Integrating Students’ Understanding of Prerequisite Concepts into Capability to Synthesize Organic Compounds

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Abstract. The capability to synthesize organic compounds requires understanding of organic chemical prerequisite concepts. Students need to integrate organic chemical concepts to analyze stages for synthesizing organic compounds. This study aims at understanding students’ organic chemical prerequisite concepts and students capability to combine their prerequisite concepts in synthesizing organic compounds using descriptive method. The respondents of this research were students from chemistry education department. The study used multiple choice with reasons test and essay test analyzed using non parametric correlation statistics. The result showed a relationship between student understanding of prerequisite concepts with conclusion of organic compounds synthesis. The result found that students have a good understanding on prerequisite concepts such as: type of reaction, starting material and reagent. Conversely, students prerequisite concepts were very lacking in the concept of carbocation ions, reaction products, electrophile formation of C-C, and disconnection of compounds.

1. Introduction
The concept of synthesis organic compound required by students in Advanced Organic Chemistry learning. Based on the implementation of Organic Chemistry learning, it is known that students still depend on familiarity with the related reaction. Futhermore, they have lack of problem solving test because they cannot reminiscence the answers or they just seek to available answers [1]. According to early research, students do not have the skills and capability to create a fit reaction mechanism [2]. Consequently, some of them tend to learn by roting or resolving problems by making an analogy. Even previous research stated that the success of an individual who resolve chemical problems begins by describing the initial structure to discover ways to solve the problems [3]. In addition, there is recognition to present a constant connection between the concepts. The integration between the concepts will have an impact on the students’ capability in completing the assignment of organic synthesis.
It also found that student assignments involved only the explanation of general term and linked it to the mechanism of reaction and the whole process transformation of a compound [4]. These examines are only part of how students answer an organic synthesis problem. These examination do not emphasis on how to solve an organic synthesis problem completely. Students have sense in advance exertion on the part that should merely be the initial stage of sequence part of the organic compound synthesis resolution. The difficulties of students accomplish the assignment is affected from students capability to resolve more complex problem that related to organic synthesis compound. Moreover, if students are given a suitable assignment in resolving organic chemical problems, then they will find no difficulties to resolve the problems. According to early research, students must given organic synthesis problems by using mechanistic solution [5]. Through this assignment, students will be more mindful to resolve organic chemistry problems mechanically. Students who learn organic chemistry requisite to practice synthesis of organic compounds in new molecular environments and different intermediates. It will make them to think about the conventional organic synthesis mechanisms. The assignments that given were out of the ordinary or simple context in which they were first taught. It is also recognized the important for an approach that connected to learning process in science with students confidence [6]. Thus, it can provide a meaningful learning for the students [7]. Meanwhile, it pedagogically provides information about how students thinking process, along with how the students resolves the problems of synthesis of a target molecule compound.

Similar with other research found if students depend on solely heuristic ability, there will be effortless or no process skill from the students to achieve the right answer [8]. Sometimes students use practical directions that help them to simplify the task and solve problems. But it has been proven regularly lead students cannot understand the current concepts [9], [10]. Even in learning chemistry, students can have misconceptions likewise in other lessons, so the misconceptions need to be identified from the beginning in order not to impede the process of student acceptance in learning [11], [12]. However, if students do not use the strategy and skills, they will not be able to achieve the intended learning outcomes. Thus, they may be capable to answer the given questions. A mental model of student can effect to student understanding because a mental model emphasizes function rather than form[13]. It is founded that students serve as subjects in the study who are not yet experts in organic They will not demonstrate consistent behavior with problem solving strategies which were successfully used by experts. Complexity of compounds considered as a factor that affected how students work with the problems. For that purpose, this paper will present about the understanding of organic chemistry concept from students and how they integrated it to resolve organic synthesis problem.

2. Method
The research used descriptive statistic method then analyzed by using nonparametric correlation test to know the integration between the level of understanding of the concept possessed by the students by way of student completion on the problem of organic synthesis. This study was conducted at one of the universities in Papua. This research involved students who were taking Advanced Organic Chemistry courses in the fifth semester of the third year. The number of students involved was 14 students in the third. The course has a prerequisite course, namely Organic Chemistry courses 1 and 2.

The instrument used was multiple choice with reasons test and essay test. Questions were related concepts in organic chemistry prerequisites such as: the type of reaction, the structure of the compound, the reaction product, electrophiles in the formation of C-C. These problems considered the connection to resolve organic synthesis problems focus on aldol condensation, benzene acylated and tertiary amine benzene. Figure 1 shows an example of a given problem for the students:
A. Example questions of understanding of prerequisite concepts:

1. From these benzene compounds, which one have the para offering groups ........

   a) ![benzene_with_one_group](image1.png)
   b) ![benzene_with_one_group](image2.png)
   c) ![benzene_with_one_group](image3.png)
   d) ![benzene_with_one_group](image4.png)

   Reason: ........................................................................................................

2. Based on the structure of the following compounds that would be appropriate to the tertiary amine compound is .......

   a) ![amine_structure](image5.png)
   b) ![amine_structure](image6.png)
   c) ![amine_structure](image7.png)
   d) ![amine_structure](image8.png)

   Reason: ........................................................................................................

B. Example of organic synthesis problems:

Write down the synthesis of the target molecule of the starting compound of the following materials:

![target_molecule](image9.png) ![starting_material](image10.png)

**Figure 1.** The example questions of understanding of prerequisite concepts and organic synthesis problems

The problems given to students is based on the synthesis problem of target molecular compounds. Data from retrieval process came from students answers. The questions were 20 items about the multiple choice with reasons used to find students understanding of the prerequisite concept. From students answer classification based on student answer. It is classified that students responded correctly (if the answer and the reason are true), and classified wrong (if the answers and reasons are wrong, or answered correctly but the reason is wrong or no reason, or no answer at all for each item). From 20 items of the questions for students’ understanding of prerequisite concepts divided into 7 items for aldol condensation compound (35% of all items), 7 items for acylated benzene (35%) and 6 items for tertiary amine benzene (30%).

The percentage outcome of understanding the concept of student prerequisites is seen as related to the percentage of the number of students who can use the prerequisite concept at the stage of each synthesis of organic compounds. The statistics used for Spearman rank correlation at significance level $\alpha = 0.05$. Spearman rank correlation coefficient value [14]. The students’ understanding of prerequisite concepts in organic chemistry owned by the students associated with subjects such as: type of reaction, the structure of the compound, starting material, the reaction product, electrophiles used, reagents, and disconnection that is then associated with a way resolve the problems of organic synthesis. This study was directed to the synthesis of aldol compounds, acylated benzene, and tertiary amine benzene.

### 3. Results and Discussion

The results of students understanding of prerequisite concepts and then viewed its integrity to resolve the synthesis compounds problem can be seen in table 1:
Table 1. Percentage of level of understanding of student prerequisite concepts and percentage of use of prerequisite concepts in answering synthesis of organic compound.

| No. | Concepts                                      | Students who understand the concept(%) | Students who used of the concept of prerequisite in answering synthesis of organic compounds (%) |
|-----|-----------------------------------------------|----------------------------------------|------------------------------------------------------------------------------------------------|
|     | A. Aldol condensation compound                |                                        |                                                                                                |
| 1   | Type of Reaction                              | 85.72                                  | 42.86                                                                                          |
| 2   | Structure of the compound                     | 42.88                                  | 14.28                                                                                          |
| 3   | Starting material                             | 85.72                                  | 28.57                                                                                          |
| 4   | The result of the reaction (Product)          | 14.28                                  | 14.28                                                                                          |
| 5   | Electrophile on C-C formation                 | 14.28                                  | 0                                                                                              |
|     | B. Benzene acylated compound                  |                                        |                                                                                                |
| 6   | Reaction of Nucleophilic Substitution         | 14.28                                  | 14.28                                                                                          |
| 7   | Reagent of acylated compound                  | 71.43                                  | 14.28                                                                                          |
| 8   | Reagent function                              | 71.43                                  | 42.86                                                                                          |
| 9   | Carbocation ions                              | 7.14                                   | 0                                                                                              |
|     | C. Tertiary amine benzene compound            |                                        |                                                                                                |
| 10  | Steering Group                                | 28.57                                  | 0                                                                                              |
| 11  | Structure of Compound                         | 50.00                                  | 28.57                                                                                          |
| 12  | Reduction Reactions                           | 57.14                                  | 14.28                                                                                          |
| 13  | Properties of Compound                        | 47.62                                  | 14.28                                                                                          |
| 14  | Disconnection of compound                     | 14.28                                  | 0                                                                                              |

Based on the result of the percentage of students' understanding of the prerequisite concept with the completion of organic matter as a whole found the existence connection. But the views of specific integrity for each compound we can seen in figure 2, 3 and 4.

![Graph](image.png)

**Figure 2.** Graphic integration level of student understanding of prerequisite concept with the use of the concept to solve the problem of synthesis of aldol condensation compounds.

Based on figure 2, it can be seen a relationship between students understanding of prerequisites concepts with the percentage of the use of prerequisite concepts on the completion of organic compounds. In aldol condensation synthesis was found that the students percentage understanding on the concept of the type of reaction and the starting material is equal to 85.72%, on the concept of compound structures 42, 88%, and on concepts of the reaction product and electrophiles in the same formation on acquiring C-C percentage of 14.28%.

In the synthesis of benzene acylated compound found the students understanding is found on the concept of type and function of reagents that have the same percentage of 71.43%, on the concept of nucleophilic substitution reaction reactions and carbocation ions are 14, 28% and 7.14%.
Figure 3. Graphic integration level of student understanding of the prerequisite concept with the use of the concept of prepay to solve the problem of synthesis of benzene acylated compound.

From figure 3, it can be seen that the absence of the meeting point is indicated if the level of understanding of the concept of student pre-requisite does not have integrity with the way of completion on this compound. These results suggest that there is no correlation between student understanding of prerequisite concepts with the percentage of the use of prerequisite concepts on the completion of organic compounds.

In synthesis of tertiary amine benzene compound, there was a sufficient level of understanding of the concept of student prerequisite on the concept of compound structure, reduction reaction and compound properties of 50.00%, 57.14% and 47.62%, respectively. The concept of prerequisite of the steering group and the disconnection of each compound 28.57% and 14.28%.

Figure 4. Integration level of students understanding of the prerequisite concept with the use of the concept of prepay to solve the problem of synthesis of tertiary amine benzene compounds.

Figure 4 suggest that there is no correlation between understanding the concepts of student prerequisites with the percentage of the use of prerequisite concepts on the completion of organic compounds. The findings obtained show that the students understanding of concepts prerequisite kind of reaction, the starting material the same percentage of 85.72%. Meanwhile, the prerequisite concepts of carbocation ions 7.14%, reaction result, electrophile forming of C-C, and disconnection of compound with equal percentage equal to 14.28%.

According to previous research shows that the question of some kind of prerequisite concept of reaction type and structure of the compound is a question which is only a repetition [15]. It is known that mostly students only give answers related to cognitive aspects of knowledge or rote just like the concept of the type of reaction, the starting materials and reagents. The student's tendency to memorize a set of rules and previous reactions in organic chemistry has been found to inhibit student learning [16], [17]. There is a lack of understanding of concepts from the majority of students so that they can not apply organic chemical concepts to solve problems related to synthesis organic compounds. In accordance with the findings on the synthesis of aldol condensation compounds students are only able to answer questions related to alcohol reactions. It is also possible to relate to students’ inadequacies, leaving them with no other way to solve the problem. It is seen in the synthesis of benzene acylated compounds found that students cannot connect between the concept of reagents used and the reaction of benzene compounds. Similarly in synthesis of tertiary benzene amine compounds, students were found unable to relate the concept of benzene compound structure with benzene reactions.

But if the views of its specific integrity, it is found an integration between understanding the concept of student prerequisites and how students apply it to the synthesis of aldol compounds. But it
is different in the synthesis of benzene acylated compounds and tertiary amine benzene compounds that show no connection. This suggests a gap between the knowledge possessed by students and the skills to achieve synthesis and retrosynthetic analysis. Students make a study based on authentic and tangible problems that are similar to the complex problems facing scientists that have an impact on improving the ability of students to think critically and learn independently and gain learning experience. This is a process of assimilation that must be passed by students to be transformed into practitioners or scientists in the field of organic chemistry [18]. Meaningful learning can be done through the implementation of the organic compound synthesis experiment in laboratory. It is known that lab work performed by the student in the laboratory can help improve the affective, psychomotor and cognitive can even evaluate students on these aspects [19–21]. In fact, through the implementation of experimental synthesis of organic compounds in the lab[22], the students involved in an authentic problems within a specific domain and not just laboratory work in the laboratory that verification [23].

4. Conclusion
Inclusive, there is a relationship between students understanding of prerequisites concepts with the completion of organic synthesis. When it is viewed, every synthesis of organic compounds found that in the synthesis aldol condensation students can apply the concepts of preference to the organic synthesis of the synthesis but different from the synthesis of terylated benzene compounds. In Tertiary amina benzene, it is found that students can not combine the concept of prerequisite with the completion of synthesis of organic compounds. It can be suggestion to Organic Chemistry lecture, for more comprehensive teach organic prerequisite concept that correlated with synthesis organic compound. Especially when they teach about benzen compound. For more further research, the learning process about this subject matter must done in inquiry and project based learning by using laboratory.

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