

PAPER • OPEN ACCESS

Indonesian Teachers' Perceptions on Green Chemistry Principles: a Case Study of a Chemical Analyst Vocational School

To cite this article: Army Auliah *et al* 2018 *J. Phys.: Conf. Ser.* **1028** 012042

View the [article online](#) for updates and enhancements.

Related content

- [Modelling Scientific Argumentation in the Classroom : Teachers perception and practice](#)
R M Probosari, Sajidan, Suranto et al.
- [Teacher's Perception about the Use of E-Learning/Edmodo in Educational Activities](#)
H Yanti, A Setiawan, Nurhabibah et al.
- [Vocational Teacher Perceptions on the use of ICT in Learning Computer Network](#)
Yannuar, D Rohendi, H Yanti et al.



IOP | ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

Indonesian Teachers' Perceptions on Green Chemistry Principles: a Case Study of a Chemical Analyst Vocational School

Army Auliah^{1*}, Muharram¹, Mulyadi²

¹Department of Chemistry, Universitas Negeri Makassar, Indonesia

²Department of Civil and Engineer, Universitas Negeri Makassar, Indonesia

*auliaarmy@ymail.com

Abstract. This study aims to describe the teachers' perception of Green Chemistry, an area of chemistry that focuses on the design of products and processes that minimize the use and generation of hazardous substances. The description of Green Chemistry is based on the teachers' perception of a Green Chemistry paradigm and how to integrate this perception into the chemistry learning process for their students. The perception and integration of Green Chemistry to achieve sustainable development in the field of chemistry needs to be promoted, especially among educators for spreading to their students. Data were collected by distributing questionnaires to 35 teachers in a Chemical Analyst Vocational School, Makassar, Indonesia. The questionnaire was based on the indicators related to the principles of Green Chemistry including prevention, economic atom, chemical synthesis safe, designing safer chemicals, solvents and compounds safe aides, design for energy efficiency, use of raw materials renewable, stages reduction reactions, use of catalysis, material design decomposition, instantaneous analysis for pollution prevention and chemical which are naturally more secure to prevent accidents. Data were analyzed descriptively to determine the percentage of teachers' perceptions of green chemistry in learning. The results showed that, in general, the majority (97.14%) of teachers at this Indonesian school reported knowledge of Green Chemistry but only 32.30 % were aware of the concept of Green Chemistry. Furthermore, 47.42% of the teachers think that green chemistry does not need to be put into learning curriculum and 31.38% believe need to be included in the learning process. These finding demonstrate that the concept of Green Chemistry has not been socialized among teachers of Chemical Analyst Vocational School of Makassar. For this reason, there is a need for developing a learning model in chemistry teaching that responds to our vision for a sustainable future.

1. Introduction

Environmental problems have plagued all parts of the world. This issue is no longer a matter of a particular country, but has become the world's problem, including Indonesia. The world community has realized the importance of good environmental management for the sake of preservation of the Earth. It is characterized by the holding of the World Environment Conference in Stockholm, Sweden in 1972 and then in Nairobi, Kenya in 1982 [1,2]. These conferences were held every ten years becoming the Earth Summit from 1992 in Rio de Janeiro, Brazil, to 2002 in Johannesburg South of Africa and the last 2012 in Rio de Janeiro, Brazil [3,4]. These events are clear evidence of the world's concern for the environment and sustainability.



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Environmental problems that occur on Earth can only be solved through education, specifically environmental education [1]. Environmental education in Indonesia has been taught in almost all subjects at all levels of school especially science subjects. In college in Indonesia, environmental education has been taught by monolithic, known as the Environmental Education (EE) and Education of Population and Environment (EPE). Although the concept of environmental education has been delivered through the education curriculum, the course has not fully covered all environmental problems, especially in terms of satisfying the needs of human life. Therefore, it takes a concept that in addition to meeting human needs, pressing environmental problems must be considered.

Chemistry is a basic science which acts as a manufacturer in fulfilling human needs. As a manufacturer, it is having a responsibility to sustain the environment. The basic concept of the various fields of science are added and integrated into the Chemical Sciences, thus giving birth to what is called Green Chemistry [5]. Green Chemistry is the use of chemistry for pollution prevention where the design of chemical products and processes are environmentally friendly and sustainable. Green Chemistry principles can be used as the primary means in designing and realizing sustainable development.

The concept of sustainability, which is borne by Green Chemistry, should be socialized and introduced at every level of education [6]. Green Chemistry learning will ensure the creation of a new generation of chemists possessing the skill and knowledge to practice environmentally friendly chemistry [7]. The success of Green Chemistry learning depends on training and educating the new generation of chemists.

The Chemical Analyst Vocational School of Makassar is one of three chemical vocational schools in Indonesia those are organized by government. Ministry of Industry, exactly. Their vision is to become an International Standard Vocational High School in Chemical Analysis specialties-based and competency that produce professional graduates. Its mission is to: (1) carry out chemical analysis of vocational education quality to meet the needs of society, the business world and the world industry at both national and international levels, (2) establish partnerships with the business world and the world of national and international industry, (3) improve the competitiveness of the industrial workforce through education and training of human resources, and (4) foster and organize social and civic functions [8].

The vision and mission statements reinforce that graduates contribute to industry more than other fields related to chemistry, especially chemical analysis. Alumnus of Chemical Analyst Vocational School of Makassar will become actors of industry in chemical fields and work in interaction with the environment. As chemical analysts, they will wrestle with chemicals; both safe and malicious materials. They need to be equipped with knowledge of "Green Chemistry" and the 12 principles that define Green Chemistry [9] can be applied in their work.

Education and teaching chemistry in accordance with the paradigm of Green Chemistry requires work and planning. Integrating the principles of Green Chemistry into learning process through conventional teaching in terms of thinking about Green Chemistry is not evident [10]. Wardencki agrees and suggested that the success of green chemistry depended on the training and education of a new generation of chemists [6]. Student at all levels have to be introduced to the philosophy and practice of Green Chemistry. Finally, regarding to the role of education in green Chemistry, all educators are required to socialize to its principles.

Based on observation of their students during work in laboratory (carried out October 13-18, 2014), Green Chemistry has not been integrated into teaching and learning chemistry in Chemical Analyst Vocational School of Makassar. Evidence is required to support these observations.

It is therefore necessary to investigate the understanding and perception of teachers in Chemical Analyst Vocational School of Makassar on Green Chemistry and the importance of Green Chemistry being integrated in the learning process.

2. Method

This is a quantitative descriptive study, aimed to understand vocational school teachers' knowledge and perceptions of Green Chemistry and its integration into the learning process. The study was conducted in Chemical Analyst Vocational School located in Makassar, Indonesia. This is one of three vocational schools in Indonesia which is related to chemicals applying.

This study began in February 2013 with observations of students in their laboratory work. This data was then followed up by a survey of teachers' perception about green chemistry in the learning process

The sample included 35 of the 53 teachers of Chemical Analyst Vocational School Makassar. There were 16 males and 19 females. Three were retired teachers and four were honorary teachers. They were, on average, more than 40 years old and had been teaching for more than 25 years. The honorary teachers had taught for five years.

The questionnaire sheets were developed based on the 12 principles of Green Chemistry [11,12]. Initially, there were 36 items in the questionnaire and each was responded on a 3-point Likert type scale from 1 = disagree to 3 = agree. This initial set of items was validated by three experts in the areas of chemistry, education, and education assessment. In the final version, 29 items were included. An example item is "Equip the students with knowledge of waste/sewage". The internal consistency of the scale was judged to be excellent with a Cronbach $\alpha = 0.88$. There was also an additional item that asked the teachers whether they would include learning the principles of environmentally friendly chemicals both in their classroom and in their laboratory. Responses were provided on a 3-point Likert scale from 'never' to 'always'.

The questionnaire sheets were given directly to the teacher participants who completed the survey individually at their schools. On average, participants completed the survey in 30 minutes.

Data from the questionnaire sheets related to teacher's perceptions about Green Chemistry. The data was analyzed for its descriptive qualities including means and standard deviations and frequencies/percentages. The photographs were inspected and summarized to complete the information about Green Chemistry in learning process.

3. Result and Discussion

Observation of the fourth grade of students' behavior of Chemical Analyst Vocational School occurred in their laboratory work and demonstrated that students did not apply Green Chemistry principles in their working. As an example, this is seen when they measured small amounts of liquid but used containers bigger than necessary. When they completed a titration process, they used a bigger Erlenmeyer than required for the number of solids. In general, they did not use a suitable container for the number of liquids that were being measured or used. They also allowed the water bath to remain in the "on position" throughout their laboratory work.

Thirty-four of the 35 teachers (97%) stated that they always included the principles of environmentally friendly chemicals both in their classroom and in their laboratory. However, overall almost half of the teachers' responses (47.42%) showed disagreement with the principles of Green Chemistry. The percentages of teachers agreeing and disagreeing with these principles are shown in Table 1. The principle of Reducing Derivatives showed the highest disagreement with 54.29% of teachers disagreeing. That is, most of the teachers disagreed with the need to minimize unnecessary derivatization substances. They did not agree with the principle of avoiding steps required in adding reagents. They disagreed with avoiding the generation of waste. In contrast, the lowest disagreed upon principles at 42.86% were 'Less hazardous chemical syntheses' and 'Inherently safer chemistry for accident prevention' – that is, wherever practicable, synthetic methods should be designed to be used and generate substances that possess little or no toxicity to human health and the environment. 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.

Table 1. Percentages of teachers agreeing and disagreeing with each of the 12 principles of Green Chemistry

NO	Indicators	Number of Item	Perception	
			Disagree %	Agree %
1	Reduces Derivatives	2	54.29	30.00
2	Prevention	3	51.43	22.86
3	Design for Degradation	1	51.43	25.71
4	Safer Solvent and Auxiliaries	4	50.71	32.86
5	Catalyst	2	47.14	34.29
6	Atom Economy	2	47.14	25.71
7	Use of Renewable Feedstock	2	47.14	31.43
8	Real-time Analysis for Pollution Prevention	1	45.71	34.29
9	Design for Energy Efficiency	5	44.57	36.57
10	Designing Safer Chemical	3	43.81	33.33
11	Less Hazardous Chemical Syntheses	3	42.86	38.10
12	Inherently Safer Chemistry for Accident Prevention	1	42.86	31.43
Overall		29	47.42	31.38

In general, the results of this study have demonstrated that almost all teachers of Vocational School Chemical Analyst/SMK-SMAK Makassar have knowledge about Green Chemistry but that they do not necessarily agree with the principles of Green Chemistry. Green Chemistry knowledge in information form is recognized and interpreted to be a perception; 11 a perception about Green Chemistry. In this study, it was also demonstrated that the teachers' perception were not in favor of integrating Green Chemistry in chemistry learning process. Only 31.38 % agreed that Green Chemistry needed to be integrated in chemistry learning process less than disagreed are 47.42 %, and the amount left over 21.20 % chose to be a neutral in this perception.

In summary, less than half of teachers of the Vocational School Chemical Analyst of Makassar have perception that Green Chemistry needed to be integrated in chemistry learning process. By incorporating Green Chemistry principles into the chemistry curriculum, these future educators can provide students with a positive message about what chemists are doing for the environment in fulfilling the obligation and responsibilities of environmental stewardship. As Burmeister has demonstrated, one of the basic models of approaching sustainability issues in chemistry education is adopting green chemistry principles in the practice of science education lab work.³ Educators would also have the opportunity to transform student perceptions about the role chemistry plays in society and to address the need to discover and develop sustainable chemistry for the future [13,14].

Alumnus of Chemical Analyst Vocational School of Makassar are intended for industrial or other fields related to Chemistry, especially chemical analysis. They will become industrial actors in the field of chemistry, a field not independent of interaction with the environment. As a chemical analyst, they always wrestle with fine chemicals as well as safe and dangerous materials. Therefore, they need to be equipped with knowledge of "Green Chemistry" -- the 12 principles of green chemistry of this research can guide and be applied in their work.

Education and training of students of Vocational Chemical Analyst Schools should integrate the learning of Green Chemistry within their overall training as teachers. Teachers who understand the philosophy of Green Chemistry will have an impact on student learning outcomes and provide students with the knowledge of environmentally friendly chemicals. They will design learning that will integrate the philosophy of Green Chemistry and give students the knowledge, attitudes and

behavior that always consider the safety of the environment. Green chemistry as a laboratory-based pedagogy was employed by Kapurdewan to educate the student teachers enrolled in a chemistry teaching methods course at school of educational studies in a university in Malaysia [14]. It was found that Green chemistry experiments could improve students' self-determined motivations. Self-determined motivation elevates an individual to perform a behavior that the individual freely chooses to carry out. These behaviors are performed for reasons originating from within the individual and maintained without the need of external incentives or in the presence of barriers to action. Furthermore, this study also showed that green chemistry could be employed as a tool to enhance self-determined motivation. In contrast, if a teacher of Chemical Analyst Vocational School of Makassar has no knowledge of Green Chemistry, it would not be possible to expect students will have the knowledge, attitudes and behavior that always consider the safety of the environment, especially in order to practice and apply chemistry.

It would be hard to expect students to have knowledge of green chemistry if their teacher do not have that understanding, and did not see that green chemistry needed to be integrated into the learning process. In accordance with the stages of the stimulus that has been described above, the positive perception of chemistry teacher about green chemistry in learning process, will lead teachers to act and behave in accordance with the expectations of the principles of green chemistry. If this is the case, then the attitudes and the behavior will be transmitted to student. However, our results showed that only 31.38% of teachers believed that principles of Green Chemistry should be integrated in chemistry teaching and learning process. To improve this percentage, the onus remains with teacher educators to increase our future teachers' positive perceptions about Green Chemistry.

This study is not without its limitations. Data on age, sex, and length of teaching was not available for this sample and may have provided further insight into the acceptance and use of Green Chemistry principles. Although the data revealed low agreement with the principles, the reasons for this were not evaluated. This is a goal for future research. Further, this study only investigated teachers' perception of the Green chemistry principles, and not those of the students. They may gain an understanding of the principles through means other than school, including media. Their knowledge and practice of these principles is another area for future research.

4. Conclusion

Green Chemistry is the tool for reduction of environmental risks from exposure to chemical hazardous facilities [15] and the way for creating a sustainable future [16,17]. Green chemistry which is the main pillar of sustainable development has not been properly socialized at Chemical Analyst Vocational School. This study has shown that almost all teachers know the term of Green Chemistry, but generally believed and have perception that Green Chemistry did not need to be integrated into the learning process. For future sustainability, it will be important to consider these perceptions and the effects they may have on the role of Green Chemistry knowledge for future sustainability. Future research might therefore consider developing and evaluating learning and teaching models that encourage the adaptation and application of Green Chemistry principles. Conclusion

Based on the result of the previous section, it can be concluded that the determination of the spatial weight matrix in GSTAR model can also be determined based on observed data. From the result of the most minimum RMSE obtained weight matrix of the Gaussian kernel in which estimation result was quite accurate, with a small error. The resulting RMSE value was more or less the same. This was because the sampling of GR log data may not be as old (based on the rock layer). For the next research will be considered taking samples in accordance with lithostratigraphy appropriate to the relative age of the rock. For prediction purpose, the Epanechnikov kernel was the best spatial weight to this data.

Acknowledgments

The author would like to thank

- 1) Prof. Peter Newcombe PhD and Dr. Krisantini of The University of Queensland, Australia for this valuable comments and manuscript editing and their advice on the content of this manuscript.

- 2) Prof. Dr. Muh. Danial, M.Si. And Dr. Muh. Anwar, M.Si. for their valuable contribution to validating the perception questionnaire about green chemistry teacher in the learning process;
- 3) Teachers of Vocational School Chemical Analyst/SMK-SMAK Makassar who have been willing to fill out a questionnaire that authors disclose; and the fourth grade students of Vocational School Chemical Analyst/SMK-SMAK Makassar to participate in this study.

References

- [1] Palmer and Joy A 2003 *Environmental Education in the 21st Century* New York: Routledge Publishing
- [2] Sain and Biliana C 1996 Earth Summit Implementation: Progress since Rio *Marine Policy* **20**(2) pp 123-143 Elsevier Science Ltd. Great Britain
- [3] Del Vecchio and Deanna 2012 The Rio+20 Earth Summit & Youth. Engaging young people in the politics of developing global environmental policy *Green Teacher* **95** p13-15 <http://search.proquest.com.ezproxy.library.uq.edu.au/docview/1032551753?pq-origsite=summon>
- [4] Sain, Biliana C, Miriam C, Balgos, Joseph Appiott and Gwénaëlle Hamon Kateryna Wowk 2014 Assessing Progress Made on the Ocean and Coastal Commitments of the 1992 Earth Summit and the 2002 World Summit on Sustainable Development for the 2012 Rio+20 Conference *Ocean Yearbook Online* **28** Issue 1
- [5] Manahan S E 2006 *Green chemistry and the Ten Commandments of Sustainability* 2nd ed. Columbia, Missouri U S A ChemChar Research, Inc. Publishers
- [6] Wardencki W, Cury o, and Namieoenik J 2005 Green Chemistry — Current and Future issues Review *Polish Journal of Environmental Studies* **14**(4) 389-395 <http://www.pjoes.com/pdf/14.4/389-395.pdf>. diakses 11 Oktober 2014
- [7] Hjeresen, Dennis L, Schutt, David L, Boese and Janet M 2000 Green chemistry and education *Journal of Chemical Education* **77**(12) pro quest pg 1543
- [8] SMK-SMAK Makassar 2012 *Visi, Misi dan Motto Sekolah Menengah Kejuruan-Sekolah Mengengah Analis Kimia Makassar* https://id.wikipedia.org/wiki/SMK_SMAK_Makassar
- [9] Anastas P and Nicolas Eghbali 2010 Green Chemistry: Principles and Practice *Chemical Society Review* **39** p 301-312
- [10] Santosa and Sri Juari 2008 *Kimia Hijau Sebagai Pilar Utama Pembangunan Lestari*. lib.ugm.ac.id/digitasi/upload/717_pp110600020.pdf. diakses 19 Februari 2014
- [11] Slameto 2006 *Belajar dan Faktor-Faktor yang Mempengaruhinya* Jakarta: Sinergi Pustaka
- [12] Sugiyono 2008 *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D* Bandung: Alfabeta
- [13] Burmeister, Franz Rauch M, and Ingo Eilks 2012 Education for Sustainable Development (ESD) and chemistry education *Chemistry Education Research and Practice* **13** 59–68
- [14] Karpudewan, Zurida M, Ismail, and Norita Mohamed 2011 Green Chemistry: Educating Prospective Science Teachers in Education for Sustainable Development at School of Educational Studies *Journal of Social Sciences USM Penang Science Publications Malaysia* **7**(1) 42-50
- [15] Tarasova N P, Ingel F I, and Makarova A S 2015 Green Chemistry as a Tool for Reduction of Environmental Risks from Exposure to Chemically Hazardous Facilities *Russian Journal of Physical Chemistry B* © Pleiades Publishing, Ltd **9**(3) pp 406–411
- [16] Vilches and Daniel Gil-Pérez A 2013 Creating a Sustainable Future: Some Philosophical and Educational Considerations for Chemistry Teaching *Science & Education Journal* **22** 1857–1872 doi 10.1007/s11191-011-9404-x
- [17] Karpudewan M, Zurida, and Ismail 2009 The Integration of Green Chemistry Experiments with Sustainable Development Concepts in Pre-Service Teachers' Curriculum Experiences from Malaysia *International Journal of Sustainability in Higher Education* **10**(2) pp 118-135 Emerald Group Publishing Limited 1467-6370 doi 10.1108/14676370910945936