Philosophy of mathematics education for sustainable development

I Widiati* and D Juandi
Mathematics Education Departement, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia

*indahwidiati@upi.ac.id

Abstract. This article aims to examine the philosophy of Education for Sustainable Development (ESD) especially on mathematics education. This study is important because education is a key element in realizing quality Sustainable Development (SD) implementation. Mathematics is the key to other fields of science. Therefore, mathematics education plays an important role in realizing Education for Sustainable Development (ESD). This article will outline the importance of Education for Sustainable Development (ESD), philosophy and psychological studies of knowledge, Skills, Issues, perspective, and Value as an important aspect of Sustainable Development (SD), and how mathematics education can support the realization of Sustainable Development objectives. The method used is a study of literature sources relevant to Education for Sustainable Education (ESD). After studying this literature, it will be designed a competency-based mathematics competence Education for Sustainable Education (ESD), then provide training and knowledge to students as research subjects to be able to design a mathematical competency-based evaluation instrument that has been designed, then qualitatively analyzed the results of the instrument evaluation, in terms of creative thinking ability. It is expected that through this program will be obtained a strategic guide in designing evaluation instruments based on Education for Sustainable Education (ESD).

1. Introduction
Education for Sustainable Development (ESD) is currently being developed in many countries. Including Indonesia who is trying to develop it in various fields in accordance with aspects contained in the ESD that is Mathematics, Science, Geography, and Language. Mathematical materials should contain the capabilities developed by ESD, mathematical problems should be designed based on Sustainable Development Goals, so that the mathematical material provided can be more useful for students and more able to develop teachers' skills and creativity in designing problems according to the problems is in the neighborhood.

Looking at current educational developments, it is important to do a design or project that can support a sustainable development program. Absolute education follows the times, and must have a long-term vision that is certainly useful for the future. Related to this, sustainable development as an important program worth fighting for. Therefore, it will first be explained about 17 Sustainable Development Goals (SDGs), namely: (1) no poverty; (2) zero hunger; (3) good health and well being; (4) quality education; (5) gender equality; (6) clear water and sanitation; (7) affordable and clean energy; (8) decent work and economic growth; (9) industry, innovation and infrastructure; (10) reduced inequalities; (11) sustainable cities and communities; (12) responsible consumption and production; (13) climate action; (14) life
below water, (15) life on land; (16) peace, justice and strong institutions; and (17) partnership for the goals [1].

The United Nation (UN) proclaimed 2005-2015 the ‘Decade of Education for Sustainable Development’, signaling the importance of ESD across fields and communities worldwide [2]. In the last for decade, a wide range of term have been used alongside ESD which emphasize different priorities and approaches, such as eco-pedagogy, education for sustainability, sustainability education, and pedagogy of place. Most approaches ask students to consider how human economic and social and cultural concern interact with the importance of conservation of natural resources [2].

Education can be a vehicle for actively promoting positive attitudes and patterns of behavior that reflect the requirements of Sustainable Development [3]. Education for Sustainable Development is all aspect of public awareness, education and training provided to create or enhance an understanding of the linkages among the issues for Sustainable Development and to develop to knowledge, skills, perpective, and values that will empower people of all ages to assume responsibility for creating sustainable futures [4].

The World Summit on Sustainable Development Report (2002) posits that sustainable development operates at three domains. They are economic domain, aims at reducing and seeking to eradicate poverty, achieving higher levels of prosperity and enabling continued gains in economic welfare; social domain-aims at reducing and seeking to eradicate other dimensions of poverty, improving the quality of education, health, housing, and other aspects of welfare of individuals and communities, and enhancing the quality of social interaction, engagement and empowerment; environmental domain-aims at reducing pollution and other negative impact on environment, mitigating the effects of industrialization and human activity, and seeking to achieve sustainable use of resources in the interest of future generations [5].

From some definition of Education for Sustainable Development (ESD), I want to rearrange to be definition from my conclusion. ESD is an effort in the field of education to instill the values of individual and social character to be responsible and cultivate a sense of love for the environment, social, culture, and economy so that through these characters, each individual can maintain life and environment in a sustainable. Mathematics Education for Sustainable Development is efforts to inculcate the value of character, skills, attitudes, and knowledge through the application of mathematics learning in the field of environment, social, culture, and economics so that learning mathematics becomes more useful in sustaining their lives sustainably and support the achievement of Sustainable Development Goal's. Because there are problems in everyday life that affect the sustainability of human life, therefore UNESCO designed the 17 goals of Sustainable Development Goal's which includes three main domains of economic, social, and environment through several approaches such as Education for Sustainability, especially Mathematics Education for Sustainable Development aims to make learning mathematics more meaningful, useful, and support the development of 21st century competence that is critical thinking, creative, communicative, and collaborative. All these competencies can be developed in mathematics subjects with the problems given in the form of applications in the economic, social, and environmental fields, so it is expected to be the guideline of student in the future in life. This explanation can be show by this schema on Figure 1:
2. Method
After conducting this literature study, I will design the competence of mathematical skills relevant to ESD competence. Through the design of these competencies will be followed by validation of research instruments to be used. Then the researcher will provide training and guidance to the students who are taking evaluation course to be developed to be able to design the evaluation instrument based on ESD. The design of the instrument was then qualitatively reviewed by the researcher and adapted to the rubric of ESD-based evaluation instrument evaluation by the researcher. The results of the evaluation will be reviewed and discussed for later to produce an ESD-based mathematics competency design.

3. Result and discussion
Education for Sustainable Development is a means to accommodate the knowledge and skills a person has to be able to solve global problems in the social, economic and environmental fields in the present and future. Education for Sustainable Development is a long-term learning process to support one's life to be better in the social, economic and environmental fields so that this can be a good and sustainable learning culture to support Sustainable Development's Goal. While Education for Sustainable Development in the field of mathematics education is a means to develop mathematical abilities and mathematical skills of students in solving Education for Sustainable Development based on mathematical problems, namely in the social, economic and environmental fields so that they can support the lives of students in the present and future.

The philosophy of mathematics may be assumed to provide a unifying framework that potentially supports an epistemological clarification of mathematical knowledge, as well as a critical reflection on the belief and value about mathematical knowledge that a teacher hold in connection with the content and the prevailing practices of mathematics teaching [6]. The philosophy of Education for Sustainable Development may be assumed that innovation in education that consist of some competences, some aspects, and some domain that all of to make education can be develop not only for now but also for sustainable in order to this education can be something that have more advantages not only for people but also for our living and environment. The philosophy of Mathematics Education for Sustainable Development may be assumed that all of theory and material in mathematics can give more advantages for our environment, economic, and society in order to all of people can love mathematics more and more because they feel any advantages from mathematics for their live.
Concept of mathematical competences is based on the Danish KOM [7]

- Thinking mathematically: knowledge of the kind of the question that are dealt with in math and the types of answer maths cannot provide, and the ability to pose such questions: recognition of maths concepts and understanding of their scope and limitations, extending the scope by abstraction and generalization of results; understanding of the certainty of mathematical considerations
- Reasoning mathematically: ability to understand and assess an already existing maths argumentation and the notion of proof, and to recognize the central ideas in proofs; knowledge/ability to distinguish between different kinds of maths statements; construction of chains of logical arguments and hence of transforming heuristic reasoning into own proofs (reasoning logically)
- Posing and solving mathematical problem: ability to identify and specify mathematical problems; ability to solve mathematical problems (including knowledge of the adequate algorithms); personal capabilities to decide a question considered as a problem
- Modelling mathematically: ability to analyze and work in existing models; ability to perform active modelling
- Representing mathematical entities: ability to understand and use mathematical representations and know their relations, advantages and limitations; ability to choose and switch between representations
- Handling mathematical symbols and formalism; ability to understand symbolic and formal maths language and its relation to natural language as well as the translation between both; rules of formal maths system and the ability to use and manipulate symbolic statements and expressions according to the rules
- Communicating in, with, and about maths: ability to understand mathematical statements (oral, written, or other) made by others; ability to express oneself mathematically in different ways
- Making use of aids and tools: knowledge about the aids and tools that are available: ability to use the aids and tools thoughtfully and efficiently.

There are several important competencies related to Sustainable Development by several experts, namely [8]

- Problem solving, critical thinking, action competence and system thinking [9]
- Imagination, critical thinking and reflection, system of thinking, partnership, learning to work together, participation in decision-making [3,10]
- Systems thinking-the ability to see the interconnections between different dimensions and the complexity of systems and situations [11,12]

Cebrian G and Junyent M (in developed a theoretical framework of the professional competencies in ESD) and elaborated eight key components [13]:

- Future/alternative scenarios visioning: understanding the different scenarios, possible futures, promoting work with different visions and scenarios for alternative and future changes.
- Contextualizing: taking into account the different dimensions of a problem or action, the spatial dimension (local-global) and the temporal dimension (past, present and future).
- Work and live with complexity: the ability to identify and connect the ecological, economic and social dimensions of problems. Generate the conditions for systems thinking in the school environment.
- Think critically: creating the conditions for critical thinking to question assumptions and to recognize and respect different trends and views in different situations.
- Decision-making, participation and acting for change: moving from awareness to action; sharing responsibilities and engaging in joint action.
- Clarify values: values clarification and strengthening behavior towards sustainability thinking, mutual respect and understanding of other values.
- Establish a dialogue between disciplines: developing teaching and learning approaches based on innovation and interdisciplinarity.
- Manage emotions and concerns: promoting reflection on one’s own emotions and as a means to reach a deeper understanding of problems and situations.

There are 5 aspect in ESD [14]

3.1. Knowledge
Sustainable development encompasses environment, economics, and society. Therefore, people need basic knowledge from the natural sciences, social sciences, and humanities to understand the principles of sustainable development, how they can be implemented, the values involved, and ramifications of their implementation. Knowledge based on traditional disciplines supports ESD.

3.2. Skills/actions
To be successful, ESD must go beyond teaching about these global issues. ESD must give people practical skills that will enable them to continue learning after they leave school, to have a sustainable livelihood, and to live sustainable lives. These skills will differ with community conditions.

3.3. Value
Values are also an integral part of ESD. In some cultures, values are taught overtly in the schools. In other cultures, however, even if values are not taught overtly, they are modeled, explained, analyzed, or discussed. In both situations, understanding values is an essential part of understanding your own worldview and other people’s viewpoints.

3.4. Perspective
ESD carries with it perspectives that are important for understanding global issues as well as local issues in a global context. Every issue has a history and a future. Looking at the roots of an issue and forecasting possible futures based on different scenarios are 21 part of ESD, as is understanding that many global issues are linked. For example, over-consumption of such consumer goods as paper leads to deforestation, which is thought to be related to global climate change.

3.5. Issues
ESD focuses largely on the major social, economic, and environmental issues that threaten the sustainability of the planet. Many of these key issues were identified at the Earth Summit in Rio de Janeiro and are found in Agenda 21 Understanding and addressing these issues are the heart of ESD, and locally relevant issues should be included in any program related to educating for sustainability.

All of the aspect in ESD much develop very well. We can say that sustainable mathematics education is the project of reorienting mathematics education towards environmentally conscious thinking and sustainable practices. It is a change effort that we cannot afford to ignore [11]. Sustainable mathematics education is about seeing the world a new through renewed mathematics. It is concerned not only with feeling large numbers, but also with feeling the global situation [11].

Topics covered in ESD are resources, culture, tourism, social institutions, pollution, physical environment, teenage pregnancy, child abuse, population growth and change, values and attitudes, and industrial activity [14] And then, any 15 guidelines for creating mathematics curriculum resources that support ESD, namely: real contexts, current issues, complexity, value, access to data, human activity, foregrounding context, interdisciplinary, sensitivity to marginalization, opening dialogue, courage, trust, access, and using technology [1].

This the relation between mathematics competences and competences of Education for Sustainable Development (ESD):
Figure 2. (Relation between mathematics competence and competences of ESD).

Based on the literature study the results show that the philosophy of Education for Sustainable Development can be view from a constructivism point of view. This is based on the view that Education for Sustainable Development based mathematics is built by a paradigm that mathematical thinking is not only to solve mathematical problems. Not only training so students are able to do arithmetic operations, but students can carry out a continuous learning process even though learning has completed. This means that the learning process is long-term because it is expecting to be able to support Sustainable Development's Goal. Through this process, it is also expecting to support the development of student character. Through Education for Sustainable Development based mathematics it is expected that students not only have the ability to think mathematically, but have sensitivity to the problems found in the surrounding environment, especially in the social, economic, and environmental fields.

After a literature study of the philosophy of ESD, researchers plan to explore more about the aspects of ESD and from a psychological point of view. This is important because the ESD aspects play an important role in implementing Education for Sustainable Development in learning. The implementation of learning must guide by these five aspects of ESD. However, the study of literature on the philosophy of ESD is the initial foundation for researchers in conducting research in the field of ESD especially in mathematics education.

4. Conclusion

The mathematics philosophy for ESD is continuous learning and synchronization between mathematics learning applications and character values. So that when looking at a mathematical problem, not only from the point of view of a solution, but students have sensitivity of intrinsic values contained in it so that it can support the development of student life in the future.

References
[1] UNESCO 2017 UNESCO MGIIEP United Nations Educational
[2] Jackson Liz 2016 ‘Asian’ Perspective on Education for Sustainable Development Routledge (Francis: Taylor Francis Group)
[3] Bonnett M 2002 Education for sustainability as a frame of mind Environmental Education Research 8(1) 9-20
[4] Jaspar JC 2008 Teaching for Sustainable Development: Teachers’ Perceptions University of Saskatchewan (Saskatoon: Saskatchewan)
[5] Azuka Festus B 2015 Mathematics Education for Sustainable Development: Implication to the Production and Retention of Maths Teachers an Nigerian School British Journal of Education 3(1) pp 45-51 Nigeria: National Mathematical Centrel, Abuja
[6] Chassapis D 2007 Integrating the philosophy of mathematics in teacher training courses.
In *Philosophical dimensions in mathematics education* pp. 61-79 Boston: Springer MA

[7] Niss M and Hojgaard T 2011 *Competencies and Mathematical Learning* IMFUFA (Denmark: Roskilde University)

[8] Vintere A and Briede V 2016 *Engineers’ Mathematic Education in the Context of Sustainable Development* Engineering for Rural Development (Jelgava: Latvia University of Agriculture)

[9] Jones P, Selby D and Sterling S 2010 *Sustainability in Sustainability Education: Perspective and Practice Across Higher Education* (London UK: Eds Earthscan)

[10] Stibbe A 2009 *The Handbook of Sustainability Literacy: Skills for a Changing World* Stibbe (Dartington: Devon, Green Books)

[11] Renert Mosche 2011 *Mathematics for Life: Sustainable Mathematics Education For the Learning of Mathematics* (Canada: FLM Publishing Edmonton Alberta)

[12] Tilbury D and Wortman D 2004 *Engaging People in Sustainability* (IUCN: Gland)

[13] Cebrian G and Junyent M 2015 Competencies in Education for Sustainable Development: Exploring the Student Teachers’ View *Journal Sustainability*

[14] McKeown Rosalyn 2002 *Education for Sustainable Development Toolkit* (Waste Management Researchand Education Institution)