Students attitude towards green chemistry and its application

S Mulyanti1,2* and A Kadarohman3*

1Departemen Pendidikan IPA, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
2Program Studi Pendidikan Kimia, Fakultas Sains Dan Teknologi, UIN Semarang, Jl. Walisongo 3-5, Semarang 50155, Indonesia
3Chemistry Education Department, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia

*riechem@walisongo.ac.id, kadar@upi.edu

Abstract. Green chemistry is one of efforts to minimize the dangerous during preparation, reaction and the product of its reaction in daily life, then the application of green chemistry will be important especially among chemistry students. This study aims at analysing students' attitude towards green chemistry and its application in everyday life. Questionnaires distributed to 190 respondents. The questionnaires gathered information on students’ opinion on green chemistry and its application in everyday life. The result indicated that most of students agree with the application of green chemistry principles, but on several principles it is known that some respondents still think it is impossible or do not want to apply it in chemistry experiments or everyday life. It can be implied that lecturers should be pay attention more to some emphasis if they want to introduce the application of green chemistry principles in teaching and learning activities

1. Introduction

In the past, environmental problem be seriously day to day, then the scientists campaign to minimize it, which called by sustainability [1], but it is not enough, because chemistry experiment problem not only consist of environmental problem, it is also problem during preparation, reaction and product of it. So that the scientists and chemist especially designed the new strategy to solve the chemistry experiment problem by applying green chemistry principles, it is concluded in 12 principles [2].

Green chemistry is currently becoming popular among undergraduate chemistry students, both in lectures in the classroom and in the laboratory [1-3]. The application of the principles of green chemistry is required in lecturing activities [4], [6], [7], so that students are no longer antipathy to the application of the principles of green chemistry both in lectures and in their daily lives. In the end, the hope for the application of green chemistry is carried out thoroughly in every aspect of life [6-8]. The 12 principles of Green Chemistry [2] are 1) Prevent waste, 2) Atom economy, 3) Less hazardous synthesis, 4) Safer chemicals, 5) Safer solvents and auxiliaries, 6) Energy efficiency, 7) Renewable feed stocks, 8) Reduce derivatives, 9) Catalysis, 10) Design for degradation, 11) Real-time analysis for pollution prevention, and 12) Inherently safer chemistry for accident prevention.

This research aimed to analyze how undergraduate student of chemistry and education chemistry apply green chemistry principles both in laboratory or their daily activity. This research will be best argument for the chemistry lecturers how to teach green chemistry to their students so that it can be
applied perfectly by them, and we can see how our life will be safer and healthier both in learning chemistry or daily activity.

2. Method
This research used qualitative method with descriptive design [11]. The research conducted by online questionnaire with 36 questions to 190 undergraduate students of chemistry and education chemistry from various state universities from Java and Sumatra islands. Respondents from the island of Java were obtained from chemistry education students from several state universities such as from Jakarta 4 respondents, from Semarang 47 respondents, and from solo 127 respondents. The respondents from Sumatra island were obtained from one state university in Medan are 12 respondents. Whole respondents came from various generations ranging from second semester students to eighth semester students.

There are 36 questions consist of 12 green chemistry principles, each principle consist of 3 questions. The question made in the form of a questionnaire with 4 answer choices, the answer scores ranging from 0 to 3, according to the subject's view about the application of green chemistry principles in each question.

3. Result and Discussion
Green chemistry were applied in several chemistry education studies, moreover it is became one of effort to promote Education Sustainable Development (ESD) in achieving Sustainable Development Goals (SDGs) [12-13]. The principles of Green Chemistry [6], [14]–[16] are applied to various fields of study in chemistry, such as organic, analytical, biochemical, and others. As well as in chemistry education, both at the level of secondary education and lectures in higher education, green chemistry has begun to be applied to the chemistry learning curriculum, so that the term green chemistry is no longer a new thing that is considered foreign, even though there are still students who do not fully know the meaning of the term green chemistry [17].

The 12 principles of Green Chemistry used as basic of questionnaire, each principle divide into 3 questions involve applied of each green chemistry principle, either in laboratory or daily activity. Each question given 4 choices answer, it scored from 0 to 3. Zero score for the answer which has no application in green chemistry principle, score 1 for the answer with little application in green chemistry principle, score 2 for the answer with enough application in green chemistry principle, and score 3 for the answer with high application in green chemistry principle.

Each of the principles of green chemistry shows a tendency that respondents generally have an opinion on the high application of green chemistry in their daily lives and when working in the laboratory [18]–[22]. Can be seen from Table 1, the average score shows the highest number on the highest score that is on the score 3, and the lowest number on the score 0.

| Table 1. The Average Number of Respondents from whole score each green chemistry principle |
|-----------------------------------------------|----------------|----------------|----------------|
|                                               | 0 (No application) | 1 (Little application) | 2 (Enough application) | 3 (High application) |
| Prevent waste                                | 0               | 3               | 62              | 124             |
| Atom economy                                 | 4               | 7               | 62              | 117             |
| Less hazardous synthesis                      | 1               | 2               | 33              | 154             |
| Safer chemicals                              | 0               | 8               | 51              | 131             |
| Safer solvents and auxiliaries               | 1               | 14              | 33              | 142             |
| Energy efficiency                            | 2               | 13              | 50              | 125             |
Figure 1. Score 0 of Each Green Chemistry Principle

Figure 1 shows that the highest number of respondents on zero score or who do not want to apply the principles of green chemistry is the eighth principle, reduce derivative. The high number of respondents shows they do not believe in the application of the principle of green chemistry in reducing the derivatization of reaction, the main target product is produced completely without any unwanted by-products and is still considered difficult for researchers in chemistry [23]. Some respondents also do not want to apply or do not believe the second principle of green chemistry can be applied, that the reaction method must be designed to maximize the incorporation of all materials used during the process until the final product (atom economy) is still considered impossible to do, even though much research can apply this principle [25-28].

The use of renewable feedstock in chemistry reaction is also still considered difficult or impossible for some respondents, even though many researchers have tried to use renewable feedstock for chemistry experiments in the laboratory [29-31]. As well as the use of catalysts that are environmentally friendly and can be easily separated at the end of a reaction, some respondents still consider this impossible, despite so many studies that have tried to apply the ninth principle of green chemistry [31]–[34].

Figure 1 also shows that all respondents agreed not to ignore the application of the fourth green chemistry principle, safer chemicals - the reaction products should be designed to use chemicals with no toxicity [35]–[37]. This shows that all respondents want the use of environmentally friendly chemicals and not harmful for use in chemical reactions, although not all chemicals used during reaction
environmentally friendly reactions. All respondents also agreed that safety during chemical reaction activities cannot be ignored, as seen in Figure 1 which shows that there were no respondents who chose answers with a zero score on the twelfth principle, inherently safer chemistry for accident prevention - Substances and the form of a substance used in reaction should be chosen so as to minimize the potential for chemical accidents, such as releases, explosions, and fires [20].

In the end, the application of the principles of green chemistry became an initiation for students at higher education levels to fully understand the chemical concepts that support every chemical reaction [38]. Educators have a big task to be able to apply the principles of green chemistry in every chemistry learning activity, so that in the end the mastery of chemical concepts is not only limited to cognitive abilities, but also affective abilities in the sustainability of ecosystem life on earth as the main mission of formulating the principles of green chemistry.

4. Conclusion
The results showed that of the 190 respondents obtained results generally they agreed with the application of the principle of green chemistry, but on several principles it was known that some respondents still considered it impossible or did not want to apply it in chemical experiments or daily life. Principles that are still considered impossible to do include atom economy, renewable feed stocks, reduce derivatives, and catalysis. This has become a discourse for teachers to be able to provide concrete examples of the application of the principles of green chemistry in teaching and learning activities, especially on principles that are still considered not applicable.

5. References
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