

# Learning Design to Integrate Scientific Character Values with Green Chemistry Insight in Basic Chemistry Course

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**Abstract**—It has been done a curriculum analysis in the form of research development to find out learning materials on Basic Chemistry course with green chemistry insight in order to realize green education. This is research and development study. This article presents the results of research at the preliminary study stage supported by references study. The results of mapping on learning materials in the Basic Chemistry courses that can lead the scientific character values with green chemistry insight, are; first, in an introduction; scientific method, the nature of matter, elements, compounds, and mixtures. Second, learning activities formulation integrates green chemistry principles in each learning material. Students learning experience can be discussion, question and answer, practice questions, create concept maps, laboratory activity, and create project tasks. Model, strategy, or method of learning that can integrate scientific character values on basic chemistry course such as discussion, cooperative, and project-based learning.

**Keywords**—learning; green chemistry; environmental; curriculum

## I. INTRODUCTION

Environmental issues have become one of the most important and most noticed issues in recent years. The word "green" has become a new trend in human daily life. Every element of society begins to realize that the Earth is not in good condition, and must take action to save our Earth together. Green chemistry is a philosophy or concept that encourages the design of a product or process which reduces or eliminates the use and form of harmful substances [5]. The principles of green chemistry can be adapted for application in human attitudes and actions in an effort to save the environment that can be realized through green education. This research has begun with chemical research on Green Chemistry, and students' understanding of character values [6].

Environmental aspects also become one of the basic references in every development process. College is a place where people are educated and matured in order to provide solutions in nation's problems. The level of progress of a country can be seen from the quality of college. Therefore, it should be a university to spearhead the forefront in solving a nation's problems, including environmental problems.

The learning that related to environmental issues actually can be integrated in each course. Green chemistry is also called sustainable chemistry, a chemical philosophy that encourages the design of products and processes to reduce or eliminate the use and creation of hazardous chemicals [5]. The Green Education Foundation (GEF) with the motto 'creates future sustainability through education', has ongoing programs [8]. In formal education, continuing education can be embedded in compulsory courses. From the investigation with systematic review method of several related research articles on how sustainable education approaches have been developed, the taxonomy is derived that: 1) the integration of continuing education can be broadly crossed with curricula, courses, or institutions. 2) through compulsory subjects, 3) the study material component of a compulsory subject, and 4) the chosen subjects [2].

Green chemistry has 12 elements that can be adapted for application in human attitudes and actions in order to save the environment [12]. Caring on environmental action can be done early by implementing in the field of education at all levels that can be realized through green education. Mitarlis (2015) conducted a research on analysis of scientific character values with green chemistry insight in order to realize green education through Basic Chemistry course got some character value that can be implemented in learning. They are: 1) common character values that can be raised in Basic Chemistry lectures include: honest, disciplined, thorough, meticulous, careful, hard work, responsibility, analytical thinking, critical thinking, creative, and caring environment. 2) The identification of the principle of green chemistry as the basis of character value with green chemistry in order to realize green education found 7 principles, such as: waste prevention, use renewable feedstock, atom economy, energy efficiency, design for degradation, real-time analysis for pollution prevention and inherently chemistry safer for accident prevention. 3) Obtained value of green chemistry science of the mapping results include: honesty, meticulous curiosity, care about the environment (smart water, smart energy, smart mobility, smart rubbish), efficient and creative (utilization of natural materials for the benefit of human and learning Chemistry), and others [6]. The findings

are will give great benefit if they can be implemented in subsequent learning.

This article discusses the results of research on curriculum analysis in research development of Basic Chemistry learning with green chemistry insight in order to realize green education. Basic Chemistry curriculum is formulated in the Semester Lesson Plan that is applied in Chemistry Department at Surabaya State University. Research and development is done to describe learning materials feasibility of Basic Chemistry course which was developed by green chemistry insight. This article is aimed to: 1) map the study materials in the Basic Chemistry 1 course which can lead to the scientific character with green chemistry insight; 2) formulate learning activities that can integrate green chemistry principles in every study material. 3) determine the model or strategy, learning method that can cover the green chemistry insight in basic chemistry course.

## II. METHOD

The type of this research is a development research, which uses (R & D) development methods proposed by Dick and Carey [9].

Overall, there are 6 stages the development stages. They are: preliminary study, reference study, material development, expert evaluation, empirical evaluation and final product. In principle, this method consists of three stages, namely: preliminary study stage supported by reference studies, development phase, and evaluation phase by expert evaluation.

This article presents the results of the research obtained only two stages; the preliminary study and reference study. The preliminary study stage was analyzed by curriculum of Basic Chemistry I course to determine the learning activities that can be integrated into science character values and green chemistry insight. The analysis is linked to a literature study of green chemistry principles in the previous research and future research perspectives. Also, it is conducted a need analysis (need assessment) underlying the main research which develop basic chemistry learning materials with green chemistry insight.

## III. RESULTS AND DISCUSSION

The curriculum analysis is conducted on Semester Guideline Course (SGC) or syllabus in Basic Chemistry I course. Based on the learning outcome, students' final capability depends on learning achievement indicator, study material and learning strategy. In this curriculum analysis, mapping and linkage between the syllabus components are used. Student learning experience is associated with the emergence of sci-

ence character values with green chemistry and the form of learning activities that will be experienced by students.

The summary of the Semester Guideline Course (SGC) as an example of mapping results up to several study materials is presented in Table 1. While a summary of mapping results related to the green chemistry student learning experience is presented in Table II.

TABLE I. EXAMPLE OF SEMESTER GUIDELINE COURSE(SGC) OF BASIC CHEMISTRY SUBJECT

No.	Competencies	Indicator	Matter	Learning Experience
1	Comprehending Chemistry as result of scientific activities that discuss about matter and universal properties.	1. Explain the step of scientific methods. 2. Explain the intensive and extensive properties. 3. Define the physical and chemical properties of element, compound and mixture	Introduction: steps of scientific method, Chemistry as scientific activity, matter and energy, intensive and extensive properties, element, compound and mixture.	1.1 Question and answer about the steps of scientific method 1.2 Giving examples of intensive and extensive properties. 1.3 Making concept map 1.4 Define each concept 1.5 Practice about element, compound, and mixture
2	Comprehending the basic of stoichiometry mainly: basic law of chemistry, atom and molecule, mole concept, and Avogadro constant, compound formula, chemical reaction, as well as molarity and equivalency	1. Explain the Basic Law of Chemistry 2. Define atom, molecule, and mole concept 3. Apply Avogadro constant and compound formula. 4. Apply chemical reaction and balancing, molarity, and equivalency in problem exercise	Stoichiometry: Chemistry Basic Law, Atom, and molecule, mole concept Avogadro constant, compound formula, chemical reaction, as well as molarity and equivalency	1.1 Problem solving exercise of Chemistry Basic Law. 1.2 Making concept map of atom and molecule, as well as mole concept. 1.3 Problem solving exercise of chemical reaction and balancing, molarity, and equivalency, 1.4 Practice of Chemistry Basic Law and chemical reactions with green chemistry insight.
3	Comprehending atomic structure development	1. Explain fundamental particle of	Atomic Structure: Basic particle, hydrogen	1.1 Study of basic particle of atom. 1.2 Making

No.	Competencies	Indicator	Matter	Learning Experience
	and discovery of basic particle of atom, according to Rutherford, Bohr, quantum mechanic and electron configuration.	atom. 2. Explain atomic theory development 3. Determine electron configuration many atoms.	atom spectrum, and atomic model of Rutherford, Bohr, and quantum mechanical, electron configuration.	media of atomic model imitation 1.3 Making concept map of atomic theory development. 1.4 Problem solving exercise of electron configuration

Based on Table 1, show the results of the mapping of learning materials in the basic chemistry I course, which can lead to the scientific character with green chemistry. A formulation of learning activities that can integrate green chemistry principles in every learning material both at the time of classroom learning with non-practicum worksheet media and learning in laboratories with practice worksheet. Strategy, model, or method of learning can cover basic chemistry lesson with green chemistry in learning model. Discussion of learning models are used at the beginning of the meeting with preliminary study materials which largely covers scientific methods, material properties, and studies of elements, compounds and mixtures. Learning experience was done by doing experiments in the laboratory to learn the elements, compounds and mixtures. The example result of mapping of learning materials was presented in Table II.

**TABLE II.** THE RELATIONSHIP OF TOPIC, LEARNING EXPERIENCE, GREEN CHEMISTRY INSIGHT, AND LEARNING MATERIALS

No.	Matter	Learning Experience	Model/strategy/method	Green chemistry insight
1	Introduction: steps of scientific method, Chemistry as scientific activity, matter and energy, intensive and extensive properties, elements, compound and mixture.	1. Question and answer about the steps of scientific method 2. Giving examples of intensive and extensive properties. 3. Making concept map 4. Define each concept	Model: Class Discussion learning model (Think Pair Share type)  Learning Strategy: making concept map	Principle No. 1: Waste prevention  Principle No. 6: Energy Efficiency, (include material, water and substance efficiency)  Principle No. 5 Benign solvent using  Principle no. 12. Inherently accident prevention

No.	Matter	Learning Experience	Model/strategy/method	Green chemistry insight
2	Stoichiometry: Chemistry Basic Law, Atom, and molecule, mole concept Avogadro Constanta, compound formula, chemical reaction, as well as molarity and equivalency	1. Problem solving exercise of Chemistry Basic Law. 2. Making concept map of atom and molecule, as well as mole concept. 3. Problem solving exercise of chemical reaction an balancing, molarity, and equivalency, 4. Practice of Chemistry Basic Law.	Cooperative learning Model  Learning Strategy: making concept map	Principle No. 1: Waste prevention  Principle No. 6: Energy Efficiency, (include material, water and substance efficiency)  Principle No. 5 Benign solvent using  Principle no. 12. Inherently accident prevention
3	Atomic Structure: Basic particle, hydrogen atom spectrum, and atomic model of Rutherford, Bohr, and quantum mechanical, electron configuration.	1. Study of basic particle of atom. 2. Making media of atomic model imitation 3. Making concept map of atomic theory development. 4. Problem solving exercise of electron configuration	Learning Model: Project Based Learning, (PjBL)  Learning Strategy: making concept map	Principle No. 1: Waste prevention  Principle No. 6: Energy Efficiency, (include material, water and substance efficiency)  Principle No. 7 Use of renewable feedstock (natural product)

Based on data on Table II, the learning experiences were designed by integrating green chemistry principles. They are; principle no1: Prevent/ reduce the formation of waste; Principle no. 6: Save energy, save chemicals when practicum; Principle No. 5: using solvents or safe chemicals; and Principle no. 12. Inherently prevent accidents. Its principles are important to be adapted as a basis of scientific character values. Aighevi & Osaigbovo (2010) assumed that students' opinion related to

global environmental literacy is used as requirement to comprehend the environmental literacy to non-science students [1].

Stevens (2014), and also Li & Lang (2015) found the affect of formal education and family toward orientation of human and natural environment relationship to students in China [10,4]. Also, orientation of students and pre service teacher to the environment after they took green chemistry lecture, showed the increasing of ecocentrism attitude and decreasing of homocentrism and egocentrism as well [3].

#### IV. CONCLUSION

Based on the results of development research on the first stage with preliminary studies by mapping the Basic Chemistry I curriculum and the study of literature related to learning, the principle of green chemistry can be concluded that:

The results of mapping of study materials in the Basic Chemistry I course can bring the scientific character with green chemistry insight. They are: on the initial of study materials which is stated in the introduction of the scientific method, the nature of matter, elements, compounds, and mixtures. Learning activities can be integrated to green chemistry principles in every learning material, both at the time of learning in the classroom with non-practicum worksheet media and learning in laboratories with practicum worksheet as well. Students' learning experience can be in the form of discussion, question and answer, practice questions, create concept maps, practicum, and create project tasks. Strategic models or learning methods which cover basic chemistry lessons with green chemistry; such as discussion, cooperative, and project-based learning model.

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