The Development of Mathematics Curriculum to Increase The Higherorder Thinking Skills in The Sustainable Development Goals (SDGs) Era

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ABSTRACT

This study discusses the development of mathematics curriculum (learning mathematics) to improve higher order thinking skills in realizing quality education in the Era of Sustainable Development Goals (SDGs). Quality education is the fourth goal of Sustainable Development Goals (SGDs). Higher order thinking skills (HOTS) are defined as thinking skills, reasoning, critical thinking, and problem solving. Mathematics education has been developing in line with learning theories development, changing of technology, and life demands as well as the using of mathematics within the globalization era in the 21st century. Indonesia has attended TIMSS and PISA study many times and the study reported that students have not been able to develop their thinking abilities optimally in mathematics subject. This research was conducted by qualitative method with data collection technique through interview and documentation. Interview conducted against the Developer of Mathematics Curriculum, Widyaiswara, and Textbook Writer. The results of study that to realize a quality education at Sustainable Development Goals (SGDs), the government has formulated basic competence inmathematics that appeals to the competence of higher order thinking skill, Creating Learning Teacher Module, and Textbook. Teachers are expected to explore further higher order thinking skills.

Keywords*: SDGs, Mathematics Curriculum, Thinking Skills*

1. INTRODUCTION

The Sustainable Development Goals (SDGs) are an aspiration for the realization of sustainable development in the long term. The SDGs themselves are a continuation and improvement of the previous program, the Millennium Development Goals (MDGs). The objectives of the SDGs cover a universal scale, with a framework that is intact in helping countries in the world towards sustainable development, through three approaches, namely economic development, openness in social order, and environmental sustainability. The SDGs agenda can be accepted and applied by each nation, while taking into account the uniqueness of each region, for example the real condition, capacity and level of development of the

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nation, as well as the priority scale and political conditions in it. There are 17 main objectives along with goals as a universal agenda which is to be realized by the Sustainable Development Goals (SDGs). The Fourth Goal of SGDs is quality education namely, ensuring open and equal education, and promoting lifelong learning opportunities for all parties. This goal focuses on acquiring basic and high skills at all levels of education, greater and more equitable access to quality education at all levels, including technical and vocational education, as well as the values needed to contribute to social life. There are 10 targets to be achieved in realizing quality education. One of the targets to be achieved is ensuring that all girls and boys receive quality primary and secondary education [1].

Internationally, the quality of education in Indonesia ranks 68th out of 113 countries around the world based on the annual report of the UNESCO Education For All Global Monitoring Report 2013 [2]. While based on the Education for All Development Index (EDI) Indonesia is at ranked 57th out of 115 countries in 2015. On on the annual report of the UNDP Human Development Report 2016, Indonesia ranked 113th out of 188 countries in the Human Development Index (HDI) with a figure of 0.689. Indonesia's 2015 HDI of 0.689 is above the average of 0.631 for countries in the medium human development group and below the average of 0.720 for countries in East Asia and the Pacific [3].

The Trend in International Mathematics and Science Study (TIMSS) and the International Student Assessment (PISA) study have become the new standard for mathematics learning. One of the objectives of TIMSS and PISA study is to know students' abilities in reasoning, identifying, and understanding, and using the necessary mathematical foundations in everyday life. Or in other words, students must have math literacy. Based on TIMMS results in 2015, in mathematics, Singapore is ranked 1st and Indonesia is ranked 44th out of 49 countries taking part in the study [4]. As for PISA Results, Si n gapura ranked 1 and Indonesia is ranked 66 out of 72 countries[5]. If we look at the results of TIMMS and PISA, Singapore occupies the highest position. This is because educational mathematics education in Singapore follows the problem-solving movement in mathematics education, coined by the American Serikan, through the Agenda of Action [6]. Problem solving has become a top priority in mathematics education in Singapore over the past two decades. Problem solving has been the focus of the theme in the Singapore mathematics curriculum for elementary and intermediate levels since 1990. Singapore composes the mathematics curriculum framework (ie, the pentagon framework) with the five relationships between components, with the center being the solution of mathematical problems [7], [8]. Skills or math skills are part of the life skills that learners must possess especially in the development of reasoning, communication, and problem solving faced in the lives of everyday learners [9]. Therefore Mathematics courses need to be given to all learners from the ground up, to equip learners with logical, analytical, systematic, critical, innovative and creative thinking skills, and the ability to work together. These competencies are necessary for schools to enable learners to have the ability to acquire, manage, and utilize information to live better in an ever-changing, uncertain, and highly competitive state.

Based on the above problems, enhancement in quality education is needed in order to spur the achievement of other goals and objectives within 17 points of SGDs. One of the steps taken to improve quality education is by developing a mathematics curriculum (learning mathematics) that can improve high order thinking skills so that Indonesian students can be equal to students in other countries, especially OECD countries and able to compete in the 21st century [10].

2. METHODE

The research applied qualitative approach by conducting interviews and documentation. Interviews were conducted on the Developers of Mathematics Curriculum, Curriculum and Books Center, Ministry of Education and Culture Curriculum and Book Center (Puskurbuk), Ministry of Education and Culture of the Republic of Indonesia, Widyaiswara from The Centre for the Development and Empowerment of Educators and Educational Personnel (PPPPTK) Mathematics, and Textbooks in Mathematics Writer of Junior High school. Documentation is done by study documents related to the mathematics curriculum, such as Basic Competences mathematics, Junior Mathematics Subject Guidance, and Mathematics Training Module, Textbook in Mathematics.

3. RESULT AND DISCUSSION

3.1 Higher Order Thinking Skills

Higher order thinking skills are defined as thinking skills, reasoning, critical thinking, and problem solving [11], [12]. Higher order thinking skills, including the ability to solve problem solving, critical thinking, creative thinking, reasoning, and decision making. Higher order thinking ability is one of the important competencies in the modern world, so it must be owned by every learner. *'Difficulty' is NOT the same as higher order thinkig* . Degree of difficulty in item not the same as higher order thinking skills. For example, to know the meaning of an *uncommon word* may have a very high degree of difficulty, but the ability to answer the problem does not include *higher order thinking skills.* Thus, *HOTS* issues are not necessarily high level problems. Higher order thinking skills can be trained in the classroom learning process. Therefore, for learners to have higher thinking skills, then the learning process also provides space to learners to discover the concept of activity-based knowledge. Activity in learning can encourage learners to build creativity and critical thinking. *HOTS* Problems can be based on real situations in everyday life, where learners are expected to apply the concepts of learning in the classroom to solve the problem. Contextual problems faced by the world community today related to the environment, health, earth and space, and the use of science and technology in various aspects of life.

Bloom stated that HOTS included analysis, synthesize, evaluation and need mastery of prior knowledge. Lower order thinking gave the foundation of higher order thinking to students learning. Student uses valuables information like abstracts, pattern, equation, or algorithm in the newest application and situation. Anderson & Krathwohl [13] has classified a thinking process dimension as shown below

Table 1. Thinking Process Dimension.

HOTS	Creating	• Creating ideas • Verbs : to construct, design, create, develop, write, formulate.
	Evaluating	• Making decissions • Verbs : to evaluate, assesst, deny, choose, decide, support.
	Analyzing	• Specifying aspects/elements • Verbs : to compare, examine, criticize, test.
MOTS	Applying	• Using informations different domains • Verbs : to use, demonstrate, illustrate, operate.

	Understanding		• Explaining ideas/concepts. • Verbs : to explain, classify, accept, report.
LOTS	Knowing or Memorizing		• Recalling. • Verbs: remember, register, repeat, mimic.

Source : Anderson & Krathwohl (2001)

3.2 Curriculum Development in the Sustainable Development Goals (SDGs) Era

Indonesia as a country that has agreed on the implementation of sustainable development goals (SDGs) is committed to the successful implementation of SDGs through various activities. In its implementation, there are several principles that have been agreed to be adopted by Indonesia. The first principle is universality. This principle encourages the application of SDGs in all countries, both developed and developing countries. In the national context, the implementation of SDGs will be implemented in all parts of Indonesia. The second principle is integration. This principle implies that the SDGs are implemented in an integrated and interrelated manner in all social, economic and environmental dimensions. This second principle has been firmly adhered to in the preparation of action plans specifically related to the preparation of programs and their activities and budgeting. The final principle is "No One Left Behind" which ensures that the implementation of the SDGs must benefit all, especially those who are vulnerable and the implementation involves all stakeholders. This principle has also been applied in every stage / process of implementing SDGs in Indonesia.

Education in Indonesia experience shift from centralization to decentralization. Based on Law Of The Republic Of Indonesia Number 23 Of 2014 About Local Government, Regarding the curriculum stated that the establishment of national curriculum, secondary education, primary education, early childhood education, and non-formal education become the authority of the central government. Based on the above the management of the curriculum structure as follows.

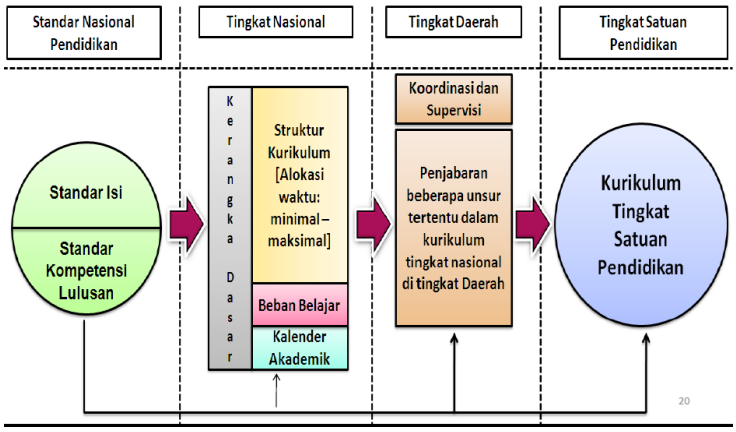

Figure 1.Curriculum Structure.

In the Law (UU) No. 20 of 2003 on the National Education System mentioned national education standard is used as a reference for curriculum development that is expected to realize the process of developing the quality of students for next generation to future

generations, which is believed to be a determinant factor for the growth of the nation and the country of Indonesia throughout the ages. Competency based curriculum is needed as an instrument to guide learners to: (1) develop the capability, character, and civilization of the nation for enhancing its intellectual capacity; and (2) educated human beings who are faithful and pious to one and only God, have noble character; who are healthy, knowledgeable, competent, creative, independent; and (3) as citizens, are democratic and responsible. Curriculum development is the process of developing a plan about the content and lesson materials to be learned along with how to learn it. Curriculum development is a deliberate and thoughtful process or activity to produce a curriculum as a guide in the process and implementation of learning by teachers in schools. A curriculum development process begins with an analysis of the need to determine people with what quality of life the curriculum must produce for the nation's generation. Given the importance of the role of the curriculum in education and in the development of human life, the preparation of the curriculum must use a strong and strong foundation.

In effort realize quality education and the purpose of national education is to developing learners'potentials so that they become persons imbued with human values who are faithful and pious to one and only God; who possess morals and noble character; who are healthy, knowledgeable, competent, creative, independent; and as citizens, are democratic and responsible., then set the Graduates Competency Standards which is the criteria of graduate qualifications that include attitudes, knowledge, and skills. To achieve the competence of the graduates, it is necessary to stipulate the Content Standards which are the criteria on the scope of the material and the competence level of the learner to achieve the competence of the graduates on the level and type of education. Content Standards for Primary and Secondary Education, here in after referred to as Content Standards, consist of Core Competence and Basic Competence Levels in accordance with certain levels and types of education. Achievement of Core Competence and mastery of the scope of the material on each subject for each class at the level of competence in accordance with the level and type of education specified by the Central Curriculum and Books. The formulation of Basic Competence in each Core Competence for each subject according to the level and type of education specified by the Center of Curriculum and Books. Basic competence is the ability and minimal learning material that must be achieved by students for a subject in each educational unit that refers to core competencies. The Elaboration of Core Competence and Basic Competence of Junior High School Mathematics is in the Regulation of Regulation of the Minister of National Education of the Republic of Indonesia Number 24 Year 2016 About Primary and Secondary Level core competence and basic competence, Appendix 15.

3.3. Mathematics Curriculum

According to Tyler, there are four things considered to be important in curriculum development. Firstly, the correlation of educational objectives which needs to be achieved; Secondly, in terms of learning experiences heading to achieve the objectives; Thirdly, leraning experiences organizations; and Fourth, it relates to the evaluations.

Mathematics curriculum in many countries nowdays, basically align with the United States of America hopes as similar with the National Council of Teachers of Mathematics Standards (NCTM), a very influential professional organization of mathematics education in the US. Since 1980s, the organization has suggested the overall reformation of learning practices in the USA. Some of the ideas in reforming learning practices are encouraging to shift the learning instructions from teacher-centered to student-centered, and transforming students

from passive learners into active learners (NCTM, 1989, 2000) [14], [15]. In learning mathematics, students are expected to increase their abilities in dealing with reasoning, problem solving, mathematical communications, mathematical connections, and in using mathematical representations. NCTM standards (2000) explained that mathematics instruction should be pointed into the thinking ability, like : (1) using and noticing mathematical connection in relation to some mathematical ideas; (2) understanding how mathematic ideas become connected from one to another for creating comprehension; (3) noticing and using mathematics within and outside contexts of math [16].

Mathematics curriculum standards should emphasize connection as one of the important processes in mathematics instructions. Learning must create students able to recognize and apply math in the context of outside mathematics. This includes creating relationships to the "real world" i.e the world outside classroom. For that reason, teachers are expected to prepare the real world situation and its context for students in order to make mathematics make sense or acceptable to them. So, students are able to get a chance to recognize and appreciate the relationships of mathematics and their life. Teachers are forced to assist students in creating more realistic correlation between mathematics and life as making the meaningful mathematics. Even connecting mathematics into the real life is not always be easy. That is why teachers need abilities to recognize and understand about the mathematical relationships and applications which can be used to develop mathematical instructions. Students establish knowledge through the investigation process by themselves.

Mathematics skills and expertise are parts of the life skills which must be owned by the learners especially in the development of reasoning, communication, and problem solving that facing up by the learners daily. Therefore, the subject of mathematics is necessarily to be given to all students started form the elementary school to provide abilities in logical thinking, analytical, systematical, critical, innovative and creative, and cooperative competencies. These competencies are needed in order students able to gain ability of gaining, managing and using information for the better life in the very much changing situations, uncertain, and very competitive. In doing the learning of mathematics, students can embrace the benefit of learning mathematics.

Mathematics education at school can contribute in achieving competency of elementary and secondary education through learning experiential, in order to :

a. Understand the concepts and apply the procedures of mathematics in the daily real life;
b. Conduct mathematics operation to simplify and analysis available components;
c. Conduct the mathematical reasoning which includes creating generalization based on patterns, facts, phenomenon, or existed data, predicting and verifying on it;
d. Solving problems and communicating ideas which represented by symbols, tables, figures, diagrams, or the medias, to clarify problems or situations;
e. Raise up positive attitudes such as logical, critical, and never give up easily in solving the problem.

According to Dr. Lambas (Developers of Mathematics Curriculum, Curriculum and Books Center, Ministry of Education and Culture).In relation to the way of overcoming the situations above, the reformation within curriculum 2013 has constructed the unlimited competency by taxonomy level of thinking process. It is junior high school the broaden and deepen of knowledge dimensions like factual, conceptual, procedural, metacognitive, and

thinking process dimensions such as remembering, understanding, applying, analyzing, evaluating, and creating.

In learning activities, students observe the occasion, event, situation, pattern, phenomenon relate to Mathematics and afterwards start to introduce mathematics modelling in several forms; asking or questioning why and how the phenomenon can be happened; collecting and digging information through trying, experimenting, reviewing, discussing to deepening the concept that relates to the phenomenon; and associating or analyzing critically in explaining the relationship between concepts and algorithm choosing which appropriate to conceive reasoning, and generalizing, also communicating what have been found in analysis activities.
In learning mathematics, several things to be emphasized as follow.

a. Learning activities under teacher guidance and supervision with using the concept and procedure correctly and systematically by prioritizing comprehension rather than memorizing the procedures.
b. Training thinking abilities to make generalization of facts, data, existing phenomenon.
c. Training skills in doing mathematical manipulation to solve the problems.
d. Training mathematical reasoning skills.
e. Problem solving based learning.

3.4 How to Improve Higher Order Thinking Skills in Learning Mathematics

According to Dr. Lambas (Developers of Mathematics Curriculum, Curriculum and Book Center (Puskurbuk), Ministry of Education and Culture of the Republic of Indonesia) how to made the developers of mathematics curriculum in improving the skills of higher order thinking in the mathematics curriculum is to formulate basic competencies that demand higher order thinking skills of students in each material. Regulation of the Minister of National Education of the Republic of Indonesia Number 21 Year 2016 About Primary and Secondary Level Content Standard which reads the Achievement of Core Competence and the mastery of the scope of the material on each subject for each class at the level of competence in accordance with the level and type of education specified by the Curriculum and Books Center. The formulation of Basic Competencies in each Core Competence for each subject according to the level and type of education is determined by theCurriculum and Book Center. We as math curriculum developers at the Center of Mathematics Curriculum have formulated basic mathematics competencies that require students to cultivate the competenceof higher order thinking skills, it can seen in basic competencies in mathematicsatRegulation of the Minister of National Education of the Republic of Indonesia Number 24 Year 2016 About Primary and Secondary Level core competence and basic competence. In the formulation of the basic competences load operational verb (KKO) and the range of material, where each material in operational verbs are required to achieve higher order thinking skills. But he also states that the rhyme still needs to be elaborated more operational within the RPP (lesson plan) and needs to be redefined. In order for Teachers can develop lessons that can improve the high level of skills Teachers must exploration andpractice associated with higher order thinking skills.

According to Dra. Sri Wardhani as The Centre for the Development and Empowerment of Educators and Educational Personnel (PPPPTK) Mathematics, improve higherorder thinking skills through the module of junior high school mathematics teacher is by way of Material description in the module featuring as optimal as possible containing examples of mathematics learning materials for students who have the potential to improve higher order thinking

skills, Activity learning activities and Task/Training participants on modules arranged in the form activities that require higher order thinking participants, as well as evaluation Problems prepared that require higher order thinking participants. She mentioned that all the materials in the module contain high orderl thinking skills . For a module containing a mathematical substance (professional) demands high-order thinking skills are displayed through: examples, problems / cases in the description of the material description, the content of learning activities, content of materials / training materials. For pedagogy-loaded modules, the demands of higher level thinking skills are presented through: providing examples of their application to the pedagogy content knowledge , the content of learning activities, the content of task materials / training of learning materials. In order for Teacher to develop lessons that can alert high order thinking skills, the teacher should continue to follow various directives and training on higher-order thinking skills. Before teachers teach with high-level thinking, the teacher must also be able to think high lorder first by making the setting of learning and questions that demand higher order thinking.

According to Dr. Abdur Rahman As'ari, M.Pd, MA as a textbook in mathematica writer of junior high school how to improve higher order thinking skills at textbooks mathematics of junior high school is one way to awaken students about the need for critical and creative thinking. We can give examples of problems that contain contradictory information (illogical problem). We can ask them to work in two ways that will produce a contradiction. That way, we hope they will experience cognitive conflict, and realize the need to be careful in facing the problem. We can also give them a matter of the universe of the variable is still not fixed. For example, specify a graphic image of the equation. Let them know that the graphics can vary depending on the universe of the conversation. The graphic image can be only 4 dots, if x and y are real numbers, two points if x and y are primes, and lines where x and y are real numbers. That way, they will be invited to be careful, and always truth seeking.

If you want to be creative, we can give to students the questions that are open ended. Moreover, the problem is ill structured and ask students to do it in project form. He also said that in the textbook the lessons contain higher order thinking skills. It should all contain higher order thinking skills. Problems that require higher level thinking skills are not necessarily a difficult question. Originally he invites children to do analysis, evaluate, and create certainly requires high-order thinking skills. For example ... we give students the 6 dots arranged into two rows ... each row there are three dots . Ask students to determine how many different triangles can be formed? How many right triangles are there? Taper? Blunt? This problem is simple, but can invite children to think high level. He also conveyed a pa which should be done by the teacher in order to develop the learning that can alert the high level skill that is by learning and learning. Teachers must develop themselves so that they are fully mastered by this higher order thinking concept, the indicators in each study new concepts, new theorems, and problem solving, and are not tired of doing reflective practices on the learning that has been done, and doing the PTK research that is MICRO, the MESO or MACRO.

4. CONCLUSION

Quality education is the fourth goal of The Sustainable Development Goals (SDGs). One of the targets to be achieved in realizing quality education is to ensure that all girls and boys receive quality primary and secondary education. Steps that can be taken so that Indonesian students obtain quality education and are able to compete in the 21st century, especially in the field of mathematics, is by learning students accustomed to solving problems that are higher order thinking skills. With mathematics that can develop higher order thinking skills and

learning not only memorizing formulas, but is done by training students 'reasoning and problems solving that relate to everyday problems, it is expected that later on there will be an increase in students' ability in reasoning and problem solving in order to improve the quality of Indonesian students in the The Sustainable Development Goals (SDGs) Era. Higher order thinking skills can be trained in the learning process in the classroom. Therefore, for students to have higher order thinking skills, the learning process also provides space for students to discover the concept of activity-based knowledge. Activities in learning can encourage students to build creativity and critical thinking. The Government has attempted to develop higher order thinking skills through the formulation of basic competencies, learning teacher modules, and textbooks, but the key to success in improving higher order thinking skills is the Teacher. Teachers are required to continue to learn and explore higher order thinking skills.

REFERENCES

[1] Bappenas, *Pedoman Penyusunan Rencana Aksi Tujuan Pembangunan Berkelanjutan (TPB)/Sustainable Development Goals (SGDs)*. Jakarta: Bappenas, 2017.

[2] UNESCO, "Education for All 2000-2015: achievements and challenges;," *EFA Glob. Monit. Rep.*, p. 232, 2015.

[3] UNDP, "Human Development Report 2016: Human Development for Everyone," *UNDP*, 2017. [Online]. Available: http://hdr.undp.org/sites/default/files/2016_human_development_report.pdf.

[4] IEA, *TIMMS 2015:International Results in Mathematics*. Boston: International Study Center Lynch School of Education, Boston College, 2016.

[5] OECD, "PISA 2015: PISA Result and Focus." OECD, Paris, p. 5, 2016.

[6] NCTM, *View An Agenda for Action*. Reston: The National Council of Teachers of Mathematics, 1980.

[7] L. Fan and Y. Zhu, "From convergence to divergence: the development of mathematical problem solving in research, curriculum, and classroom practice in Singapore," *ZDM*, vol. 39, no. 5–6, pp. 491–501, Sep. 2007.

[8] J. Anderson, "Mathematics Curriculum Development and the Role of Problem Solving," in *ACSA Conference 2009*, 2009, pp. 1–9.

[9] NCTM, *Principles to Actions: Ensuring Mathematical Success for All*. Reston: National Council of Teachers of Mathematics, 2014.

[10] OECD, "PISA 2015 Draft Mathematical Framework." Organisation for Economic Co-Operation and Development, Paris, 2016.

[11] F. J. King, L. Goodson, and F. Rohani, "Higher order thinking skills: Definition, teaching strategies, assessment," *Publication of the Educational Services Program*. Center for Advancement of Learning and Assessment, 1998.

[12] S. M. Brookhart, *How To Assess Higher Order Thinking Skills in Your Classroom*. Alexandria, Virginia: ASCD, 2010.

[13] L. W. Anderson and D. R. Krathwohl, *A Taxonomy for Learning, Teaching and Assesing : A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Longman, 2001.

[14] Research Advisory Committee of the National Council of Teachers of Mathematics, "NCTM Curriculum and Evaluation Standards for School Mathematics: Responses from the Research Community," *J. Res. Math. Educ.*, vol. 19, no. 4, p. 338, Jul. 1988.

[15] NCTM, *Principles and standards for school mathematics*. Reston: National Academies Press, 2000.

[16] D. Suryadi, *Mathematics Education*. Bandung: Universitas Pendidikan Indonesia, 2011.