

Indonesia's Issues and Challenges on Quality Improvement of Mathematics and Science Education

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1. Background

The Republic of Indonesia is a country located in Southeast Asia and Oceania, and comprises 17,508 islands with the area of 1,919,440 square kilometers, about 6,000 of which are inhabited. They are scattered over both sides of equator. Lying along the equator, Indonesia has a tropical climate, with two distinct monsoonal wet and dry seasons. Temperature differs little throughout the year; the average daily temperature range in Jakarta, capital city, is 26 – 30°C, with high humidity with average of about 80%. With a population of 230 million people, it is the world's fourth most populous country and has the world's largest population of Muslims. Its average population density is 134 people per square kilometer, although Java, the world's most populous island, has a population density of 940 people per square kilometer. About 60% of the total Indonesian population lives in Java whose area is about 10% of the whole land area, as can be seen on the map below. Many islands contain rugged mountains, dense jungles, swamps, and valleys. There are around 200 volcanoes, of which 60 are still active. Because of these geographical conditions there are many areas very difficult to reach.

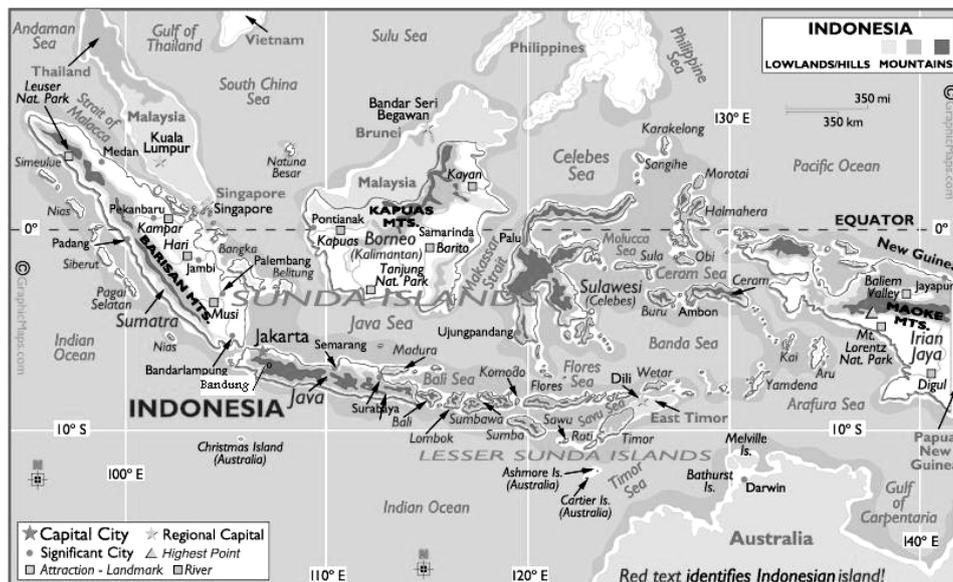


Figure 1 Map of Indonesia

All of these conditions have posed communication/transportation problems among geographical regions and ethnic groups, and the rural/remote areas are deprived of the fruits of development due to delivery problems. As far as education is concerned, people in such areas cannot be easily and adequately equipped with textbooks, curriculum guidelines and laboratories as well as other types of educational service. Some schools in isolated areas are seldom, if ever, visited by their supervisors and their teachers, for many reasons, rarely have the opportunity to attend in-service training. Another problem is related to young teacher's reluctance to take up teaching appointments in these areas. This has partly resulted in the mismatched teaching assignment.

Throughout Southeast Asia, Indonesia has the greatest diversity of culture due to differing histories of the people's contact with and responses to the outside world. In spite of all these differences, people are united by being "Indonesian" as clearly expressed in the motto "Bhineka Tunggal Ika" or "Diversity in Unity". The pluralistic nature of the Indonesia society requires that people tolerate differences in order to establish a peaceful and harmonious life. Understanding each other's customs and ways of thinking is then a necessity.

Indonesia has abundant natural resources such as metallic minerals (gold, silver, nickel, etc.), oil, and natural gas; rain forests with their biodiversity; seas with their various types of fish; and fertile land on which a lot of trees and plants can grow. Indonesia's estimated gross domestic product (GDP) for 2008 is US\$511 billion (nominal) with per capita GDP of US\$2,239. The service is the largest sector in the Indonesian economy accounting for 45% of GDP. This is followed by industry (41%) and agriculture (14%). While major industries are petroleum and natural gas, textile, apparel, and mining, major agricultural products include palm oil, rice, tea, coffee, spices, and rubber.

Indonesia's high population and rapid industrialization present serious environmental challenges, which are often given a lower priority due to high poverty levels and weak, under-resourced government. These issues include large-scale deforestation (much of it illegal), over-exploitation of marine resources, and environmental problems are also associated with rapid urbanization and economic development, including air pollution, traffic congestion, mismanagement of garbage disposal, and lack of reliable water and waste water services. These environmental problems may mean that basic education has not significantly contributed to effective life in the community yet. Disparities of qualified teachers among regions may be considered as one of the contributors to the environmental problems. Moreover due to the decentralized system of government, which has been implemented since 2001, the problem has been worsened by the people's rising regional ego, which has resulted in oversupply of teachers in some areas and undersupply in other areas.

2. School System

The Law No 20 of 2003 (National Education System) stipulates that education in Indonesia be defined as a planned effort to establish a study environment and education process so that the

student may actively develop his/her own potential to gain the religious and spiritual level, consciousness, personality, intelligence, behavior and creativity to him/herself, other citizens and for the nation. According to the constitution, education in Indonesia is divided into two major parts, formal and non-formal. The formal education consists of primary (six years), secondary (first three years for junior secondary and another three years for senior secondary education). The first nine-year education (primary and junior secondary) is compulsory. The Ministry of National Education (MONE) and the Ministry of Religious Affair (MORA) are responsible for education in Indonesia. Indonesia schooling system is shown in Figure 2.

Early childhood education. Children start receiving education at 3, 4, 5 or 6 years of age at play group or kindergarten. The majority of kindergartens are private ones; more than forty-nine thousand kindergartens, 99.4% of the total kindergartens in Indonesia are privately operated.

Basic education: Basic education comprises six-year primary and three-year junior secondary education. Children aged 6 or 7 start attending primary school. This level of education is compulsory for all Indonesian citizens, as stipulated in the national constitution. In contrast to the majority of privately run kindergartens, most primary schools are government operated public schools, accounting for 93% of all primary schools in Indonesia. There are around 22,000 junior secondary schools in Indonesia with a balanced ownership between public and private sector. After graduating from junior secondary school, students may move on to senior secondary school.

Secondary school: There are two different types of schools; senior secondary school generally known as the abbreviation of "SMA" (Sekolah Menengah Atas), and vocational senior secondary school known as "SMK" (Sekolah Menengah Kejuruan). SMA differs from SMK in the purposes and contents of study. The students at SMA are prepared to advance to higher education, while students at SMK are prepared to be ready to work after finishing their school without going to university/college. It is not compulsory to attend high school after nine-year primary and junior secondary education. Islamic senior secondary schools and Islamic vocational senior secondary schools are under the jurisdiction of MORA.

Higher education: After graduation from senior secondary school, students may attend university (higher education). Higher education institutions are categorized in two types: academic education and professional education. There are 3 types of higher education institutions: university, institute, and academy or college. Universities and institutes may have academic education of undergraduate, master, and doctorate programs as well as professional education of diploma 4 (D4), first professional (SP1), and second professional (SP2) programs. Academy or colleges have diploma 1 (D1), diploma 2 (D2), and diploma 3 (D3) programs only.

| Age | Level of Educ | Academic Education | | Professional Education MONE/MORA | | | |
|-----|----------------------------|-----------------------------------|-------------------------------|-------------------------------------|------------------------|-------------------|----------------------|
| | | MORA | MONE | | | | |
| 27 | Higher Education | Islamic Doctorate Program S3 | Doctorate Program S3 | Second Professional Program SP2 | | | |
| 26 | | | | | | | |
| 25 | | | | | | | |
| 24 | | Master Program S2 | Master Program S2 | First Professional Program SP1 | | | |
| 23 | | | | | | | |
| 22 | | | | | | | |
| 21 | | Islamic Under Graduate Program S1 | Under Graduate Program S1 | Diploma 4 Program D4 | Diploma 3 Program D3 | Diploma 2 Program | Diploma 1 Program D1 |
| 20 | | | | | | | |
| 19 | | | | | | | |
| 18 | Secondary school | Islamic SSS | Senior Secondary School (SSS) | Vocational SSS | Islamic Vocational SSS | | |
| 17 | | | | | | | |
| 16 | | | | | | | |
| 15 | Basic Education | Islamic JSS | Junior Secondary School (JSS) | | | | |
| 14 | | | | | | | |
| 13 | | | | | | | |
| 12 | | Islamic Primay School | Primary School | | | | |
| 11 | | | | | | | |
| 10 | | | | | | | |
| 9 | | | | | | | |
| 8 | | | | | | | |
| 7 | | | | | | | |
| 6 | Early Child hood education | Islamic kindergarten | Kindergarten | | | | |
| 5 | | | | | | | |
| 4 | | | | | | | |

Figure 2 Indonesia schooling system

3. Current situation of Indonesian education

Educational statistics for Indonesia for 2007 are summarized in Tables 1 and 2. There were 144,567 primary schools accommodating 26,627,427 students. As to access, gross enrollment ratios are 115.5% for primary, 92.5% for junior secondary and 50.5 % for senior secondary schools respectively, which seem to be relatively good figures. Drop out rates are less than 3% for primary, junior and senior secondary schools, while that for higher education is as high as 12.1%. In terms of pupil/teacher ratio, relatively favorable conditions have been maintained with 18 for primary, 14 for junior secondary and 12 for senior secondary schools. Average class sizes are far bigger than pupil/teacher ratios with 27 (primary), 37 (junior secondary) and 35 (senior secondary). Due to the decentralization of educational administration, teacher allocation policy differs from one region to another resulting in the oversupply of teachers in some areas and undersupply in others.

As far as teachers are concerned, while more than 70% of teachers at secondary schools are qualified (71.1% for junior secondary and 79.7% for senior secondary), only 22.2% are qualified at the primary level. Upgrading of teacher teaching qualification since the 2005 Teacher Law (S1 degree (bachelor degree) required) has created a large number of unqualified teachers particularly at the primary level. Actually many of primary school teachers (47.9% or 691,443 persons) have only D2 (two years education after senior secondary school) certificate. While the proportion of bachelor degree holders looks high at the junior secondary level (69.9%), there are a considerable number of mathematics and science teachers, especially in remote areas, who do not have a bachelor degree in mathematics or science major because not many local teacher training institutions are offering mathematics and science majors. The decentralization of educational administration has negative effects on this issue as well because each regional education administration tends to recruit teachers from local universities/training institutions regardless of their quality. This is also causing mismatch of teachers, which hinders improvement in quality of mathematics and science education.

Table 1 Overview of Indonesian Education (2007)

| Components | PS | JSS | SSS |
|---------------------------|------------|-----------|-----------|
| Schools | 144,567 | 26,277 | 10,239 |
| Students | 26,627,427 | 8,614,306 | 3,758,893 |
| Class size | 27 | 37 | 35 |
| Teachers | 1,445,123 | 621,878 | 305,094 |
| Students to teacher ratio | 18 | 14 | 12 |
| Qualified teacher | 22.15% | 71.18% | 79.74% |

Table 2 Teachers condition (2007)

| Teacher | SSS | D1 | D2 | D3 | S1 | S2 | Total |
|---------|---------|--------|---------|--------|---------|-------|-----------|
| PS | 377,476 | 19,028 | 691,443 | 37,022 | 317,355 | 2,808 | 1,445,132 |
| | 26.12% | 1.32% | 47.85% | 2.56% | 21.96% | 0.19% | 100% |
| JSS | | 48,913 | 36,545 | 90,731 | 434,473 | 8,215 | 621,878 |
| | | 7.87% | 5.88% | 14.60% | 69.86 | 1.32% | 100% |
| SSS | | 6,932 | 5,174 | 34,550 | 236,995 | 6,893 | 305,852 |
| | | 2.27% | 1.69% | 11.30% | 77.49% | 2.25% | 100% |

4. Quality issues of mathematics and science education

Several indicators will be discussed to measure the level of Indonesian quality of human resources as well as mathematics and science education. These indicators include human development index (HDI), Third International Mathematics and Science Study (TIMSS), mathematics and science competitions, and national examinations. Recently, the United Nations Development Program released a report of HDI on October 5, 2009, compiled on the basis of data for 2007. It covers 180 UN member states (out of 192). The HDI is a comparative indicator to measure people's well being, comprising life expectancy, literacy, education and standards of living for countries worldwide. According to the 2007 HDI data, Indonesia is ranked the 111th, below the Philippines (108th), Thailand (87th), Malaysia (66th), Brunei (30th), and Singapore (23th). Considering that education is one of the four HDI components being measured, such a condition indicates that education in Indonesia is still left behind the neighboring countries. Since education quality is closely related to the quality of human resources, Indonesia human resources are still far from being desirable and below that of the neighboring countries.

TIMSS is a comparative international study on mathematics and science achievement. In the field of mathematics and science conducted in 2007. In this study Indonesia is ranked the 36th for mathematics (out of 48 countries), below Thailand (29th), Malaysia (20th), Singapore (3rd), and the 35th for science (out of 48 countries), below Thailand (22th), Malaysia (21th) and Singapore (1st). These data indicate that the quality of mathematics and science education is lower than that of the neighboring countries.

In contrast, although the quality of education in Indonesia is in general far from being desirable, it should be noted that a number of Indonesia students have individually shown indicated world class learning achievements as evidenced in their success in some international mathematics and science competitions, obtaining gold/silver/bronze medals. In 2009, primary school students won 73 medals (gold: 13, silver: 20, and bronze: 40) in four competitions in mathematics and science. Those competitions are listed below.

1. 10th International World Youth Mathematics Intercity Competition in Durban, 5 – 10 July 2009.
2. 3rd Wizards at Mathematics International Competition in Lucknow, 27 Oct – 2 Nov 2009
3. 6th International Mathematics and Science Olympiad for Primary School 2009 (IMSO) in Yogyakarta, 8 -14 Nov 2009
4. International Mathematics Competition in Iloilo city, the Philippines 24 Nov – 2 Dec 2009

Interestingly, individually Indonesian students have reached a high level of intellectual development through quality education, but the average achievement of Indonesian students is below that of their counterparts in the neighboring countries. It is not surprising because it is only few students who won the competition, have good opportunity to access good learning facilities and processes.

Another indicator for measuring quality of mathematics and science education is the results of national examinations. All students of grade 9 (junior secondary school) and grade 12 (senior secondary school) are obliged to take the national examination for main subjects such as Indonesian, English, mathematics, and science for junior secondary school students, and Indonesian, English, mathematics, physics, biology, and chemistry for senior secondary school students majoring in science. The passing point of average score is set by the government at 5.5 for graduation. In 2008/2009, 95% of 2,658,216 participants of junior secondary school students passed the national examination with the average scores of 7.60 for mathematics and 7.32 for science respectively. Similarly, senior secondary school students did well in the national examination, 96% of them (622,058) passing the examination with the average scores of 7.71 for mathematics, 7.93 for physics, 8.30 for chemistry and 7.16 for biology. It seems that students' achievements in the national examinations are better than TIMSS. The different achievements between TIMSS and the national examinations may be explained by the fact that different goals are set and different levels of examination questions are given.

Results of the national examinations for both junior and senior secondary school students have satisfied policy makers and politicians as far as scores are concerned. Unfortunately, the national examinations have negatively affected curriculum implementation. In order for as many students as possible to pass the examinations, teachers tend to have the students memorize contents of the textbooks and teach them techniques about how to answer multiple choice questions by giving them drills. These students do not learn and understand mathematics and science, but merely memorize mathematical and scientific formulas for the examinations.

5. Policy for improvement of education quality

5.1 Teacher certification. Government of Indonesia has done tremendous efforts in improving teacher quality, massive improvement of qualification, competence, certification of teachers and educational personnel. Based on Law No. 14 Year 2005, which stipulated teacher as a profession. Teachers should meet qualification of at least 4-year Bachelor. Lecturers should meet

qualification of at least Master/Ph.D. level. Teachers and lecturers should have teaching certificates. By year 2014, about 1.75 million teachers should achieve qualification of at least 4-year Bachelor, 150,000 lecturers should achieve qualification of at least Master/Ph.D, 2.7 million teachers, and 130,000 full time lecturers should have teaching certificates. The salary of educators should be doubled whenever they get teaching certificates. The progress in 2007, MONE was successful in providing scholarship to 350,000 teachers for qualification upgrading and certification for 147,217 teachers. However, how to maintain the teacher's performance after getting teaching certificates.

5.2 International Class. In responding to globalization issues, Ministry of National Education has established piloting of international classes at all levels (from primary to senior secondary schools) in every district. Public schools which met requirement may propose a number of international classes. Parents pay relative expensive tuition fees for international class. The international classes are equipped with good facilities such as air conditioner and multimedia teaching facilities with good class size of 30 students per class. English is used as medium of instruction in mathematics and science international classes. If parents want for free tuition fees, their children should go to regular class with limited learning facilities. In fact, it is not many students and teachers can communicate in English so students did not engage in depth mathematics and science learning since teacher centered type of teaching dominated mathematics and science classes.

5.3 School-based INSET. Indonesia University of Education in cooperation with MONE and JICA has developed a School-based In-Service Teacher Training under SISTTEMS project (Strengthening In-Service Teacher Training of Mathematics and Science Education at Secondary Level) at District of Sumedang since 2006. The objectives of the project are to develop a model of continuing teacher professional development through subject-based lesson study and to disseminate the best practice of developed INSET to other districts. Sumedang district office of education set up an INSET day, Wednesday for mathematics teachers and Saturday for science teachers. Activity of subject based lesson study was done parallel in 8 working groups twice a month on the in-service training day. Six hundred mathematics/science teachers have participated in the subject-based lesson study. Twenty to forty mathematics or science teachers attended the regular meeting at a school within the working group. Teachers and teacher educators of Indonesia University of Education worked collaboratively to conduct research lesson in promoting student active learning. The developed INSTET has changed teacher's attitude from teaching to learning. Teaching style changed from lecturing to facilitating student active learning. Teachers utilized optimally available science equipment for student experiment. When they did not have science equipment for student experiment, teachers could use local materials. Teachers also asked students to prepare hand-made science equipment. Teachers were more democratic in teaching, let students had different ideas, instead of judging "wrong or right". Teachers learnt from others through observing and reflecting the lesson, so that they put into daily teaching

practice. It was found that disparities in teaching quality between teachers in rural and urban areas were reduced.

6. Conceptual Framework of Schooling System

The model contains inputs (the human and financial resources available to education), processes (what is taught and how it is taught), and outputs (consequences of schooling on students from different backgrounds). Figure 3 depicts how these elements are likely to be logically related.

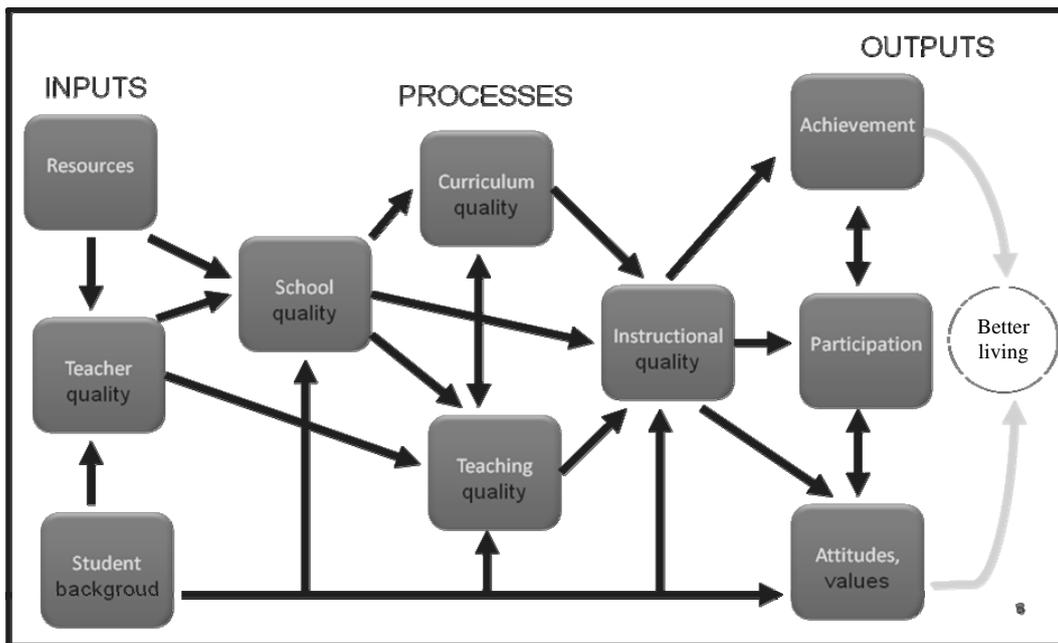


Figure 3 Linkage among educational elements (Shavelson, et al., 1987)

Inputs to education system include fiscal, capital, and human resources, student characteristics, and teacher qualifications, such as teacher credentials. Educational processes may be thought of as a set of nested systems. School translates resources into education, it creates an academic ethos that establishes achievement expectations, and it sets goals and policies so that these expectations can be realized. Curriculum is the content of education and medium of exchange between teacher and student. Teachers, working within curriculum, draw on their subject matter and pedagogical knowledge to translate the curriculum for students in a comprehensible way. Teachers draw on multiple instructional methods, and this affects outputs such as achievement, participation, and attitudes. Accumulation of good educational process result better life.

Challenges in mathematics and science teaching

Teacher quality plays an important role in mathematics and science teaching. As mentioned earlier, there were high percentage of under qualified and mismatch mathematics and science

teachers contributed to the low quality of mathematics and science teaching. These teachers tend to dominate mathematics and science classes, instead of let students learn. We still find a situation of mathematics and science teaching with teacher centered in Indonesia. Students were copying notes or listening to the mathematics or science teachers. There were no interaction among students and they got boring in mathematics and science classes. Therefore, it is challenge to shift from mathematics and science teaching to mathematics and science learning (Figure 4). Collaborating with teachers has been done regularly for 3 years in promoting mathematics and science learning applying modified Japanese tradition of lesson study under JICA cooperation. We facilitated teachers worked collaboratively to think problems and share views to design a lesson plan that promotes student active learning through hands-on activity, mind-on activity, daily life, and local materials. Then, it was tried out at real class and students activities were observed to collect data for further discussion following class session. It is slow but sure to shift teacher's mind set from teaching to learning. We found improvement of the teachers in facilitating student learning. They let students explore through experiment mathematical and scientific phenomenon (Figure 5). The developed in-service teacher training resulted in improving teaching quality within the district site.



Figure 4. Mathematics and science teaching in conventional ways



Figure 5. Students engaged in mathematics and science learning

7. Conclusions

Quality of mathematics and science education now becomes national issues in Indonesia. Indonesia has abundant natural resources but lack of human resources to manage or process the natural resources so that Indonesians do not get maximum benefit of the natural resources. Underqualified teachers and disparities in teacher quality resulted low quality of mathematics and science education in Indonesia. Quality of Indonesia mathematics and science education needs to be improved for promoting quality of human resources with technology to be able to manage/process abundant natural resources for better living. Government of Indonesia has paid more attention on teacher quality through qualification upgrading and continuous teacher professional development through placing high priority on teacher recognition and welfare.

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