Recognizing students’ abilities to work through synthesis organic pathways

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Abstract. Students usually use organic synthesis organic pathways to completing the synthesis organic problems. It is important to the student to follow the role each pathways in synthesis organic compound. This study aims to recognize students' abilities to work through synthesis organic pathways. This research is using descriptive method. The respondents of this research were 14 students from chemistry education department. The study used essay test to recognize each steps of organic synthesis. Data were taken from percentage of students’ answers in each synthesis organic pathways. The nonparametric differentiation statistics used in this research to know the differences for each synthesis organic compounds. The result showed students used pathways of aldol condensation, acylation of benzene, and amine primary benzene is the same level of confidence. The result found that students the highest used steps in identify the structure of the compounds in synthesis organic and the lowest in the steps where students should find the right reagent and conditions for the reaction, write a mechanism reaction, show the complete synthesize.

1. Introduction

It is actually important to work with organic synthesis pathways as a guide in solve organic synthesis problems. It is known that all chemist used it as a strategy. Frequently the organic synthesis aspect considered as a difficult matter that have been done by students [1]. It may be possible because the students should be able to integrate all aspects that they know about organic synthesis.

In the previous research which was found that the students’ understanding of prerequisite concepts closely related with their capability in synthesis organic compound [2]. It has been research that provides scaffolding for students can help them to solve the problem of organic synthesis [3]. They have been used problem solving method to synthesize organic compound [4-6].

In other study, they were applying research project method to find out about students preparation in solving the synthesis organic compound cases. Students learning process about organic synthesis subjects were not only expected successful at the organic laboratory course. That is also known can improve generic science skills and critical thinking [7-9]. However, it is necessary through the way
students answers the problems of organic synthesis problems. It is about how they plan and choose the right stages of synthesis organic. Therefore, we recognize that there are various opinions from experts about the stages of solving organic synthesis problem. We will make it simple by choosing the aspects that we think its essentials [10]. Likewise, this research will only be seen from several aspects of the synthesis of organic compounds. According to the previous research we want find out how students do their synthesis organic problems. The exactly purpose is we want to recognize students’ abilities to work through synthesis organic pathways.

2. Method
The descriptive method used in this research by expending a data percentage of students’ works in synthesis organic compound and the nonparametric differentiation. The participants were 14 students from one state of university in Papua and they were in third years.

Data took from students’ answers when they have given the essay test about synthesis of organic compounds and create the checklist table according to their answers. This research only comprehended several aspects of the synthesis from aldol condensations, acylation of benzene, and amine primary benzene. It perceive to recognize students work in each steps of synthesis organic compounds. The aspect from student work that have been our focus are: (a) identify the structure of compound (the functional group or the bonding in the compound); (b) realize the differences (C-C bond/transformation of functional group) by choosing the right site in the compound to make disconnection/functional group interconversion; (c) use a retrosynthesis ways (backward way from target molecule to starting material); (d) write the starting material; (e) show the available reaction to synthesis the compound; (f) find the right reagent and conditions for the reaction; (g) write a mechanism reaction; (h) show the complete synthesize.

Data analysed by the differentiation test to find out whether there are the differences from each organic compound synthesis. The Kruskal Wallis test with critical point 0,05 were using for this research in order to know the differences between synthesis of aldol condensation, acylation of benzene and amine primary benzene [11]. The instrument used for synthesis organic matter was essay test. Questions were related to organic synthesis focus on the compounds structure.

Examples of organic synthesis problems:
Write down the synthesis of the target molecule of the following materials (pay attention the structure of target molecule until complete synthesis)

1. [Diagram of Target molecule and Starting Material]

2. [Diagram of Target molecule and Starting Material]

Figure 1. The example essay questions of organic synthesis problems.

The problems that given to students were based on target molecule compounds synthesis. Data from retrieval process came from students answers. From the organic synthesis problems we identify what kind of synthesis steps that chosen by students to solve problems of organic synthesis problems.
3. Results and discussion

Synthesis organic is complicated problems that need some ways to work with it. Beside all the concepts are the students usually should be mastery it. It is also have a strategy how to solve the problems of synthesis organic become more available to do it. In the first, the students are given the essay test. The test gives them a question how to synthesize the simple organic compound as the target molecule from the given starting material. The students answers in the worksheet paper, and we analyse their answer like in table 1.

| Code | Used pathways in synthesis organic compound | Percentage of students that used the pathways in synthesis Aldol Condensations compound (%) | Percentage of students that used the pathways in synthesis Acylation of Benzene (%) | Percentage of students that used the pathways in synthesis Amine primary Benzene (%) |
|------|---------------------------------------------|-----------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| a    | Identify the structure of compound (the functional group or the bonding in the compound) | 80.75                                         | 70.45                                           | 70.25                                           |
| b    | Recognize the differences (C-C bond/ transformation of functional group) Use a retrosynthesis ways (backward ways from target molecule to starting material) | 40.25                                         | 50.75                                           | 50.25                                           |
| c    | Write the starting material                  | 60.50                                         | 55.75                                           | 40.25                                           |
| d    | Show the available reaction to synthesis the compound | 70.25                                         | 40.25                                           | 40.75                                           |
| e    | Find the right reagent and conditions for the reaction | 60.75                                         | 60.50                                           | 50.25                                           |
| f    | Write a mechanism reaction                   | 45.25                                         | 50.25                                           | 30.25                                           |
| g    | Write the complete synthesize                | 50.25                                         | 30.00                                           | 25.25                                           |
| h    |                                             |                                               |                                                 |                                                 |
| Average of percentage of students that used the pathways in each synthesis organic compound | 56.00                                         | 42.80                                           | 37.10                                           |

Based on the table 1 we find that mostly used pathways from each synthesis is in a code student used to identify the structure of compound (the functional group or the bonding in the compound). It seen from the table that the percentage of students that used the pathways in synthesis of aldol condensations compound, the acylation of benzene and the amine primary benzene are 80.75%, 70.45%, and 70.25%. It seems that student still can work clearly through these pathways and do not have a significant difficulty.

From table 1, we can also perceive that student do not usually used the pathways in code f, g, and h. It is caused student need hardly think to integrate all of their ability to work with it. In f code shows where student should find the right reagent and conditions for the reaction. For synthesis of aldol condensation, the acylation of benzene, and amine primary benzene are just 45.25%, 50.25%, and 30.25% of students that used the organic synthesis pathways. In g code percentage of students that used steps to write the mechanism for each synthesis are 40.00% (aldol condensations), 40.25% (acylation of benzene), and 30.05% (amine primary benzene). The findings of this research indicate that for the complete synthesis steps shows students percentage are 50.25% (aldol condensations), 30.00% (acylation of benzene), and 25.25% (amine primary benzene). From the analysing data found that average of percentage of students that used the pathways in each synthesis organic compound are 56.00% for aldol condensation, 42.80% for acylation of benzene and 37.10% for amine primary benzene. From the result shows like in figure 2.
Figure 2. Diagram of percentage students that used the pathways in each synthesis organic.

Diagram from figure 2 shows that the pattern for each synthesis almost the same. Each of them has the highest percentage in a code and the lowest in h code. It makes a sense that we have the diagram like this. It is because each steps of synthesis organic compound have a different level of understanding. If we talk about just to identify the structure so it means maybe students just have memorization the structure before. But in the level of show complete synthesis of organic compounds then it becomes more difficult. Students will be thinking critical by combine all the knowledge that they need to do the synthesis. They also must have creativity to think to complete this pathway.

Furthermore, in order to recognize if there are differences between students work in each organic synthesis problems then we used the Kruskal Wallis test as the statistic for analysed the results. We have the result of the statistic like in table 2.

Table 2. The statistic result of Kruskal Wallis test.

|                         | Percentage of students used the pathways |
|-------------------------|-----------------------------------------|
| Chi-Square              | 2.881                                   |
| df                      | 2                                       |
| Asymp. Sig              | .237                                    |

According to the result of statistic in table 2 confirm that the chi-square value is 2.881. By looking at the chi-square table for degrees of freedom or (df = 2) at a significant level of 5% (0.05) then it shows the value of chi-square obtained 5.991 and Asymp. Sig obtained 0.237.

As it have been known that since the chi-square calculates less than chi-square table like 2.881 is less than 5.991 and the significant value is 0.237 > 0.05. It means that there is no significant difference in the level of percentage used of synthesis organic pathways between the three types of synthesis organic compound. In other words that the percentage of students used pathways of aldol condensations, acylation of benzene, and amine primary benzene is the same at the 5% confidence level.

Students tend to have troubles in solving an organic chemical synthesis. It cause them do not have critical thinking skills to predict a reaction result of organic compounds or precursor/starting material compounds from target molecules. Based on the research, in order to study organic chemical synthesis required a strategy that can be used. It will assistance students to be able encounter the achievement of desired conceptual understanding in learning [12,13].

The strategy in the organic synthesis of learning can assist through laboratory practice leading to the synthesis experiments of organic compounds through guided inquiry [14]. Thus, it can help to direct the student toward conceptual change and in addition to improving students' critical thinking skills.
4. Conclusion
Eventually this research concluded that students used pathways of aldol condensations, acylation of benzene, and amine primary benzene is the same confidence level. Even from each steps recognize that student necessary identify the structure of the compounds in synthesis organic. Inversely is different with the steps where students should find the right reagent and conditions for the reaction, write a mechanism reaction, show the complete synthesize as the lowest used. Therefore, we required to lead the students to work in some project based learning in synthesis organic so they will develop all their capability in synthesis organic compound. Moreover, it can increase their critical thinking skills and develop generic science skills.

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