion of scientific literacy in schools, as it prepares the next generation to be significant, scientifically literate participants in the preservation of a just, democratic society.Recent research has identified various factors influencing scientific literacy, including a student's economic, social, and cultural status (Demir, 2016), a teacher's attitude toward scientific literacy (Dragoș and Mih, 2015), a student's science attitudes and interests (Jannah et al., 2020), a student's aptitude and level of training (Shaffer et al., 2019), and English proficiency (Martinez-Hernandez et al., 2015; Palines and Ortega-Dela Cruz, 2021). However, the present study aims to explore socio-demographics to determine their causal effect on PISA scientific literacy.

The social utility of scientific literacy is particularly significant in the current age of pandemics and misinformation. Scientific literacy serves as a weapon to combat misinformation (International Commission on the Futures of Education, 2020), a means to restore trust in scientific knowledge (Motoki et al., 2021; Rutjens et al., 2017), a tool for social transformation (Valladares, 2021), and a key to societal development (Reddy, 2021; Ilgaz, 2019). In light of these considerations, the current study attempts to rationalize support for the promotion of scientific literacy among students in basic education while considering an array of socio-demographic factors that may directly or indirectly affect student performance."

Apparently, the Philippines scored far below the average for scientific literacy when it joined PISA for the first time in 2018. This effort highlighted the initiative of the Department of Education to measure educational learning outcomes against global standards and country performances on education. The Philippines' 15-year-old learners were assessed to establish a baseline data on which the government can work (DepEd, 2019).

In light of the PISA 2018 scientific literacy result, there is much more to accomplish. The Philippines lagged behind participating developing countries. Scores sink to Level 1b in terms of scientific literacy—this is the lowest level of attainment in scientific literacy (See OECD PISA 2018 database; OECD, 2019b). In terms of Scientific Literacy, the Philippines performed significantly worse than all ASEAN countries that took part in PISA 2018. In PISA 2018, the Philippines received an average Scientific Literacy score of 357 points, significantly lower than the OECD average of 489 points. Filipino students' average score falls within Proficiency Level 1a. As a result, a typical 15-year-old Filipino student can recognize or identify explanations for scientific phenomena using basic science knowledge. They can conduct structured scientific investigations with no more than two variables with additional guidance (DepEd, 2019).

Nevertheless, the DepEd is optimistic towards the challenges posed by the result of PISA 2018 by joining large-scale assessments such as PISA, Southeast Asia Primary Learning Metrics (SEA-PLM), and Trends in International Mathematics and Science Study (TIMSS). The findings of the large-scale assessments will be used

to inform DepEd'sSulongEduKalidad campaign. SulongEduKalidad ("boost or push education quality") is DepEd's rallying cry for a national effort to improve education quality, guided by a masterplan to implement aggressive reform in four key areas: (1) K-12 curriculum review and updating; (2) learning environment improvement; (3) teachers' upskilling and reskilling through a transformed professional development program; and (4) engagement of stakeholders for support and collaboration (DepEd, 2019).

The optimistic standpoint towards the poorly faring performance on PISA 2018, with an emphasis on scientific literacy, is shared by Filipino researchers. Cordon and Polong (2020) argue that the government is continuing to improve integration efforts from teachers, schools, and curriculum, despite the fact that the results of students' science literacy in PISA 2018 were insufficient. In view of this, Palines and Ortega-Dela Cruz (2021) recommend that school leaders must increase moral and financial support to science departments, and, establish linkages with local government units to acquire science and technology laboratory equipment.

Reflecting on the dire achievement of Philippines' 15-year-olds compared globally, scientific literacy can serve as a tool that will bring about change to society. Scientific discoveries and technological advancements lead to dramatic transformation of how people live throughout history. Past ages are also testaments that allowed humanity to thrive through scientific knowledge. The benefits that can be obtained from becoming a scientifically literate individual will never be discounted especially in an age of information and interconnectedness. Scientific literacy allows society to be developed (Reddy, 2021) and transformed (Vallardares, 2021). Scientifically literate citizens propel society to a more just and democratic place to live in (Yacoubian, 2017).

Scientific literacy and society, then, have a mutual and inextricable relationship. Evidently, as argued earlier, scientific literacy benefits society to becoming developed. But, then, society shapes the landscape for scientific literacy. Countries with higher scores on scientific literacy in the 2018 PISA results have developed economies such as those found in East Asia, North-Western Europe, and North America. When there is strong support for science education, there is a chance that performance in scientific literacy will improve.
But how about developing countries such as the Philippines? Poor performance in large-scale assessments may be linked to development challenges of the country.

Back in 2018, the baseline year for this study, International Monetary Fund (IMF, 2018) reported that rising inflation, tighter global financial conditions, and persistent poverty and inequality posed challenges for the Philippines. Inflation is being driven by higher excise taxes, rising global energy prices, a weaker peso, and difficulties in managing rice supply. Bank credit outpaced economic growth. Physical and human capital drove digital divide.Development indicators, measured as socio-demographics, such as access to social services, school infrastructures and rural-urban disparities may be associated with student performance—at least at the macro level of analysis, which this study hopes to endeavor. When performances are compared across regions, one is tempted to hypothesize that they are positively related to certain socio-demographics to some extent. Students scoring at the bottom of performance on scientific literacy seem to be found in regions 8, 9, and 12 (DepEd, 2019). These are among the regions with high poverty incidence (PSA, 2020) as an example for socio-demographics.

Other socio-demographics describing the regional contexts such as household and school demographics, regional competitiveness and budget allocation will be explored in this study. There may be optimism in the study of large-scale assessment on scientific literacy (e.g., Cordon and Polong, 2020) and its implication to societal development, but the literature in this field is scanty. Moreover, researchers recommend that an in-depth study of the relationship between PISA and certain socio-demographics—like family and school—may be conducted to explore "puzzling results" (Orbeta, Jr. et al., 2021).

By exploring multiple socio-demographics such as household-related and school-related demographics, regional competitiveness, and regional budget allocation on education that significantly relate with PISA scientific literacy performance of the Philippines, a conglomerate of knowledge will be established to serve as a basis for education policy framework. To elevate the performance of regions with lower PISA scientific literacy scores, a comprehensive educational policy framework is needed. This framework should take a holistic approach to address the various factors that contribute to low performance in scientific literacy.

There is much to do with the Philippine's performance in scientific literacy. Science educators must be at the forefront of instruction and policy implementation. But the challenge has just begun for science educators in terms of the baseline data provided by different large-scale assessments entered into by the Department of Education. In this regard, this study contributed to a growing interest on a large-scale assessments of educational learning outcomes in the Philippines through the perspectives of a science educator. This study, then, investigated the link between learner's scientific literacy performance and regional sociodemographic development indicators across the regions of the country in order to develop a framework that helps achieve higher PISA-scientific literacy.

Methods

This study aimed to determine the causal relationship of regional PISA-scientific literacy with certain regional socio-demographics in the Philippines. Specifically, this study sought to answer the following problems: (a) Is there a significant correlation between the socio-demographics and PISA-Scientific Literacy score? And (b) What educational policy framework can be proposed to improve regional performance in PISA-scientific literacy?This study utilized a quantitative, descriptive, causal-comparative research or ex post facto research, a method to determine the relationship of 2018 PISA scientific literacy scores with socio-demographic profiles of each region in the Philippines.

Causal-comparative research seeks to identify the origins or consequences of existing differences between or among groups of people. The basic causal-comparative approach starts with a noted x`difference between two groups and then searches for possible causes or consequences of that difference (Fraenkel et al., 2018). This design was appropriate because the researcher sought to "identify cause-and-effect relationships by forming groups of individuals in whom the independent variable is present or absent, and then determining whether the groups differ on the dependent variable" (Gall et al., 2007; Creswell and Creswell, 2018).
This study attempted to identify regional sociodemographic factors related to the performance of 15-year-old Filipino students in the PISA 2018 results on scientific literacy, thus science is the only learning area considered.

PISA scientific literacy scores and certain socio-demographics were compared between and across all the regions of the Philippines excluding the Negros Island Region and Bangsamoro Autonomous Region in Muslim Mindanao which had recent issues and transitions coinciding with the years near to PISA 2018.
Data collection, retrieval, recoding, reorganization and interpretation were accomplished from December 26, 2022, until February 25, 2023. In cases of unavailability of data for 2018, nearest 2019 data were used.

This study utilized published data from different Philippine government agencies. The 2018 PISA scientific literacy scores were obtained from the 2019 report of Department of Education (DepEd). For the household and school related demographics, data were obtained from Philippine Statistics Authority as published in their 2018 Official Poverty Statistics of the Philippines and the 2019 Annual Poverty Indicators Survey. Regional competitiveness datasets were computed through the online database of Department of Trade and Industry (DTI) on cities and municipal competitiveness index. While the data for the regional budget allocation were obtained from the Department of Budget and Management through the approved General Appropriations Act (GAA) and from the Department of Education's (DepEd) consolidated Statement of Appropriations, Allotments, Obligations, Disbursement and Balances (SAAODB) as of December 31, 2018 Data collection was limited to what is institutionally and officially published, and, to which nearest year of release as compared to PISA 2018. Ex post facto research was utilized in this study thus highlighting its limitation to the most relevant and available data needed.

Results and Discussion

Correlation between the Household-Related Socio-Demographics and PISA-Scientific Literacy Score

Correlation between PISA-scientific literacy score across the household-related sociodemographic profile such as number of families, poverty incidence and average family size is presented in Table 1. Result shows that PISA-scientific literacy score has moderate positive correlation with number of families in 2018 and 2019 with each having a respective r score of .644 and .642 and p-value of .007 and .007 at 0.05 level of significance. Therefore, the null hypothesis is rejected at 0.05 level of significance. This means that as number of families increases across regions, PISA-scientific literacy scores are most likely to increase.PISA-scientific literacy score has also significant moderate negative correlation with poverty incidence among families across all regions. Result yielded an r score of -.627 and a p-value of .009 at 0.05 level of significance.

Thus, the null hypothesis is rejected at 0.05 level of significance. This means that as percentage of poverty incidence among families increases the PISA-scientific literacy scores are most likely to decrease. Regions with higher poverty incidence are most likely to yield a lower student performance in PISA-scientific literacy. This result corroborates the findings that a socioeconomic status of a country is somehow related to success rates in PISA (Bakir, et al., 2015; Kahraman and Celik, 2017).

Findings also reveal a negligible negative correlation between PISA-scientific literacy score and average family size with an r score of -.283 and p-value of .288. The null hypothesis is rejected at 0.05 level of significance. This means that average family size in regions has no relationship with PISA-scientific literacy score.

Table 1. Correlation between PISA-Scientific Literacy Score and Household-Related Socio-Demographics such as Number of Families, Poverty Incidence among Families and Average Size

PISA-Scientific Literacy score	Number of Families (2018)	Number of Families (2019)	Poverty incidence among families (2018)	Average family size (2019)
Pearson r	*.644	*.642	*-.627	-.283
p-value	.007	.007	.009	.288

**Correlation is significant at the 0.05 level (2-tailed)*

Correlation between PISA-scientific literacy score across the household-related sociodemographic profile such as number of families owning household conveniences (cellular phone, television, cable subscription, personal computer, and internet connectivity), number of families who used internet in the last six months, and, family expenditure on education is presented in Table 2.Results reveal that PISA-scientific literacy score has significant moderate positive correlation with number of families owning household conveniences such as cellular phone, television, cable subscription and personal computer with each having a respective r score of .645, .637, .595, and, .673, and a p-value of .007, .008, .015, and, .004. Correlation with household conveniences such as cellular phone, television, and personal computer are significant at 0.05 alpha level, while cable subscription is significant at 0.05 alpha level. This means that regions which have higher number of families owning household conveniences such as cellular phone, television, cable subscription and personal computer tend to have a higher PISA-scientific literacy. Therefore, the null hypothesis is rejected at 0.05 level of significance. Access to such household conveniences plays an important role in a student academic life. These findings agree with Ilgaz et al. (2019), and, Altun and Kalkan (2019) whereby they pointed out that educational inputs and shortage of educational materials are related to PISA-scientific literacy performance.

Contrary to the previous household conveniences, internet connectivity has negligible positive correlation with PISA-scientific literacy score yielding to an r score of .129 and p-value of .633. Thus, in terms of internet connectivity, the null hypothesis is accepted. This means that internet connectivity has no direct relationship with regional student performance on PISA-scientific literacy. However, the present study also found that there exists a significant, moderate positive correlation between the number of families using the internet in a given region and student performance in the PISA scientific literacy assessment, as evidenced by an r score of .678 and a p-value of .004 at a significance level of .05. Based on these findings, the null hypothesis is rejected at the 0.05 level of significance, indicating that regions with higher numbers of families using the internet are more likely to exhibit higher student performance in scientific literacy, as assessed by PISA. These results suggest that internet access plays a role in facilitating student learning and, thus, an important factor to consider in educational policy decisions aimed at improving student performance.

Findings also reveal that PISA-scientific literacy score has significant moderate positive correlation with family expenditure on education yielding to an r score of .685 and a p-value of .003. Thus, the null hypothesis is rejected at 0.05 level of significance. The findings indicate that regions with greater family expenditure on education are more likely to exhibit higher PISA scientific literacy scores. It can be inferred that a higher level of family

investment in education has a positive correlation with regional student performance in PISA scientific literacy. Family expenditure on education can be translated as a direct support to students that affects their emotional and mental state of being given the socio-cultural climate in the Philippines towards family. This somehow agrees with Orbeta, Jr. et al. (2021) that household characteristics such as support are positively correlated with PISA-scientific literacy scores

Table 2. Correlation between PISA-Scientific Literacy Score and Household-Related Socio-Demographics such as Number of Families Owning Household Conveniences, Number of Families Who Used the Internet in the Last Six Months of 2019, and Family Expenditure on Education

PISA-Scientific Literacy score	**Number of Families Owning Household Conveniences (2019)**					**Number of Families who used Internet in the last 6 months (2019)**	**Family expenditure on education (2019)**
	CP	*TV*	*Cable*	*PC*	*Internet*		
Pearson r	*.645	*.637	*.595	*.673	.129	*.678	*.685
p-value	.007	.008	.015	.004	.633	.004	.003

NOTE: CP- Cellular Phone; TV- Television; Cable- Cable Subscription; PC- Personal Computer; Internet- Broadband internet, or fiber internet, or DSL;

**Correlation is significant at the 0.05 level (2-tailed)*

Correlation between the School-Related Socio-Demographics and PISA-Scientific Literacy Score

Correlation between PISA-scientific literacy score across the school-related sociodemographic profile such as teacher-student ration, classroom-student ration, school-student ratio, and, additional classroom requirements is presented in Table 3.Results revealed PISA-scientific literacy score has significant moderate positive correlation with school-student ratio with an r score of .659 and a p-value of .004. correlation is significant at 0.05 level of significance. Therefore, reject the null hypothesis. This means that schools in each region with higher average student ratio are most likely to have higher PISA-scientific literacy score. Student population in regions with higher PISA-scientific literacy tend to be higher and diverse in nature. This may be pointed out to a school climate that nurtures diversity and fosters socialization and interaction among the students. Such learning environment is linked to higher performance in scientific literacy (Palines and Ortega-Dela Cruz, 2021). Altun and Kalkan (2019) also found that school climate affects the performance in PISA-scientific literacy.

On the other hand, there are no observed significant correlation between PISA-scientific literacy score and teacher-student ratio, classroom-student ratio, or, in terms of additional classroom requirements. Each has respective r score of -.203, .350 and -.035, and, a p-value of .452, .184, and .897. The null hypothesis, therefore, is accepted at 0.05 level of significance. This means that teacher and physical classroom environment do not tend to affect PISA-scientific literacy score correlatively. These findings somehow disagree with the conclusions of Palines and Ortega-Dela Cruz (2021) which found that teacher-factors and classroom learning environment affect scientific literacy skills.

Table 3. Correlation between PISA-Scientific Literacy Score and School-Related Socio-demographics such as Teacher-Student Ratio, Classroom-Student Ratio, School-Student Ratio, and, Additional Classrooms Requirements

PISA-Scientific Literacy score	**Teacher-Student ratio** (SY 2018-2019)	**Classroom-Student ratio** (SY 2019-2020)	**School-Student ratio** (SY 2018-2019)	**Additional Classroom Requirements** as of 2019
Pearson r	-.203	.350	*.659	-.035
p-value	.452	.184	.006	.897

**Correlation is significant at the 0.05 level (2-tailed)*

Correlation between PISA-Scientific Literacy Score and Regional Competitiveness

Correlation between PISA-scientific literacy score and average overall regional score on competitiveness is presented in Table 4. Findings reveal that PISA-scientific literacy score has low positive correlation with the average overall score per region yielding to an r score of .345 but p-value of .191. Therefore, the null hypothesis is accepted at 0.05 level of significance. This result means that the computed mean of provincial competitiveness scores that constitute regional score have no direct relation with regional student performance in PISA-scientific literacy. This result opposes the findings of Demir (2016) that performance in PISA-scientific literacy is associated with student's economic, social, and cultural status. It also defies the conclusions of Bakir, et al. (2015) and Kahraman and Celik (2017) that a country's socioeconomic status is linked with success rate in PISA-scientific literacy.

Table 4. Correlation between PISA-Scientific Literacy Score and Regional Competitiveness.

PISA-Scientific Literacy score	**Average Overall Score per Region**
Pearson r	.345
p-value	.191

**Correlation is significant at the 0.05 level (2-tailed)*

Correlation between PISA-Scientific Literacy Score and DepEd Regional Budget Allocation

Correlation between PISA-scientific literacy score and regional budget allocation to DepEd in terms of amount allotted and amount utilized is presented in Table 5. Results reveal that PISA-scientific literacy score has significant moderate positive correlation with amount allotted and amount utilized obtaining an r score of .532 and .528, and, a p-value of .034 and .035. The correlation is significant at 0.05 alpha level; thus, the null hypothesis is rejected. This means that regions that have higher budget allotment from the national government tend to have higher performance in PISA-scientific literacy. Likewise, budget utilization has direct relationship with regional PISA-scientific literacy score. These findings corroborate the studies of Bakir, et al. (2015), Ilgaz et al. (2019),

Kahraman and Celik (2017) and Palines and Ortega-Dela Cruz (2021), which surmise that educational inputs, administrative support, and funding for availability of educational materials are linked to performance in scientific literacy.

Table 5. Correlation between PISA-Scientific Literacy Score and DepEd Regional Budget Allocation

PISA-Scientific Literacy score	Amount Allotted	Amount Utilized
Pearson r	*.532	*.528
p-value	.034	.035

**Correlation is significant at the 0.05 level (2-tailed)*

Educational Policy Framework for Improving Performance in PISA-Scientific Literacy

Figure 1 presents the educational policy framework for improving performance in PISA-scientific literacy based on the findings of the study.

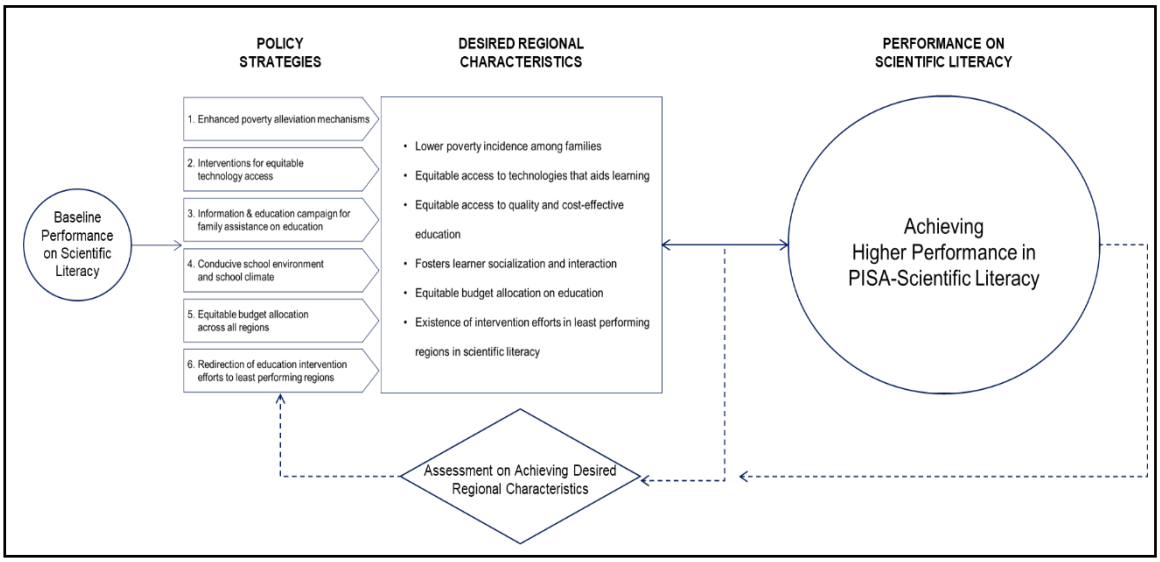

Figure 1. Educational Policy Framework for Improving Performance in PISA-Scientific Literacy

The framework relied on what can be surmised and concluded from the datasets and results presented in this chapter. The framework begins with a baseline performance on scientific literacy and proceeds to policy strategies inferred from this study. First, from the observation that poverty incidence significantly correlates with PISA-scientific literacy, mechanisms must be established and enhanced to alleviate poverty across all regions in the Philippines. Second, technology access aids learning. However, it must be equitable across all regions. Third, programs that promote cost-effective education are already existing but information concerning them needs to be disseminated to support family expenditure on education. Fourth, school environment and climate must be conducive. This happens when the next strategy is satisfied—providing an equitable budget allocation across all regions. Lastly, intervention efforts must be redirected to least performing regions in scientific literacy. Policy strategies have corresponding desired regional characteristics. These characteristics must be congruent with

strategies. Desired regional characteristics serve as an ideal socioeconomic state that is driven to achieving higher performance in PISA-scientific literacy.

Conclusion and Recommendations

The findings of the study revealed that certain regions in the Philippines had higher or lower scores in PISA-scientific literacy and that these scores were associated with various socio-demographics. Specifically, socio-demographics related to household conveniences, such as cellular phones, television, cable subscription, personal computer, and internet use, showed a significant correlation with PISA-scientific literacy score. The study also found a moderate positive correlation between PISA-scientific literacy score and school-student ratio, as well as between PISA-scientific literacy and regional budget allocation on education.

Thus, this study provided valuable insights into the factors that influence PISA-scientific literacy in the Philippines and highlighted the need for concerted efforts to address the challenges faced by the education sector in the country. This study recommends that interventions should be implemented to address poverty incidence among families, promote equitable access to technologies that aid learning and socialization, and enhance the school environment experience that fosters better learner socialization and interaction in the midst of growing diversity of learners. Moreover, the study emphasized the importance of allocating equitable budget on education across regions and redirecting education intervention efforts to least performing regions in terms of PISA-scientific literacy.

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