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The Evolution of Indonesian and American Science Education Curriculum: A Comparison Study

ABSTRACT*: Curriculum reform is an important strategy to improve the quality of education and human resources in order to increase economic development to better compete in a globalized world. This paper focuses on curriculum development in Indonesia, comparing Indonesian school curriculum to USA (United States of America) school curriculum, and analyzes several factors that strongly influenced Indonesian and American curriculum design and curriculum decision-making. Curriculum development in Indonesia, from independence in 1945 to today, is characterized by cycles of planning and revision. Currently, the goal of the new curriculum requires students to be able to appreciate and implement honesty, discipline, responsibility, compassion (tolerance and working together) and politeness, self-confidence, and effective interactions in social and natural environments. Science curriculum development in the USA schools started with private educational religious institutions. Nowadays, students are encouraged to use scientific information to make choices about issues that arise in everyday life, engage intelligently in public discourse, and debate about important issues that involve science and technology. Several aspects must be taken into account in order to reform the science education curriculum, especially in Indonesia. In designing curriculum, decision makers should involve many parties, such as higher education, researchers, politicians, scientists, teachers, parents, social and religious community leaders, and industrialists.*

KEY WORDS*: Curriculum Development; Science Education; Indonesian and American; Curriculum Design; Curriculum Implementation.*

INTRODUCTION

Why is there a need to reform school curriculum in a country? Various answers to address this question reflect different perspectives on the question. The first and foremost answer relates to the economic issue and wealth of the people of a nation even since *Chellean* times. In his parable, *Saber Tooth Curriculum*, J.A. Peddiwell (1939) explained, "the educational goals to construct the curriculum were providing more and better food, shelter, clothing, and security" (Peddiwell, 1939:28).

In modern perspectives, food, shelter, clothing as well as security become primary needs of the community and are strongly influenced by personal economics and wealth (Utomo, 2005). The economic growth of a nation is affected by many factors, such as natural resources, culture, human

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resources, and the development of science and technology. Thus, in order to increase economic development, a country should be concerned with how to improve the quality of human resources through superior education as well as how to combine and incorporate the latest developments into the school curriculum to provide citizens with a relevant educational background, so that they can play a role in a modern globalized world. Parallel to this notion, the main goal of restructuring curriculum in Hong Kong is improving the quality of education and preparing students for lifetime learning to build a knowledge-based society (Yeung, Lee & Lam, 2012). Indonesia has been struggling to increase its economic growth by providing high quality human resources through education. Since the 1970s, the education reform policies in Indonesia have concentrated on developing quality of life for the purposes of national development (Utomo, 2005). In order to ensure greater position in the global market place, the government has targeted areas of the national curriculum to improve the quality of education (MoNE, 2003a).

Many attempts to improve the quality of education have been conducted through the teacher recruitment method, teacher certification program, teacher training in the home country and abroad, providing textbooks, as well as revising school curricula based on current international trends and issues in education and national and global needs (MoNE, 2003b).However, based on the results of the PISA (Programme for International Student Assessment) in 2012, Indonesia was ranked 64th out of 65 participating countries (cited in Safrudiannur, 2015). This result indicates that there is no improvement of students' scientific literacy from the previous PISA in 2009, which Indonesia was ranked 66th out of the 74 participating countries.

Furthermore, A.J. Ganimian & R.J. Murnane (2016) reviewed 223 evaluations of educational initiatives from 56 low and middle-income international sites, including Indonesia. Their findings indicate that when countries expand school options and reduce the cost of school attendance, more students are able to attend school, but student achievement does not consistently improve (Ganimian & Murnane, 2016).

In order to improve student achievement, better resources must be coupled with a change in children's daily school experiences. Although teacher incentives might result in greater student achievement for very low performing student populations, improving teacher practice is a necessary condition for increasing student achievement.For those reasons, there is a need to examine science curriculum development in Indonesia, comparing Indonesian school curriculum to a developed country's school curricula, in this case is the United States of America; and analyzing several factors that strongly influenced curriculum design and curriculum decision making in order to achieve the national purpose, increasing the quality of human resources in Indonesia.

CURRICULUM DEVELOPMENT IN INDONESIA

Understanding the history of curriculum development in Indonesia, since 1945, will provide insight into what has been done in the past, how curriculum was implemented, what strengths and limitations existed in the curriculum, and what experiences should be taken into account to design the new curriculum. Curriculum development in Indonesia has been planned and revised from 1947 until 2013, and will be described further in the following section.

"Rentjana Peladjaran" or Lesson Plan Curriculum in 1947. The first curriculum introduced in Indonesian schools after independence was *Rentjana Peladjaran* or Lesson Plan Curriculum. This curriculum followed the school curriculum made by the Dutch during the 350-year colonial period and began the process of changing from Dutch interests to the national interest. Because the situation in the nation was strongly influenced by the recent fight for freedom from the Dutch, the government designed the new curriculum that was oriented to build the character of the Indonesian people as independent, sovereign, and with equal opportunity for all citizens (Sutisna, 2011).

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The educational principles of this curriculum were based on the State Philosophy for the Republic of Indonesia and the Five Basic Principles (*Pancasila*) that are: (1) Belief in the One and Only God; (2) Just and Civilized Humanity; (3) the Unity of Indonesia; (4) Democracy Guided by the Inner Wisdom in the Unanimity Arising out of Deliberations Amongst Representatives; and (5) Social Justice for All the People of Indonesia (*cf* Nishimura, 1995; and Taniredja, Afandi & Faridli, 2012).

This first curriculum was derived into two main parts that included a list of subject matter and time allocations for each subject domain. In 1952, this curriculum was revised to provide more emphasis on the relationship between subject matter content and daily life events, as well as to include physical education and art education (Saputri, 2014).

Curriculum in 1964 and 1968. In 1964, the government of the Republic of Indonesia conducted a review and revision to enhance the previous curriculum. In the new curriculum *Rentjana Pendidikan 1964* (Educational Plan 1964), the goal of education was to strengthen academic knowledge at the elementary level for the Indonesian people. The revised elementary education program placed emphasis on knowledge and practical functional activities (Sutisna, 2011).

The five main subjects included in this curriculum were morality, higher level thinking skills, artistic expression, life skills, and physical education. These subjects concerned the development of creativity, values, participatory skills, craft, and morale of students (Hamalik, 1993).The government renewed *Rentjana Pendidikan 1964* in 1968. The Curriculum 1968 was restructured into the development of life based on *Pancasila*, fundamental knowledge and special skills. The objective of the Curriculum 1968 was to fulfill the human rights of Indonesian people that include having a strong and healthy body, enhanced intelligence and physical skills, morals, manners, and religious beliefs (Sutisna, 2011).

Curriculum 1975 and 1984. Trends to provide an education that is effective and efficient based on the MbO (Management by Objective) strongly influenced the development of Curriculum 1975. These curriculum components included objective based content and strategies that were written with more detail into lesson units following an instructional systems development procedure. A typical lesson unit covered general objectives, particular instructional objectives, content, learning resources, learning activities, and evaluations (Sutisna, 2011).

Particularly in the reform of science education, this curriculum provided instructional objectives, but left the challenge of recognizing and positioning relevant instructional materials and lesson planning completely to the teachers (Thomas, 1991). In order to implement Curriculum 1975 properly, training courses were given to principals, teachers, and administrators. In this context, M. Thair & D.F. Treagust (1997) write, as follows:

> [...] for teachers, this training had three separate components: science content of curriculum; use of scientific apparatus to carry out experiments; and the methodology involved in producing activity based lessons in the classroom (Thair & Treagust, 1997:584).

In subsequent reviews, Curriculum 1975 was further developed to produce Curriculum 1984 to address the current trends in science education at that time. Curriculum 1984 emphasized the process skills approach that aimed to achieve not only the objectives of learning, but also skills that were gained in the learning process. In this curriculum, students were asked to engage actively in learning pursuits through observation, classification, and reporting. This curriculum was based on instructional objectives (Sutisna, 2011).

Instructional objectives are statements that describe what students will know or be able to do on completion of the lesson in a specific allocated time. Thus, in order to make the learning process more effective and efficient, before teachers start their lesson, they have to design the specific instructional objective that is possible to be achieved during their instructional period.In order to develop teacher's competences in designing instructional objectives, the Indonesian government conducted teacher training, both in country and overseas. In one example described by T. Somerset (1988), about 12 selected science teachers completed a twelve weeks teacher-training abroad program that covered content knowledge, practical work, classroom teaching instruction, and teacher training methodology (Somerset, 1988). On returning to Indonesia, these teachers were expected to train their colleagues in a teach-the-teacher model.

However, Curriculum 1984 had several limitations. For example, the learning content presented in the Curriculum 1984 presented broad and unfocused science concepts and included what many deemed as irrelevant knowledge. Teachers and students experienced difficulty with the higher level objectives presented in the new curriculum (Drost, 1998). In addition, the concept of student active learning, while theoretically elegant and with evidence to show better results in piloting schools, proved difficult to bring to scale (Khoiriyah *et al*., 2015).

The implementation of active learning strategies resulted in many irregularities and teacher modifications when applied nationally. Unfortunately, many schools were unable to interpret and implement the concept of student active learning with a high degree of fidelity.

Curriculum 1994. Curriculum 1994 was a refinement of the Curriculum 1984. Changes in the way classes were delivered and goals of learning were unique characteristics of the Curriculum 1994 (Dharma, 2008). The previous class organization was one learning year divided into two semesters while in the Curriculum 1994, one learning year evolved into three *caturwulan* or trimesters, one *caturwulan* was equal to 4 months (Wirianto, 2014). The motivation for this change was to provide students with shorter learning segments and more opportunity to learn content knowledge gradually.

The main goal of this curriculum was developing students' conceptual understanding and skills in solving problems. Even though the curriculum encouraged students to develop their conceptual understanding and problem-solving skills, in fact, most Indonesian classrooms still practiced rote learning and memorization in teaching and learning activities as well as methods of assessment. Most of the assessments were paper and pencil written tests that commonly measured lower-order thinking skills, such as defining scientific terms or providing examples that related to some science principles. Plausible reasons for this situation could be both the teachers were not trained well on how to apply this curriculum in the classroom and the lack of proper monitoring for the implementation of this curriculum in schools (Yeom, Acedo & Utomo, 2002).

Curriculum 2004. The reform in educational policies continued when the regime of President Soeharto collapsed in 1998 (Sato, 2003). At this time, regional authority was granted to the district or city level, bypassing the provincial government (Gaylord, 2008). In 2004, the curriculum reformed into a CBC (Competency-Based Curriculum). This CBC was intended to provide greater flexibility in responding to changes in society, such as the rapid developments in information and communication technology (Utomo, 2005).

The new curriculum focused on developing students' competence individually or in a group in order to achieve standard competence of learning objectives established by the government or MoEC (Ministry of Education and Culture) of the Republic of Indonesia. Although the curriculum was enacted as the core standards across Indonesia, provinces and cities were encouraged to adjust the curriculum to promote their regions' priorities. The local content curriculum required all elementary and junior secondary schools to allocate 20% of all instruction to locally designed subject matter (Bjork, 2004).

The MoEC encouraged schools to create a local content curriculum course that fit the unique condition of the community they served (Torar & Wahono, 2016). For example, a school in Papua might decide to offer instruction in mining, while an institution located in the riverside area of Borneo could create a course on fishery. In this context, K. Lewin (1985) claimed, as follows:

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> [...] curriculum quality has frequently been perceived to depend more directly on the availability and distribution of physical plant and material resources for schools than on the less tangible characteristics of the infrastructure that supports these (Lewin, 1985:129).

Moreover, the Curriculum 2004 also had a stronger content orientation with many topics that had to be covered in one learning year compared to the previous curricula. To implement the new program, local governments or schools needed to use general operating funds or to collect funding from other sources. Accordingly, C. Bjork (2003) wrote as follows:

> [...] on some occasions, the funds were taken out of the donation that parents remit to the school each month (Bjork, 2003:196).

Additionally, even though teachers had freedom to design several components in the curriculum, limitations still existed due to the tradition, culture, demands of parents and community, districts and provincial regulations, and financial matters as well. Despite the intentions of the reformers, teacher contributions in developing curriculum did not fulfill the expectation of the central government. However, teacher contributions in curriculum planning and development were still compulsory (Marsh & Willis, 2007).

School-Based Curriculum 2006. In 2006, the MoEC (Ministry of Education and Culture) of the Republic of Indonesia introduced KTSP (*Kurikulum Tingkat Satuan Pendidikan* or School-Based Curriculum), the revised version of Curriculum 2004. The implementation of school-based curricula gives more freedom to schools and school committees to develop school curriculum, determine the vision, mission, and objectives of education initiated by the school (Firman & Tola, 2008).

The freedom was expected to encourage teachers and schools to take part in curriculum planning and school development. Under KTSP, the central education authority developed general competences and minimum content outlines, while individual teachers were to develop their subject curricula, including formulating learning objectives, selecting content, teaching strategies as well as developing learning evaluations independently. L. Parker & R. Raihani (2011) declare that:

> [...] this curriculum stressed the achievement of standardized competencies that students had to achieve, and the development of life skills to prepare graduates to survive in life after school (Parker & Raihani, 2011:715).

It can also provide an opportunity to students to develop skills and competencies relevant to the local needs and potentials and thus increase their ability to contribute to the development of their district or provinces (Suprihatiningrum, 2012).

After being implemented in 2006, several evaluations and analyses conducted by the MoEC (Ministry of Education and Culture) led to the conclusion that in its current condition, graduate competencies are not emphasizing values education. Teaching and learning processes remain based on teacher centered learning, and stress cognitive aspects (Kemdikbud RI, 2013).

Moreover, several important competencies are not developed effectively by Curriculum 2006; for example, confronting future challenges around environmental issues and globalization (Sadiman, 2009). This curriculum does not fully prepare students with competency for understanding and tolerance for others, who have different perspectives, awareness of social changes in local, national, and global contexts, or living in a global community.

Curriculum 2013. Evaluation of School-Based Curriculum yielded several areas for development and revision in the school curriculum. The rationale for this curriculum is because there are some challenges that have to be confronted in the future. Those challenges include growth in the population of individuals of working age, i.e. 15 to 64 years old as defined by the OECD (Organization for Economic Cooperation and Development) in 2015, the development of a globalized world, information technology, knowledge, and pedagogy, as well as current social phenomena (Kemdikbud RI, 2013; and OECD, 2015).

Based on these findings, the MoEC (Ministry of Education and Culture) revised and enhanced the Curriculum 2006 into an advanced version called Curriculum 2013. The core competencies for example in Junior High School are designed as four interconnected categories relating to religious beliefs, social attitudes, science content knowledge, and the application of knowledge.

Curriculum 2013 is designed mainly based on core competencies and basic competencies. Core competencies are some qualities that have to be achieved by the students after they complete the learning processes. Whereas basic competencies are skills that students build upon subject matter (Kemdikbud RI, 2014). A unique feature of Curriculum 2013 is that both core and basic competencies at the elementary level focus preferably on good manners and behavioral education. However, at the secondary level, the learning processes are centered in developing high order thinking skills.

The content of Curriculum 2013 for science has a specific purpose (Falak, 2014). The overarching structure and matter of science are integrated to introduce life science, environmental science, and various advantages of Indonesian as an archipelago country. Because of this framework, life science and environmental science dominate the substance of the curriculum, while physical science and chemistry will be studied to corroborate students' understanding about the natural world and its phenomena. The impact of physical science and chemistry are applied to living things and the environment.

Curriculum 2013 also strongly supports multiculturalism (Suparno, 2017). One of its graduate competencies requires students to be able to appreciate and demonstrate honesty, discipline, responsibility, tolerance, politeness, and self-confidence in social and natural environments. Students should have abilities in strengthening equality, accommodating differences, and participating actively in building harmonious relationships in society. Mostly only the MoEC and higher education faculty initially designed this curriculum.

These groups identified new standards and basic competency levels and attached learning indicators to describe them. Next, the MoEC selected around 6,000 schools at the elementary, middle, and senior high schools level across Indonesia to implement this curriculum. Teachers from those schools were prepared with specific training using activity-based teaching approach to implement Curriculum 2013 from MoEC staff or university faculty member.

This notion is supported by A. Koul (2014), who stated that teachers' development program should be designed to be activity-based teaching closely related to students' prior knowledge and their surrounding environment rather than conventional methods, such as lecture from the experts (Koul, 2014). Starting in July 2013, the selected teachers educated their students using the guidance of this new curriculum.

The experts also monitor their classroom activities, so that they can assess teacher performance, conduct an evaluation, and provide some suggestions for better learning activities in the next session. The number of piloting schools will be increased gradually every year until this curriculum is applied in all schools in Indonesia.

CURRICULUM DEVELOPMENT IN THE UNITED STATES OF AMERICA

As a developed country, investigating the progress of science curriculum in USA (United States of America) schools is very interesting. The development of science curriculum actually started in the USA and has been followed by other nations in the world (Blum, 1979). Furthermore, the USA has regional educational standards and a solid tradition of local control (Schmidt *et al.*, 2001).

Control and power in the USA educational system, traditionally, are highly influenced by independent organizations, or school boards. School boards are representatives of the local community, selected by members of that community through campaigns and elections in the community in a school district or appointed by the State Governor. Currently, the federal government is attempting to become more involved in the educational system to improve the quality of schools. Thus, it is very interesting to examine a

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contrast of power and control in education that has been applied in other countries, such as in the USA, in order to obtain information about the advantages and disadvantages in decentralized education systems.

Historically, the control of USA public schools has been primarily in the hands of local school boards with state government having ultimate legal responsibility. J. Spring (2008) stated that through the NCLB (No Child Left Behind) Act in 2001, the USA federal government employed greater power and reduced the local control in public schools (Spring, 2008). An important feature of NCLB was the federal government provision of funding to public elementary and secondary education.

A condition of using this funding required the state government to agree to implement a range of activities asked for by the federal government, including determining the academic standards and testing programs, public reporting of test scores, identifying and improving schools failing to meet adequate yearly progress, using particular types of reading programs, offering school choice plans, and a host of other provisions in the legislation (Spring, 2008). The following section will describe the history of science curriculum development in the USA schools.

The First One Hundred Years, 1776–1875. In the decades after USA (United States of America) independence from Great Britain was declared in 1776, public education was recognized as a necessary force for socialization (Bybee, Powell, & Trowbridge, 2008). Most educational institutions were private and religious based. When religious groups created and managed their own schools, the presence of strong religious views and the virtual absence of more widely held secular views posed no significant, overt problem (Eisner, 1979).

According to R.W. Bybee, J.C. Powell & L.W. Trowbridge (2008), during the late eighteenth and early nineteenth century, the religious indoctrinations decreased and utilitarian objectives increased in schools. An effect was that curriculum based on religion was replaced with more practical curriculum with several options of subject matter, including science, agriculture, and navigation. After the depression of 1873, because of the economic and social reform, educators followed with clear demands for more science in the classroom (Bybee, Powell & Trowbridge, 2008:71).

In order to fulfill the demands of social and economic changes as well as the effect of the industrial revolution, the aim of public education was changed to provide a more general understanding about the concept of science and technology. Relevant to the idea of focusing more on science and technology, in the 1870s, the USA had a broader range of subjects in their school curricula, such as mathematics, art, science, and geography. Teachers attempted to link these subjects with each other during instruction. Nevertheless the USA school also taught non-academic competencies, for example sewing, gardening, creating pottery, and weaving (Cuban, 1984).

From 1870 to the 1950s. Science became part of the school curriculum during the 19th century, both in Europe and in the USA (United States of America) in large part, because of the urgings of the scientists themselves (DeBoer, 2000). The development of science and technology demanded an increase in scientific literacy. In 1892, the Committee of Ten, a group of educators mostly representing higher educational interests, stated that all students should be taught the same curriculum regardless of whether they planned to attend college (Maitland, 2007; and Bybee, Powell & Trowbridge, 2008).

The Committee designed the subjects to be taught and the hours per week and weeks per year to be devoted to each subject. Through learning science, students would develop inductive thinking skills as well as scientific attitudes through investigations and independent inquiries such as experiments or other laboratory learning activities (Bybee, Powell & Trowbridge, 2008).

By 1915, the emphasis in science education shifted to goals wider than those for college entrance (Maitland, 2007; and Bybee, Powell & Trowbridge, 2008). At this time, the broadened science curriculum attempted to provide students with various learning activities and experiences to prepare them to compete in the job market. However, the requirements set by the various standardizing committees, such as the Committee of Ten and the Committee on College Entrance Requirements helped to ease the transition from high school to college, but they also formalized the college preparatory role of high school (DeBoer, 1991).

A few years later, the influence of college entrance requirements was not the only main concern on the development of science education curriculum. In 1918, publication of the *Cardinal Principles* by the commission on the Reorganization of Secondary Education stressed the importance of organization and sequencing of secondary science as well as pointed out social goals beyond the traditional knowledge goals (Bybee, Powell & Trowbridge, 2008).

From this perspective, science education curricula was not only concerned with college entrance requirements but also tried to accommodate students' interests and needs, and social demands, as well as explore students' abilities to construct their knowledge based on real experiences. G. DeBoer (1991) stated that it was a period of confirmation of child-centered education, the importance of real world application, the social importance of knowledge, and the need to make school learning enjoyable and meaningful to students (DeBoer, 1991).

Late 1950s to 1983. As the 1960s approached, the USA (United States of America) science education community was becoming more and more interested in the strategic role of scientific knowledge in society, especially given the recent launching of the earth orbiting satellite Sputnik by the Soviet Union in 1957 (DeBoer, 2000). Because of this event, trends of science education reform at that time focused more on producing people, who understood science and were aware of employment opportunities in science fields. The curriculum emphasized the understanding of science content knowledge using inquiry. Scientists also took a huge part in designing the content of science education. They also played other important roles, such as research mentor, content knowledge specialists, instructional development collaboration, and role models (Lederman, 2003). This contribution resulted in students learning about science and the natural world through an abstract model. Only a few topics were linked to the students' daily experiences.

The curriculum development in the post-Sputnik era focused less on personal needs and more on military and national defense and preferentially presented theoretical aspects of science. However, many science educators did believe that the goals of science education should be for personal development and to help individuals adjust to life in modern society (DeBoer, 2000).

In 1982, the NSTA (National Science Teachers Association) introduced the STS (*Science-Technology-Society*) Curriculum. The aim of the STS Curriculum was to give students knowledge about the science/society interface and the ability to make decisions about science related social issues (DeBoer, 2000). This curriculum provided learning opportunities for students to observe the social issues that arose in their daily experiences, in media such as newspaper and magazines.

Students were encouraged to investigate the social problems in groups, design and implement action plans to overcome the problem, analyze the strength and limitations of their action plan, and give further suggestions to revise it into a better model or plan. With insufficient teacher preparation and acceptance of the new model and a tradition of strong local control of schools, the STS Curriculum was only implemented in some districts (Rubba & Weisenmayer, 1991; and Mansour, 2009).

Year 1990s to 2013. In 1989, USA (United States of America) mathematics educators and mathematicians introduced national standards with two publications: *Curriculum and Evaluation Standards for School Mathematics* by the NCTM (National Council of Teachers of Mathematics), in 1989; and *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* by the NRC (National Research Council), in 1989. The NCTM capability had a pivotal role in the expansion of other education standards, for instance the *National Science*

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Education Standards (NRC, 1996).

In the same year, the AAAS (American Association for the Advancement of Science), with its Project 2061, issued *Science for All Americans,* describing scientific literacy for all high school graduates. The NSTA (National Science Teachers Association) followed with the publication of *The Content Core Using Scope, Sequence & Coordination Project* (AAAS, 1989; and Aldridge, 1992).

Begun in 1992, the *NSES (National Science Education Standards)*, in 1996, was part of the USA governments' approach to education reform, an approach that involves setting national goals and the standards for meeting them (DeBoer, 2000).

President George W. Bush supported this meeting by establishing the National Education Goal Panel and this support continued with the next elected President, William Clinton. In this context, NCSESA (National Committee on Science Education Standards and Assessment), in 1996, states as follows:

> The standards for content define what the scientifically literate person should know, understand, and be able to do after 13 years of school science (NCSESA, 1996:13).

Thus, school becomes the place to implement those standards and students will able to achieve a comprehensive knowledge and understanding about science after they graduate from school.

In December 1994, the NSS (National Science Standards) were released as a draft document for nationwide review. The standards provided specific criteria about the principles that underlie the vision of scientific literacy for all students. They also stated the basic principles about teaching and teacher standards, teacher's professional development of skills and knowledge, as well as science education assessment standards. As for the content knowledge, the NSS emphasized the implementation of inquiry in the science classroom; linking the traditional subjects, such as physical and life science, chemistry, earth and space science to technology; and highlighting the knowledge of history and nature of science (cited in NRC, 1996).

Furthermore, the standards also set the criteria on quality and interaction among schools, districts, and the larger communities, so that all parties could help students achieve the goals. An important point in the creation and release of the National Science Education Standards was that although researchers from the National Research Council, an arm of the USA government, supported them, they were issued as guidelines for the states and not directives. Each state was allowed the option to adopt them as written, or amend them to better suit local interests. Many states produced individual state versions of these standards, such as the Ohio Academic Standards for Science (DoE Ohio, 2011).

Year 2013 to Future. As the second decade of the twenty first century dawned, the NRC (National Research Council) established the CCF (Committee of Conceptual Framework) for New K-12 Science Education Standards. This committee accepted responsibility for advancing a conceptual framework that would define core ideas in physical science, life science, earth and space science, and engineering and technology as well as crosscutting concepts and practices for the classrooms of the 21st century (NRC, 2012).

Based on the report of the CCF for these New K-12 Science Education Standards, the NRC, in July 2011, declared as follows:

> [T]he ultimate goal of this framework is to ensure that at the end of 12th grade, all students have some appreciation of the beauty of and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussion in related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choices, including (but not limited to) careers in science, engineering, and technology (NRC, 2012:9).

The main reason for establishing a new standard for USA (United States of America) science education was mainly because of the continued development of the science of teaching and learning based on the recent research in science education. Armed with the ideas and practices in those relevant research studies in teaching and learning in science education, the committee and design team contracted by NRC (National Research Council) prepared and revised the draft, which was released for public comment in July 2010. The extensive inputs from the public were used to revise and redesign the outline of the framework (NRC, 2012).

The framework was developed with several guiding principles, which are children's competency in learning science; focusing on core ideas; continuous development of understanding; balancing both knowledge and practice; connecting students' interest and experiences; and promoting equity among students. Moreover, the framework also has a unique structure that consists of three dimensions (NRC, 2012). Those dimensions are: Dimension 1 (scientific and engineering practices), Dimension 2 (crosscutting concepts), and Dimension 3 (core ideas in science discipline).

In Dimension 1, the practices that scientists and engineers actually engage in are identified and introduced to students. Eight essential elements are included in the curriculum: (1) asking questions or defining problems; (2) designing and applying models; (3) conducting an investigation; (4) analyzing and interpreting data; (5) applying mathematical principles and computing skills; (6) reasoning and offering solutions; (7) evaluating the evidence in a discourse; and (8) obtaining, evaluating, and presenting the result of investigation (NRC, 2012). Student opportunity to engage in these practices and explore their central importance to science and engineering represent a central tenet of the Frameworks (Duschl, 2012; NRC, 2012; and Reiser, Berland & Kenyon, 2012).

Dimension 2 focuses on crosscutting concepts that bridge disciplinary boundaries. The explanatory value of these concepts re-occurs throughout much of science and engineering. Introduction of these core concepts intends to provide students with an organizational framework to connect knowledge across science and engineering disciplines into a coherent world view (Duschl, 2012). The committee identified seven concepts that encompass scientific and engineering domains: (1) patterns; (2) cause and effect; (3) scale, ratio, and quantity and its relevancy to a system's structure and enactment; (4) systems and system models; (5) energy and matter; (6) structure and function; and (7) stability and change (Duschl, 2012; NRC, 2012; and Reiser, Berland & Kenyon, 2012).

Dimension 3 emphasizes disciplinary core ideas in physical sciences, life sciences, earth and space science, engineering and technology, and the application of science. Each core idea covers several essential topics. Those topics will be studied from elementary to secondary level with increasing complexity, from the simplest to the most multifaceted phenomena. The standard's originators have planned that at the end of grade 12, students would achieve a broad and thoughtful knowledge base about the phenomena in nature and its application in real life (Duschl, 2012; NRC, 2012; and Reiser, Berland & Kenyon, 2012).

Following the release of the *Framework,* a collaboration of 26 lead partner USA states along with a team of 41 writers with broad expertise in both science and science education created the internationally benchmarked new science standards. The *Framework* document was used as the main reference source for both structure and content in developing the *Next Generation Science Standards* (NGSS Lead States, 2013).

Many institutions, such as NRC (National Research Council), NSTA (National Science Teachers Association), and AAAS (American Association for the Advancement of Science) worked together to complete the NGSS (*Next Generation Science Standards*). Early drafts of the NGSS were released for broad public comment to produce a document that represents collaboration across stakeholders in science, science education, higher education, and industry (AAAS, 1989; Aldridge, 1992; and Reiser, Berland & Kenyon, 2012).

The final product *Next Generations Science Standards*, published in Summer 2013, provides a high quality set of standards that can prepare students to be successful in career and life. Individual states and school districts are encouraged to use the NGSS either as written, or as a blueprint to create individual standards linked more closely to

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local concerns and interests. Because of the tradition of local control of schools, the USA Federal government cannot mandate the adoption or implementation of these standards (NGSS Lead States, 2013).

DISCUSSION

Both science curriculum development in Indonesia and the United States of America is a long-term and complex process. V.M.Y. Cheng (2010) emphasized that "curriculum reform is such a complicated process, which has no simple direct path" (Cheng, 2010:18). The history of the development of science education curriculum, both in Indonesia as well as in the United States of America, describe two emerging factors that strongly influenced curriculum design and curriculum decision making in education.

Firstly, ***Collaboration among Parties.*** In Indonesia, science curriculum is strongly influenced by the government policies through MoEC (Ministry of Education and Culture). The government sets the core competencies, basic competencies, and minimum standards of learning process (Power & Cohen, 2015). Teachers and schools are able to select learning activities, teaching strategies, methods of assessment, and resources of learning activities that will be conducted in the classroom based on students' interest and needs, the availability of materials, culture, and the students' development of mental and thinking processes.

Because the standards are similar, the implementation of the curriculum and learning activities in the classroom has similar patterns across Indonesia (Madya, 2010). The similarity of standard competencies and content knowledge shared by Indonesian schools enable students to transfer from one school to another school in different regions all over Indonesia without much difficulty. It also facilitates the measurement of student's achievement and national comparisons simply by taking national examinations conducted by the central government.

On the contrary, science curriculum in the United States of America is designed at the state and district level (NRC, 2012). In this case, the curriculum will have more opportunity to explore local resources and may be tailored for the natural and social resources that are available in that place. Furthermore, the curriculum decision-making involves many parties, such as school boards, principals, teachers, parents, social community, higher education, and industry as well. Collaboration among those parties will produce a strong curriculum, because they will provide various learning experiences, stages of continuing education, and relevant goals that fit to the economic and social needs of the community that the schools serve.

However, student transfer from state to state is complicated by the lack of uniformity in school curriculum. Also, national assessments of science learning must reflect a wide diversity of science standards and local interests, and may not reliably measure science learning in all communities using a single assessment instrument.

Secondly, ***Curriculum Goals.*** In general, the goals of science education curriculum in Indonesia are fostering students to appreciate and practice their religion, integrating character education in learning science, developing students' cognitive, psychomotor and affective skills, and improving students' science process skills. Compared to the goals of science education curriculum in the USA (United States of America), the goals of science curriculum in Indonesia are relatively constant, even though they have experienced steady reforms on curriculums' structure and content from 1947 to today.[1]

In the USA, the goals of science curriculum change based on the current demands and needs of the nation. For example, the needs to fulfill college entrance requirements caused the curriculum change to be more appropriate with the standards determined by the CEEB (College Entrance Examination Board). Another example was the orbiting of the Sputnik satellite by the Soviet Union in 1957 that triggered greater emphasis on science content knowledge into the curriculum (DeBoer, 2000).

[1]See, for comparison perspective, "Goals for Science Education". Available online at: https://www.nap.edu/read/11625/chapter/4 [accessed in Pontianak City, Indonesia: September 15, 2016].

Furthermore, the USA curriculum clearly promotes connecting science subjects with technology. As a developed nation, the USA has remarkable infrastructure and high technology levels. Those facilities provide much information, such as videos, films, digital books, and other internet sources to support and enrich students' learning experiences.

On the contrary in Indonesia, teachers are encouraged to do so, but it is not mandatory for them, because those facilities are only available in the big cities in Indonesia (*cf* Mulyasa, 2006; and de Ree *et al*., 2016). Establishing a reliable infrastructure and communication service is an ongoing challenge in Indonesia. Thus, teachers have to deal with accessible supplies and facilities in their local region to design the lesson plans and conduct the lessons.

On the other hand, both curricula share similar ideas about science learning processes in the classroom. Science learning activities are designed to encourage students to discover concepts and to connect the knowledge with their own experiences as well as to support inquiry learning and develop problem-solving skills.

CONCLUSION

The discussion above leads to several conclusions about the elements that must be taken into account in order to reform the science education curriculum, especially in Indonesia: (1) what are the ongoing and recent developments in science education internationally and are they relevant to the national needs; (2) what level of involvement is desirable by third parties besides the government and school in designing the curriculum; (3) how best to balance authority between central and local authorities in designing the curriculum; and (4) who should fund educational initiatives. Additional research is needed to determine how much and what the specific role of each party should be in designing curriculum.

Suggestions that can be offered to improve the quality of the curriculum are:

First, in designing curriculum, decision makers should gather much information from current international educational research, global and present national needs, and patterns and trends of science education development for the future.

Second, curriculum decision makers should actively involve many parties, such as higher education, researchers, politicians, scientists, teachers, parents, social and religious community, and business leaders, in the development of curriculum. Various perspectives provided by different cultural, economic, educational, and religious backgrounds will increase the opportunities for learning, learning experiences, and enhance the content and teaching strategies of curriculum. Involving a broad spectrum of leaders also may provide stronger community support for educational reform movements.

Third, central government should increase opportunities by transferring some authority to provinces and cities in designing curriculum. The central government can determine the national standard of competencies that should be achieved by students and leave other components in curriculum to be developed by local governments. In this way, provinces and districts can develop their own science curriculum based on local content relevant to the human resources and natural resources of their communities. These curriculum and learning activities can also promote local economic and cultural development.

Fourth, the development and implementation of science curricula at the local level should be monitored and supported by funding, establishing cooperation among institutions and job markets, and providing professional development for school staff. Central government, members of the community, higher education, scientists, industry, and other parties that have connection both direct and indirect to education in Indonesia should act to support these efforts.[2]

[2]***Authors' Declaration:*** We, the undersigned, declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by both of us.

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