Survey of principles and techniques about synthesis of organic compounds and green chemistry

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Abstract. An experimental synthesis of organic compounds should be a means of learning that can facilitate students to better understand the basic concepts and techniques of organic compound synthesis. This study aimed to identify how the implementation of synthesis experiments of organic compounds and their effects on the mastery of basic principles and techniques about the synthesis of organic compounds. Data were collected through observations, tests of the principles and techniques of synthesis of organic compounds, and a questionnaire of Green Chemistry. After conducting the experiment, it was identified that there is an improvement on students’ achievements on the principles and techniques of synthesis of organic compounds. Although, after the test, there were still some weaknesses related to the basic principles of synthesis of organic compounds and thus, it is still needed an experiment that can improve basic principles of synthesis of organic compounds and apply the principles of green chemistry.

1. Introduction

An experiment is one of learning methods. Through experiment the students are given the opportunity to prove the theory of a learning that has been obtained in the classroom. The experiment gives students the experience in applying what they have learnt and conducting experiment is better than simply listening to a lecture in the class. Therefore, the learning process will be more meaningful. Laboratory is defined as: a) a place of scientific training, including experiments and other activities that help students acquiring scientific skills, b) a workshop in which factual science is done or where scientific activities are conducted under a conducive environment, c) includes participation in a range of experiment, observational and demonstration activities that provide opportunities for students to develop understanding practical and theoretical concepts through problem solving [1].The important things which should be considered in the implementation of the experiment are students’ preparation, making of the experiment flow chart, teamwork during the experiment, and writing report of the work in the laboratory. When writing the report, the students are led to construct the ideas from what they have already done and learned, and what has happened during the experiment [2].
An experiment in the laboratory can be a good method to improve students’ ability on organic chemistry, such as the principles and synthesis technique of organic compounds. Learning of organic chemistry through experiment can improve the principles about organic chemistry, which students have gotten about its theories in the class, the experiment also can improve the technique in organic chemistry [3,4].

Organic chemistry experiments are carried out through several stages; a) introducing the usual techniques were modified to also include student collection and organization of information about the experiment, b) having students incorporate their data into the design of new procedures to perform in subsequent laboratory sessions, c) during this first part of the course by promoting reflection, analysis, and interpersonal communication about science, d) structured individual and group review exercises were developed for the student-designed procedures also allow student identification of errors, ultimately improving the procedure design [5].

Green chemistry is a new approach in synthesis process which is safe for health and environmental friendly [6]. Some experiments can be done by applying alternative materials to the synthesis of organic compounds [7,8]. The need to apply the principles of Green Chemistry to the learning activities became the focus that began to be developed in various educational institutions, such as the activity of organic compound synthesis activity. Green Chemistry in the field of organic chemistry began to be developed in lectures and practice [9,10].

2. Method
This study applied a survey method [11]. The study was conducted to 33 students of chemistry education department in one of university in Bandung. They have finished conducting experiment of synthesis organic compounds. The data was collected through an observation, a test about principles and synthesis technique of organic compounds, and a questionnaire about Green Chemistry. Analysis techniques using SPSS 20.

3. Results and discussion

3.1. Description of implementation organic compound synthesis experiment
Organic Compound Synthesis Experiment is separated from the learning activity in the class and integrated with isolation technique. Thus, it was only covered two themes during the experiment. Before conducting the experiment, the students prepared the experiment design, including the flow chart about the experiment that they did. The experiment preparation and design were then tested by laboratory assistant chosen from students. Then they conducted the experiment with their team. Lastly, one of the team members wrote the report about their experiment [1,2].

Based on the observation of the average value from each experiment with the final test score, it was found that there was an improvement on students’ learning outcomes. This was reinforced by the calculation of SPSS which obtained the correlation value with r = 0.815. This result of the observations showed that students’ achievement was improved after conducting the experiments of organic compound synthesis which is in line with their obtained ability after the synthesis experiments [3,4].

3.2. The principles and techniques about synthesis of organic compounds
From the figure 1, it was obtained the information that most of the students still have difficulty in the principles of reaction required during the synthesis of organic compounds (test 1-7). The score was less than 50, especially, the more detailed division of reactions, such as various nucleophilic substitution and elimination (test 2, 4,5). Similar result was also obtained when its application to synthetic compounds, such as types of additions and aldol condensation reaction (test 6 & 7), which is one of the discussions of synthesis experiment that has been conducted.
From the result of basic techniques of synthesis test, showed in figure 2. It was obtained the information that the students are still having difficulty on the role of compound components during the synthesis process (test 1&2). In contrast, the students are also well informed about the part of the activities undertaken during experiment activities (test 3-5). Thus, it can be concluded that the students have mastered the skills of synthesis techniques after conducting experiments of organic compound synthesis [4].

3.3. **The principles of green chemistry on the implementation of the organic compound synthesis practice**

Based on the figure 3, it was obtained the information that almost all students agreed that the experiment can improve the mastery of basic concepts of organic compounds, either in the form of substitution reactions, elimination, additions, and reactions that occur in the experiment that has been implemented (questionnaire 1-5). A lower percentage of students (43, 8%) who knew the relevance between organic compounds that are synthesized with the underlying reaction concepts (questionnaire 6). From this we can conclude that the students have not fully understood the interrelationships between organic chemistry concepts in the experiment, whereas the experiment should be able to improve students' conceptual knowledge [1].

**Figure 1.** Principles about synthesis of organic compounds.

**Figure 2.** Techniques about synthesis of organic compounds.
This figure also showed that almost all students knew the dangers of the materials used in the synthesis of organic compounds. They expect that it was important of the use of materials which are more environmental friendly in the laboratory experiments (questionnaire 8 & 9) [7]. However, less than half of the students knew about the alternatives ingredients (questionnaire 7) which are more environmental friendly, especially when they were asked about Green Chemistry (questionnaire 10) We can conclude that although students do not understand Green Chemistry but they understand how sustainability in the experiment is urgently needed and expected to be implemented. So that application of Green Chemistry principles to organic chemistry experiments is required [6,9,10].

4. Conclusion
The result of this research showed how the implementation experiments of synthesis of organic compounds were conducted. The synthesis experiments were incorporated with the isolation activities of natural product. Thus, there were not many experimental themes which can be conducted. After conducting the experiments, it was identified that there was needed an improvement on students’ achievement of the principles and techniques on the synthesis of organic compounds. Although, after having a test, there were still some weaknesses related to the basic principles of synthesis of organic compounds. Thus, it is still needed a further experiment model which improve the basic principles of synthesis of organic compounds and apply the principles of Green Chemistry.

Acknowledgement
The authors would send their gratitude to Kementrian Riset dan Teknologi Dirjen Pendidikan Tinggi (RISTEK Dikti) which funded this research.

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