Fostering Decision-Making Skills Through Socio-Scientific Issues in the 2013 Curriculum

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ABSTRACT

Industry 4.0 has challenged 21st-century society through future employment and workforce trends shifting. Decision-making is one of the thinking skills urgently needed to achieve job success in this disruptive era. As the skills in choosing the best solution to the socio-scientific issues (SSI), decision-making is closely associated with scientific literacy. Indeed, Indonesia has committed to developing decision-making skills implicitly by emphasizing scientific literacy in the 2013 Curriculum. However, these efforts have not met the expectations. The present study aims to describe the development strategy of decision-making skills in the context of SSI in the junior high school 2013 Curriculum. Various constructs of decision-making were reviewed to formulate the appropriate framework. Delivering the SSI articles in the initial stage of instruction and stimulating students to choose the SSI's best solution through four cognitive processes guided by students' worksheets can be established as the decision-making strategy. As the explicit scaffold in the worksheets, the cognitive processes include identifying the SSI, formulating alternative solutions, evaluating alternative solutions, and making decisions.

Keywords: *Decision-making, Socio-scientific issues (SSI), Science education, Junior high school, 2013 curriculum*

1. INTRODUCTION

The latest industrial paradigm, labeled as Industry 4.0, is transforming the society through its core concepts, digitalization and automation mechanisms. The integration between the virtual and physical world marks this digitalization era through the Cyber-Physical System (CPS), which encourage the rapid development of information and communication technology [1]. It is not surprising that the primary constructs of digitalization, the Internet of Things (IoT) and Artificial Intelligence (AI), are now an integral part of 21st-century society that affect how they live, think, and work. This phenomenon challenges them, both at present and in the future.

The shift in future employment scenario is a real challenge due to Industry 4.0 [2]. Changes in workforce trends have increased the gaps in work-skills mismatch, leading to the mastery of new skills [3], such as decision-making. The World Economic Forum [4] in The Future of Jobs Reports formulates ten work-related practical skills for achieving future job success: complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, service orientation, negotiation, cognitive flexibility, judgment and decision-making. Furthermore, Grzybowska & Lupicka [5], through an in-depth exploration of various relevant literature and official documents, identify eight managerial competencies that need to be possessed in Industry 4.0: creativity, entrepreneurial thinking, problem-solving, conflict-solving, decision-making, analytical skills, research skills, and efficiency orientation. Indeed, decision-making is worth considering as a fundamental ability needed to adapt to this disruptive era.

Education promotes the improvement of human resources quality according to the times by equipping the technical and non-technical skills [6], such as supporting decision-making-oriented learning that allow students to become a well-informed citizen. Science education is responsible for making it happen [7]. According to the European Commission's statement [8], science education and learning are essential to improve the culture of scientific thinking and inspire people to use scientific evidence-based reasoning to make decisions. The National Committee on Science Education Standards and Assessment also affirm that the mastery of various thinking skills such as argumentation, problem-solving, or decision-making is the main element of citizenship education acquired through science instruction [9].

Decision-making in science education can be articulated as students' ability to discuss and interpret complex socio-scientific issues (SSI) and knowledge related to economic, social, and political aspects of life, which require them to decide the best attitude and action among the alternatives daily [10,11]. The ability to use scientific knowledge to make informed decisions in the context of SSI is the essence of scientific literacy [12-15]. It provides the theoretical rationalization of decision-making within the scientific literacy framework.

The achievement of Indonesian students' scientific literacy globally through the Program for International Student Assessment (PISA) can represent the decision-making performance based on their correlation above. Despite Indonesia's active participation since 2000, the achievement remained in the bottom ten category among the other OECD countries [16]. Hence, it is critical to design decision-making-oriented instruction in SSI that matches Indonesia's current curriculum setting, i.e., the 2013 Curriculum. This attempt is necessary because SSI implementation into science education curricula and everyday science classrooms still face some difficulties [17].

Regarding the identified gap, this study aims to describe the appropriate development strategy of decision-making skills in the context of SSI in the junior high school 2013 Curriculum based on various theoretical constructs of decision-making proposed by researchers. The article is divided into two main parts. The first main part is a theoretical introduction to the nature of decision-making skills in science learning. The next part presents the development framework of SSI's decision-making skills in the junior high school 2013 Curriculum with the STEM approach.

2. METHODS

This research is descriptive qualitative. This study describes a strategy for developing decision making in the context of IDO in the 2013 Junior High School Curriculum. Data collection was done by using worksheets.

3. RESULT AND DISCUSSION

3.1. The Nature of Decision-Making Skills in Science Learning

Psychologists and educational experts have variously defined the constructs of decision-making skills. Decision-making refers to the skills of choosing the most appropriate alternative or action as a solution, among other alternatives [18,19]. Decision-making also implies a commitment to act based on the evaluation process of argumentation [20].

There are two significant theories of decision-making: (a) a descriptive theory, based on the concept of how decisions are made in real life; (b) a normative theory, based on the concept of how decisions should be made [21]. Most of the decision-making research in science learning adapts the normative theoretical framework that uses a rational approach as an analytical process to make effective decisions. With the normative perspective, decision-making skills can be assessed objectively [22].

Normative decision-making skills reflect more on the sequential process rather than quick action. Some logical and systematic sequences of decision-making processes have been proposed and tested empirically in a science classroom discourse, shown in Table 1. Therefore, it can be summarized that decision-making is the skills in choosing the best solution to the SSI (in the context of science learning) through four cognitive processes: identifying the SSI, formulating alternative solutions, evaluating alternative solutions, and making decisions.

Table 1. Various constructs of decision-making skills

Hong & Chang [23]	Eggert et al. [24]	Lee & Grace [25]	Lunenburg [26]
a. Recognizing problem to decide b. Identifying the problem	a. Describing the SSI	a. Identifying stakeholders and their possible views b. Identifying and collecting necessary information or evidence to inform arguments	a. Identifying the problem
c. Organizing knowledge corresponding to the problem being solved d. Gathering information	b. Developing solutions to the SSI	c. Generating options for resolving the issue	b. Generating alternatives

Hong & Chang [23]	Eggert et al. [24]	Lee & Grace [25]	Lunenburg [26]
e. Comparing and analyzing alternatives f. Evaluating each alternative by attributes	c. Evaluating solutions to the SSI	d. Considering the pros and cons of options; identifying values underlying options e. Formulating criteria for evaluating options	c. Evaluating alternatives
g. Selecting the decisions		f. Making decisions with justifications	d. Choosing an alternative
		g. Sharing the decisions among students in the same location h. Sharing the decisions with students in a different location	e. Implementing the decision
	d. Suggesting improvement to solutions		f. Evaluating decision effectiveness

The decision-making topic is conceptualized empirically in various ways by researchers. Most of them use SSI as a productive context for the decision-making process. For instance, Lee [27] developed a learning approach that uses the smoking issue as a context for directing junior high school students in Hong Kong to make informative decisions. Besides, arguments can support the decision-making process so that the two variables are interconnected. For example, Jiménez-Aleixandre [28] defined argumentation as a process of evaluating theoretical claims based on empirical evidence; hence, argumentation is positioned as competence to choose criteria that can prompt the best decisions. Engineering design can also bridge the mastery of decision-making skills, as the research findings by Altan et al. [29] that pre-service science teachers' decision-making skills increased significantly after the application of design-based learning as an approach in STEM-based learning.

3.2. The Development Strategy of Decision-Making Skills in the 2013 Curriculum

The commitment to develop decision-making skills in Indonesia, as stated in the 2013 Curriculum, has been built implicitly by emphasizing scientific literacy. Responding to the 2018 PISA results, which placed Indonesia in 70th place out of 78 participating countries, Indonesia's Minister of Education and Culture instructed the stakeholders to immediately evaluate the quality of education whose global trends are oriented toward 21st-century skills, including scientific literacy. This instruction can be accessed directly on the official website of Indonesia’s Ministry of Education and Culture (https://www.kemdikbud.go.id/).

The need for the development of decision-making skills in the junior high school 2013 Curriculum is represented indirectly by the Graduate Competency Standards in the knowledge dimension as follows: "*able to link factual, conceptual, procedural, and metacognitive knowledge at the technical and specific levels about science, technology, arts, and culture in the context of oneself, family, school, community, and the surrounding environment, nation, state and regional area*". The process of using knowledge in the context of everyday life implies the urgency of decision-making as an evaluative process of scientific literacy. Students' knowledge gained through science learning within the 2013 Curriculum is needed to decide the best action in responding to SSI in everyday life.

The learning material mapping, which provides the opportunity to contextualize the socio-scientific decision-making process in the 2013 Curriculum, is presented in Table 2. These contexts have met SSI criteria, which are complex, unlimited, most controversial, and socially crucial without concrete solutions [30]. Students must consider the social, economic, ethical, and moral aspects in responding to SSI, so these various perspectives lead to various solutions [31].

Table 2. The SSI context in the 2013 Curriculum

Basic Competence (Knowledge Dimension)	SSI Learning Contexts
Grade 7	
3.5 Analyze the concept of energy, various energy sources, and energy changes in everyday life, including photosynthesis.	National and global energy crisis
3.8 Analyze the appearance of environmental pollution and its impact on the ecosystem.	Environmental pollution due to industrial activities
3.9 Analyze climate change and its impacts on the ecosystems.	Climate change
Grade 8	
3.6 Describe various additives in food and beverages, addictive substances, and their impact on health.	MSG causes stupidity, the controversy over the closure of cigarette factories, doping use by athletes

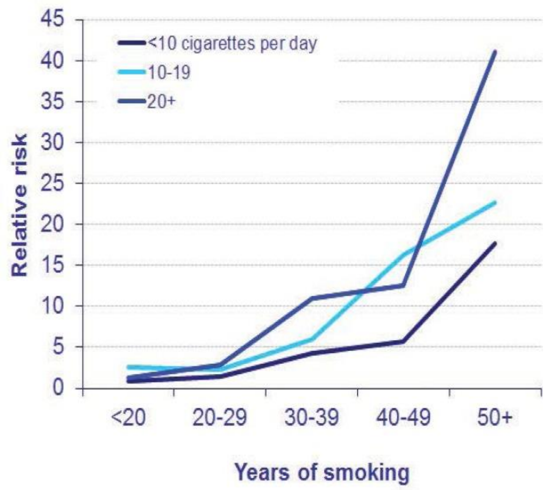
Basic Competence (Knowledge Dimension)		SSI Learning Contexts
3.9	Analyze the respiratory system in humans and understand disorders of the respiratory system and efforts to maintain the respiratory system's health.	The COVID-19 pandemic
Grade 9		
3.5	Apply the concept of electrical circuits, energy and electric power, electrical energy sources in everyday life, including alternative sources of electrical energy, and various efforts to save electrical energy.	The controversy over the construction of nuclear power plants, uneven distribution of electricity, utilization of alternative electrical energy sources
3.7	Apply the concept of biotechnology and its role in human life.	Genetic engineering controversies such as cloning, GMOs, and stem cells

Decision-making-oriented science instruction should be begun by initially introducing the issue as an authentic learning context [32]. The SSI can be presented by delivering two articles that substantially contradict each other on students' worksheets. Thus, solutions can be generated from various perspectives. Using the worksheets, teachers can provide pedagogical scaffolding to navigate students read and evaluate the

Article 1

Tobacco cigarette consumption is one of the lung cancer/tumor triggers. Smoking causes about 90% of lung cancer cases in men and 70% in women. Tobacco smoke contains more than 4,000 chemicals. Among the thousands of these chemicals, there are about 50 substances that are carcinogenic (cancer trigger) and poisonous. Some of the dangerous chemicals include benzene, formaldehyde, ammonia, acetone, tar, nicotine, carbon monoxide, arsenic, and hydrogen cyanide.

The risk of lung cancer increases with the length of time and the amount of tobacco smoking. Figure bellow presents a graph of the relative risk of lung cancer, according to the duration and intensity of smoking. Cancer Research UK reported this graph in 2013.



Adapted from:

Furrukh, M. (2013). Tobacco smoking and lung cancer: Perception-changing facts. Sultan Qaboos University Medical Journal, 13(3), 345−358.

Roosihermiatie, B. & Suharmiati. (2012). Gambaran

Article 2

The Ministry of Industry explained that Indonesia's cigarette industry had increased the value of local raw materials in plantation products such as tobacco and cloves. Besides, the cigarette industry is considered the labor-intensive and export-oriented sector, capable of supporting economic growth.

The Ministry of Industry also noted that the cigarette industry sector's total workforce was 5.98 million people. A total of 1.7 million of them work as tobacco and clove farmers. In 2018, cigarettes and cigars' export value reached US$ 931.6 million, increasing 2.98% compared to 2017.

Adapted from:

Kementerian Perindustrian RI. (2019). Industri Hasil Tembakau Tercatat Serap 5,98 Juta Tenaga Kerja. Retrieved from https://kemenperin.go.id/ (April 18, 2020).

penggunaan tembakau/rokok pada tumor/kanker paru di Indonesia: Riset kesehatan dasar 2007/2008. Buletin Penelitian Sistem Kesehatan, 15(3), 298−304.	

Figure 1. Two contradict articles on the controversy over the closure of cigarette factories in Indonesia

multiple perspectives of a given SSI [33] and encourage them to give justifications and arguments for their decision-making [34].

Figure 1 presents two sample articles on the controversy over the closure of cigarette factories in Indonesia, which aligns with Basic Competency 3.6 on Grade 8 (Table 2). The first article describes the health risks of smoking, while the second article describes the cigarette industry's contribution to the national economy. Through this issue, students must make decisions equitably by considering aspects of public health and the economy. Stimulant questions on the students' worksheets that can promote students' performance in each cognitive decision-making process based on these articles are shown in Table 3.

4. CONCLUSION

The fostering commitment of decision-making skills in Indonesia has been raised implicitly through the Government's vision of improving scientific literacy. However, these efforts have not met expectations.

Delivering the SSI article and stimulating them to choose the SSI's best solution through four cognitive processes guided by students' worksheets can be established as the strategy to develop decision-making skills in science instruction.

Table 3. Examples of stimulant questions on the worksheets

Cognitive Process of Decision-Making	Stimulant Questions	Responses Expected from Students
Identifying the SSI	If you are a doctor, you will undoubtedly support the closure of cigarette factories. Why is that?	As a doctor, I support the factory's closure because it can reduce the number of cigarettes and decrease the number of people who suffer smoking-related illnesses such as cancer, heart attack, stroke, tuberculosis, diabetes, etc. According to the empirical evidence stated by Cancer Research UK, a person who consumes more than 20 cigarettes per day for more than 50 years has a lung cancer risk of more than 40%.
	If you are an economist, you will undoubtedly reject the cigarette factory closings. Why is that?	As an economist, I refuse the factory's closure because it will increase Indonesia's unemployment level and reduce the export sector. Based on the Ministry of Industry report, the cigarette industry sector absorbs 5.98 million workforces and reaches an export value of US$ 931.6 million in 2018. If 50% of the cigarette factory is closed, around 3 million people will become unemployed, and Indonesia will lose the value of cigarette and cigar exports around US$ 466 million. Finally, it will impede Indonesia's economic growth.
	The closure of cigarette factories is a controversial issue and has some impacts on Indonesian society. What are the impacts on the economic and public health aspects?	Impact on the economic aspect: a) cause massive layoffs; b) give some financial disadvantage to the tobacco and clove farmers as raw materials suppliers; c) reduce Indonesia's export commodities; d) reduce tax revenue. Impact on the public health aspect: the risk of lung cancer or other diseases due to cigarette consumption (mouth and throat cancer, heart attack, stroke, tuberculosis, diabetes, and other diseases) is better controlled, both in active and passive smoking cases.
Formulating alternative solutions	Suggest two creative solutions to solve this issue!	Proposed solutions for this issue: a) cigarette factories do not need to close their industry if they succeed in innovating their products by reducing the levels of addictive and harmful substances; b)

Cognitive Process of Decision-Making	Stimulant Questions	Responses Expected from Students
		not closing the cigarette factory, but only limiting the amount of production and determining a strict term of sale (especially the consumer age and amount of buying); c) close cigarette factories, but equip workers with entrepreneurial skills in various fields through training pieces; d) closing cigarette factories, then switch the workers to other labor-intensive sectors, for example, the food and textile sectors.
Evaluating alternative solutions	Describe the advantages and disadvantages of all the solutions you proposed!	1st solution: innovation in cigarette products. Advantages: a) control the risk of smoking-related illness; b) keep maintaining Indonesia's economic stability. Disadvantage: require a lot of innovation and research costs. 2nd solution: equip workers with entrepreneurial skills. Advantages: a) ensure worker independence, so the unemployment rate does not increase; b) reduce (but not entirely) the risk of smoking-related illness. Disadvantages: a) cost a lot because one training session is not enough to guarantee worker independence; b) it is not necessarily reducing the number of unemployed; c) affect factory workers and tobacco farmers.
Making decisions	Based on the analysis of each solution, choose the best solution for your decision! Explain your choosing criteria reasonably!	Based on each solution's advantages and disadvantages, I choose the first solution: innovation in cigarette products. The decision I made was based on a reasonably balanced consideration of economic and public health aspects (it does not benefit only one aspect). Meanwhile, the second solution I offer (equip workers with entrepreneurial skills in various fields through training) have less effectiveness in the economic aspect.
	How does this decision affect the economic and public health aspects?	Economic aspect: the cigarette industry continues to support Indonesia's economic growth. Public health aspect: the risk of smoking-related illness is controlled better because addictive and carcinogenic chemicals are reduced in innovative cigarette products.

Nowadays, decision-making has become the central focus of science education research globally. However, it gains a lack of attention in Indonesia. Therefore, another significant breakthrough in decision-making-oriented learning strategies is needed to equip students facing the new civilizations due to Industry 4.0.

AUTHORS' CONTRIBUTIONS

The first author (D.A.) performed the analytical review and took the lead in writing the manuscript. The second author (Z.K.P.) provided critical feedback and helped shape the study.

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