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PROMOTING SUSTAINABILITY IN UNDERGRADUATE PROGRAM: STUDENTS' PERCEPTION IN GREEN CHEMISTRY COURSE

Risnita Vicky Listyarini
Chemistry Education Study Program, Department Mathematics and Science Education, Sanata Dharma Univeristy
risnita.vicky@usd.ac.id
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Abstract
Global challenges such as climate change, decreasing natural resource and environmental pollution become major threats to global society now. Transformation toward sustainability should be promoted in practices. Universities and higher education (HE) plays an essential role in shaping the individual way of thinking and acting to become sustainability change-maker. This research aimed to study about students' perception towards implementation of Green Chemistry Course in undergraduate program of Chemistry Education Study Program, Sanata Dharma University. Through the implementation of green chemistry course, it is expected to promote sustainability to prospective teachers. Findings from this research indicated positive perception towards GreenChemistry Course in terms of students' awareness of environmental issues and implementation of principles of green chemistry in life.

Keywords: education for sustainable development (ESD), green chemistry course, sustainability in higher education (HE)

Introduction
Global society nowadays faced global challenges such as climate change, decreasing natural resource and environmental pollution. There is a need in the movement toward more sustainable practices. Sustainability development refers to the development which can meet people's needs in the present without ignoring the needs of future generations (Eilks & Rauch, 2012). Implementation of sustainable development does not involve only one particular area but severalareas in our daily life including education. It is believed that education has an essential role in achieving sustainable development. Education for sustainable development has always been promoted by UNESCO. Since 1992, UNESCO has been actively promoting Education for Sustainable Development (ESD) and through program UN Decade for ESD from 2005 to 2014. Follow up program include Global Action Program (GAP) on ESD (UNESCO, 2011, 2017).

UN release new global framework toward sustainability with 2030 Agenda for Sustainable Development. The main issues of 2030 Agenda are 17 Sustainable

Development Goals (SDGs). It addresses global challenges those related to inequality education, climate, environmental degradation, prosperity, and peace and justice. The main purpose for SDGs is to ensure a sustainable, amicable and flourishing life for people now and in the future (UNESCO, 2017). For reaching the goals, government and stakeholders needs to be involved. Transformation towards sustainable development implicates a change in the individual way of thinking and acting. Thus, education plays a central role in shaping individuals to become sustainability change-maker.

Higher education (HE) has a great role to promote sustainability and can be called a change agent (Stephens, 2008). HE has meaningful contribution in preparing and shaping prospective individual becoming decision maker, policymaker in the future. Thus, it is necessary to include sustainability in curriculum (Kim E. Walker, 2004; Tilbury, 2004). Recent finding stated that every student should have the opportunity to learn sustainability in HE regardless of study program (Tilbury, 2004). In line with the global challenges, chemistry education should take part in promoting sustainability for today and future society (Burmeister & Eilks, 2013; Hamidah, 2017).

Chemistry Education Study Program of Sanata Dharma University commit to providing holistic experiences for students. Chemistry Education Study Program has the vision to become a leading study program in printing competent and humanist prospective teacher for conducting research and community service in education and chemistry areas with the principle "Chemistry for Sustainable Future". The contribution of chemistry education in education for sustainable development (ESD) can be done with promoting Principles of Green Chemistry. Green Chemistry aims to make chemistry more efficient in using energy, minimizing waste and produce innovative products using minimal natural resources (P. Anastas & Eghbali, 2010). Various experimental design, new material, and product are developed with consideration of the needs of future generation.

Education in chemistry is faced with challenges to prepare competently and actively contributed young generation in society. Students need to be prepared with competencies and problem-solving skill related to social, environmental and sustainable development issues. Students as a part of future generation are expected to learn sustainable chemistry and environmental friendly. Thus, Green Chemistry should be introduced to students as early as possible. Students are guided to grow awareness and importance of sustainable strategy in chemistry research.

In the curriculum of undergraduate program of Chemistry Education Study Program, Sanata Dharma University, Green Chemistry Course is a mandatory course for Chemistry Education Study Program students. However, students from different study program at Sanata Dharma University can take Green Chemistry Course as an elective course. This purpose of this study is to investigate the students' perception towards implementation of Green Chemistry Course in undergraduate program of Chemistry Education Study Program, Sanata Dharma University. Through the implementation of green chemistry course, it is expected to promote sustainability to prospective teachers and awareness in terms of

awareness of environmental issues and implementation of principles of green chemistry in life. The elaboration mentioned above raise importance in conducting research and making Sanata Dharma University as a pioneer in the implementation of Green Chemistry Course in undergraduate program in Indonesia.

Theory

The concept of green chemistry is introduced in the beginning 1990s in a scientific forum and vastly adopted by mass media as new approach in chemistry. Green chemistry approach also known as sustainable chemistry is new approach in chemistry to solve the problem related to environment in terms of waste production, process or reaction step used. Anastas & Warner (1998) develop the formulation "Twelve Principles of Green Chemistry". The Twelve Principles of Green Chemistry give guides for chemists to design process in chemistry with aim of sustainability. The concept of Green Chemistry has been applied in industry sectors such as cosmetics, pharmaceutical, and energy. The concept of Green Chemistry has a large impact not just in industry but also in education, environment, and society.

Table 1. The Principles of Green Chemistry ((P. T. Anastas & Warner, 1998)

1. Prevention	It is better to prevent waste than to treat or clean up waste after it has been created.
2. Atom Economy	Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. Less hazardous chemical synthesis	Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to people or the environment.
4. Designing safer chemicals	Chemical products should be designed to affect their desired function while minimizing their toxicity.
5. Safer solvents and auxiliaries	The use of auxiliary substances (e.g., solvents or separation agents) should be made unnecessary whenever possible and innocuous when used.
6. Design for energy efficiency	Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.
7. Use of renewable feedstock	A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. Reduce derivatives	Unnecessary derivatization (use of blocking groups, protection/de-protection and temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
9. Catalysis	Catalytic reagents (as selective as possible) are superior to

	stoichiometric reagents.
10. Design for degradation	Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. Real-time analysis for pollution prevention	Analytical methodologies need to be further developed to allow for real-time, in process monitoring and control prior to the formation of hazardous substances.
12. Inherently safer chemistry for accident prevention	Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions and fires.

Green Chemistry can be used as a learning approach of teaching chemistry to promote environmental literacy to students. Green chemistry is considered an appropriate tool to increase awareness and teach practical problem-solving skill through the content of chemistry (Haack, 2005; Karpudewan, 2011). Green chemistry is closely related to environmental issues and can be described as interdisciplinary in origin. It can promote integrative learning practice and train student to become a problem solver. Student can use critical thinking and communication skill to solve the problem related to chemistry, environment and socio-scientific issues in daily life.

HE should implement environmental literacy and ESD in curriculum in particular in teacher training curriculum. Teacher training institutions have the crucial role because they are producing prospective teacher. In some manner, teacher is key role in changing and shaping the individual way of thinking and acting. Teacher in school can influence their student by using learning and teaching way which promote sustainability.

Lack of implementation of ESD in the classroom, teacher training and in educational research may be one of the obstacles in the progress of sustainable development. Curriculum and pedagogies in HE should focus on general education skill. Students should learn how to be involved in societal debates and participate actively in society. Thus, chemistry education and ESD contribute to the realization of sustainable development. In practices, controversial socio- scientific issues related to environmental or industrial can be chosen to give the students perspective precisely how societal issues are managed (Burmeister & Eilks, 2013). It guides the students to contribute to sustainable development in the present and future society that they live.

Several efforts for implementation of ESD has been made in chemistry education and pedagogy. Some examples are taken from Germany and Malaysia with the comparison in Indonesia. Germany is a notable country for actively ESD in HE. Implementation of ESD has been done in secondary education and HE through the development of course module on sustainability issues and ESD in German pre-service chemistry teacher education (Burmeister & Eilks, 2013; Burmeister, Rauch, & Eilks, 2012; Burmeister, Schmidt-Jacob, & Eilks, 2013). ESD in Malaysia has been implemented in academic program from different HE

within science, social science, and engineering disciplines at graduate and postgraduate levels (Reza, 2016). In addition, Green chemistry was employed in chemistry teaching methods course (Karpudewan, 2011).

Implementation of ESD in Indonesia is limited to inclusion of topics from environmental. The green chemistry and its relation to sustainable development are not explicitly taught in tertiary level students. Therefore, green chemistry isnot well known for students as well as chemistry teacher. Implementation of ESD at HE in chemistry in Indonesia was initiated by UGM through German Academic Exchange Service (DAAD) over a series of green chemistry research project and a master's dual degree program in chemistry (Hamidah, 2017). All of them were held at graduate and postgraduate level. Considering the aforementioned, Sanata Dharma University attempt to implement ESD as early as possible through Green Chemistry Course for undergraduate program in Chemistry Education Program. With the ESD goal in mind, Green Chemistry Course is expected to promote students' awareness of environmental issues and implementation of principles of green chemistry in life

Method

This research was a survey study set in Sanata Dharma University. Green Chemistry Course was held in Chemistry Education Study Program, a department in the Faculty of Education and Teacher Training. All enrolled students of Chemistry Education Study Program were required to take Green Chemistry Course as a mandatory course in the first semester of their study. Students from another department in Sanata Dharma University may take Green Chemistry Course as an elective course. This research employed questionnaire instruments using Google Form which consisted of closed-ended and open-ended questions. The problem formulations for this research are:

1. What is students' perception related to awareness of environmental issues and the implementation of principles of green chemistry in life after joining Green Chemistry Course?
2. What is students' perception of the implementation of Green Chemistry Course to promote sustainability in HE?

The survey was conducted at the end of 2018/2019 fall semester to 39 respondents. The respondents were students from Chemistry Education Study Program (29 students), Biology Education Study Program (6 students) and Elementary Education Study Program (4 students) and aged from 17-20 years. Discussion forum in class, assignments and observation were reviewed in addition to the survey.

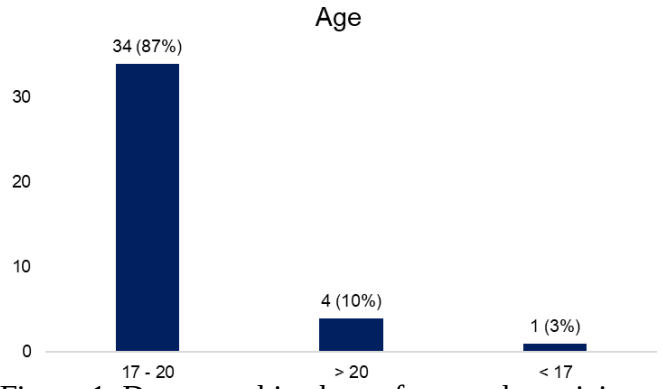

Figure 1. Demographic chart of research participants

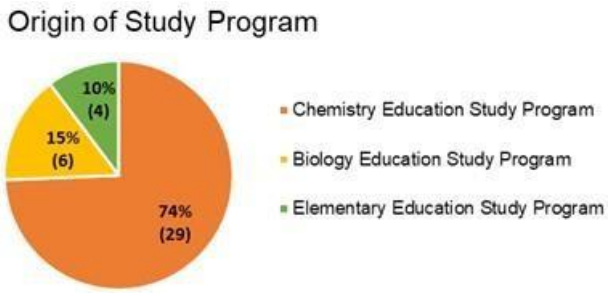

Figure 2. Demographic data of research participants

Findings and Discussion

Implementation of ESD in course explicitly called Green Chemistry Course in the undergraduate program is considered new in Indonesia It is making Sanata Dharma University as the pioneer in implementing those course in undergraduate level at HE. This study showed positive perception towards Green Chemistry Course to promote sustainability in HE in terms of student's awareness of environmental issues and implementation of principles of green chemistry in life.

As a starting point of the survey, the students were asked about their familiarity and interest with Green Chemistry Course. The bar chart below shows that only half of total respondents said that they have heard about Green Chemistry (45.20% agree and 28.60% disagree) and understand the meaning of Green Chemistry before joining the course (54.80% agree and 19.00% disagree). Almost all of the students were excited in joining Green Chemistry Courses (95.2% agree). This means that the students feel interested and open in learning the new topics related ESD.

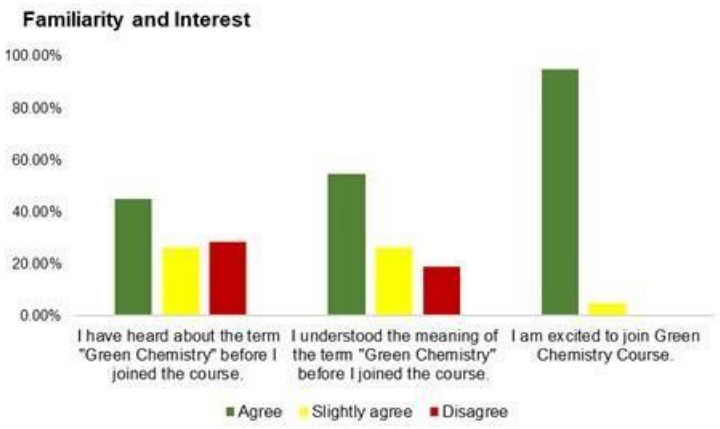

Figure 3. The result of questionnaire in terms of familiarity and interest in Green Chemistry Course

Learning Green Chemistry is closely related with environmental issues. Through Green Chemistry Course, the students were exposed to different topics covering environmental issues such as water resources, air pollution, energy resources, and chemical substances in daily life. Andraos & Dicks (2012) elaborate that one of the effective ways to use "real-world" case studies or up to date case studies to teach Green Chemistry in HE. The discussion in class and the assignments were made for the students based on real-life issues so the students can understand how society deals with environmental issues in reality. Several topics for assignments were described in Figure 4.

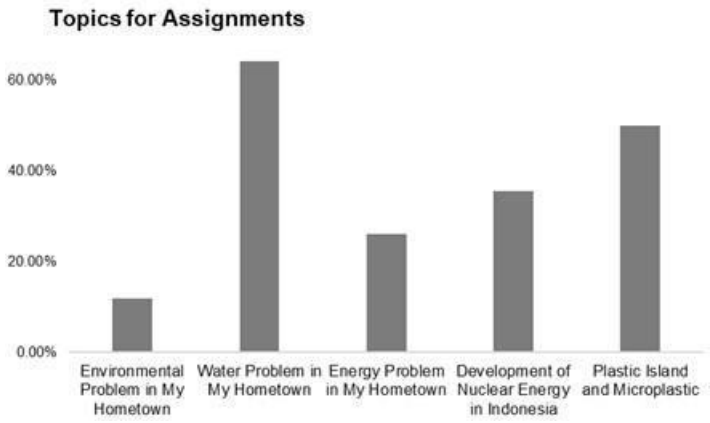

Figure 4. Topics for assignments in Green Chemistry Course

Topic for assignments are related to environmental issues (water and energy) and recent issues (plastic island and microplastic). The students were asked to make a short essay or opinion related to the topics. For making them more personal, the topics were connected to the context of their hometown. In fact, the students are coming from different provinces in Indonesia. Green Chemistry Course is expected to be an effective tool to make the students understand and aware of the environmental issues in their hometown. Some of them probably will

come back to their hometown and working there. It is hoped that the students will contribute actively to their hometown's issues. The inclusion of local context is the goal of ESD pedagogies. The students develop toward positive change and a sense of social justice as members of the community (UNESCO, 2012a). The survey was conducted to know which the most interesting topic for students. The most interesting topic for the students was "Water problem in my hometown" (64.30%) and followed by "Plastic island and microplastic" (50%). From Figure 4, it can be inferred that students were the most interested in knowing the problem at their hometown through the topics of assignments.

The student's awareness of environmental issues was surveyed. All of the students one hundred percent do think that they understand more about the environmental issues through Green Chemistry Course. In addition, they become more aware and care about the environmental problems in their hometown from the topics covered in Green Chemistry Course (97.6 % agree, 2.4 % slightly disagree).

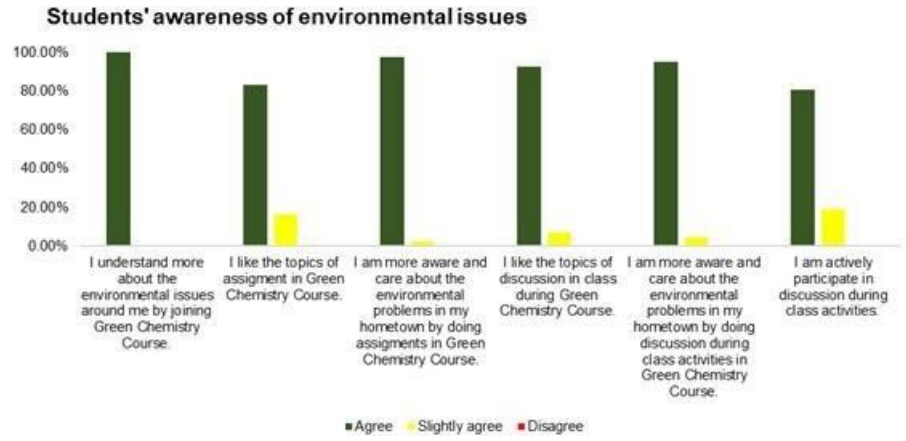

Figure 5. Students' awareness of environmental issues.

From the Figure 5, it indicates positive perception of students that Green Chemistry Course can promote students' awareness in environmental problem. The results above also supported by the results of open-ended questions.

P2: "I became more aware of the environmental problems that were happening around me. I feel happy because I can know the situation around me, but also feel concerned about all the damage that happened"
P10: "It is nice because I can know more about problems that occur in the environment around me and can better understand how to overcome or reduce the problem"

In addition to the student's awareness of environmental issues, the students were asked about their perception of principles of green chemistry. The principles

of green chemistry were introduced to students in class activities by lecture and discussion. As the conclusion, for the final exam of Green Chemistry Course, the students were asked to make a short paper. The problem formulation for the exam was:

> "Propose an idea or solution to solve the environmental problem covered the Green Chemistry Course or in your hometown by using Twelve Principles of Green Chemistry!"

The purpose of the final exam was to ask the students to implement the knowledge of Twelve Principles of Green Chemistry that they already got to be implemented into real-life solution. By doing their final exam, they will collect data either from books, journals or trusted online sources about one particular environmental problem that they choose, how to overcome the problem and implement the Principles of Green Chemistry to solve the problem. This approach leads to discovery learning for the students (Andraos & Dicks, 2012). It is expected the students will use their critical thinking and creativity to solve the problem. Pedagogies with ESD goal encourage the students to ask question,analyze, discuss and think critically of contexts (Robert Laurie, 2016; UNESCO, 2012a). Several titles of shorts paper taken from students' final exam are presented in Table 2.

Table 2. Titles of short paper taken from students' final exam in Green Chemistry Course

No	Title of short paper
1.	Utilization of Aquatic Plant (*Cyperus papyrus*) as Phytoremediation of River Polluted by Household Waste
2.	Use of Purple Sweet Potato Starch as an Environmentally Friendly Plastic Material
3.	Making Soap using Used Cooking Oil
4.	Design of Utilization of River Waste into Green Chemical Based Compost Fertilizer in the Sa'dan River, Toraja
5.	Bio-paper Cup
6.	Use of Dry Corn Skin in Making Ink Markers based on Green Chemistry Principles
7.	Use of Kesumba Keling Plant Seeds (*Bixaorellana l.*) as Eco-friendly and Safe Hair Coloring
8.	Design of Utilization of Carica Seed Waste into Green Chemical-Based Compost as the Control of Carica Waste in Wonosobo Regency
9.	Utilization of Waste as a Source of Electric Energy
10.	Utilization of Corncob as Adsorbent for Industrial and Textile Field Waste

The topics proposed by students are discussed about different environmental problem for instance water pollution; wastewater management; environmentally friendly products: biodegradable plastics, eco-friendly ink marker, eco-friendly hair coloring; and energy problem. It indicates that the students are aware of several environmental issues around them. Students were asked about their perception of Principles of Green Chemistry. The results of the survey about perception of Principles of Green Chemistry is presented below.

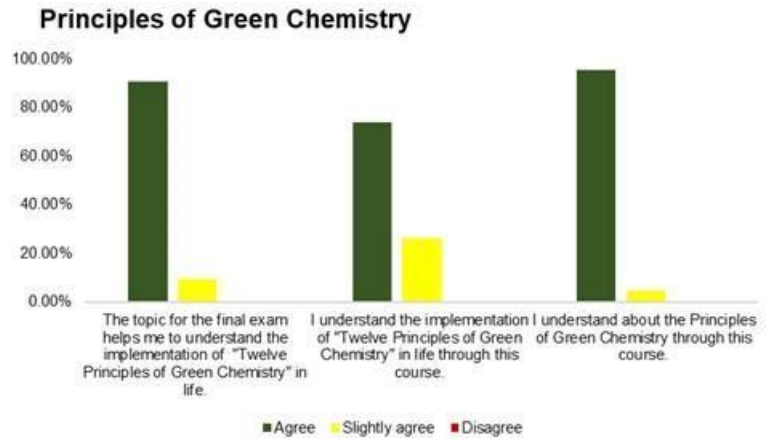

Figure 6. Students' perception of principles of green chemistry.

Figure 6 shows that 90.5% of the students agree that the problem formulation in the students' final exam help them to understand the implementation of Principles of Green Chemistry in life. The chart above shows that overall 95.2% of the students understand the Principles of Green Chemistry. This result is supported by the results of open-ended questions.

> P8: "I can understand what the principles of green chemistry in theory and how to apply it in everyday life."
> P28: "My impression is that I am happy because with this course I have come to understand that in fact, chemistry is not always dangerous, but on the other hand chemistry is very useful to save the world."

Nevertheless, there are still a small number 4.8% of students do not understand the Principles of Green Chemistry. It can be caused by some factors such as the unfamiliarity with the term. The term of "Green Chemistry" is still unfamiliar for some students as shown in Figure 3.

> P33: "I had pleasant experiences after attending this lecture, although it is rather difficult to understand the material because green chemistry is something that is still unfamiliar to me. Nevertheless, I still enjoy this lecture."
> P25: [...] I was very happy because I am able to learn the problems caused by the use of chemicals, and get a solution to overcome this problem.

> However, I did not understand the difficult words I had just heard for the first time. I'm still confused in some part of the course.

In line with ESD goals, Green Chemistry Course intend to make students familiar with Principles of Green Chemistry with can be implemented in various sector, not just chemistry. It leads to the positive change of students' way of thinking and acting in a way they develop social responsibility as a member of society. Thus, students' perception of implementation of principles of green chemistry were evaluated. The students were asked about their perspective after attending the course. Figure 7 showed the students' perception after joining Green Chemistry Course.

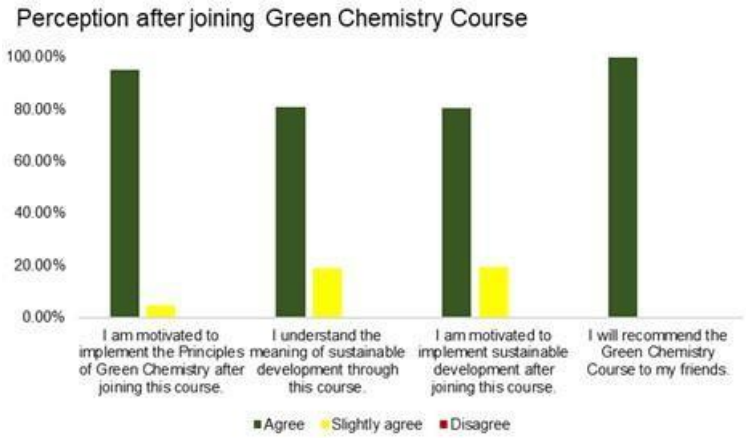

Figure 7. Students' perception after joining Green Chemistry Course

The majority of students, 95.2% of the students feel motivated to implement the Principles of Green Chemistry after joining the course. In addition, 80.5% of the students agreed to feel motivated about implementation sustainable development after joining Green Chemistry Course. These results are also supported by the results of open-ended questions.

> P16: "I felt very motivated when I attended this Green Chemistry Course. Because I can know the impact, how to reduce and find solutions to overcome the negative effects caused by the use of chemicals themselves."
> P24: "After taking Green Chemistry Course, I gained a lot of knowledge. I feel happy by following this course because of the many benefits. The knowledge that I have gained will be given to my students later when I have become a teacher."

The results indicate that Green Chemistry Course can stimulate toward positive change in students' way of thinking and acting in the present and in the future as the member of society. In particular, the student stated that they will spread the knowledge from Green Chemistry Course to their prospective students later when they become a teacher. This behavior supports the ESD goal in

pedagogy. Teachers are one of the agents that have a bigger chance to convince the number of student during their career (Powers, 2004). Their methods ofteaching and learning may influence the students toward sustainability. In addition, From Figure 7, one hundred percent of the students stated that they will recommend Green Chemistry Course to another student. It shows that regardless the origin of the study program, either Chemistry Education, Biology Educationor Elementary Education, it is important to introduce the concept of sustainability in HE.

Conclusion

Green Chemistry Course has contributed to promoting sustainability in HE. The topics covered in Green Chemistry Course is multidisciplinary and related to environmental issues. The students are encouraged to analyze, discuss and think critically to solve the problem based on the context in society. This supports the goal of ESD in pedagogy.

The finding from this research indicated positive perception toward implementation of Green Chemistry Course to promote students' awareness of environmental issues and implementation of Principles of Green Chemistry in life. The survey in this course did not provide quantitative analysis using, for instance, SPSS measurement in order to ensure validity. Therefore, the current researcher suggests that future researchers include statistical analysis to increase the reliability of survey results.

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