Experiment laboratory design of the dyestuff from secang (Caesalpinia Sappan linn) to improve conceptual understanding students of textile chemistry

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Abstract. Textile waste contributes for one-third of the world’s waste. Natural dyes can be a solution to reduce it. Secang (Caesapina Sappan linn) is one of the natural dyes used to dye textiles and gives red effect. The experiment of dyestuff from secang is expected to make students of textile chemistry major having the ability to understanding of knowledge about colour, dyestuff structure, and the process of making it in order to solve problem. The research subjects were 32 students textile programme of chemistry major in one of the polytechnics in Bandung. Instruments used in the form of observation, questionnaires, interviews, deal to daily activities score and Midterm test. From the results of statistical calculations obtained conclusion there is a relationship of experiment activities conducted with the understanding of the concept of students and there is a difference conceptual understanding students before and after the application of experiment design.

1. Introduction
Dyestuff chemistry practice is a masterpiece of craftsmanship for second year students majoring in textile chemistry. This practice comprises the manufacture of natural dyes and synthetic dyes. One of the expected learning outcomes of this course is the students have the ability to master the knowledge of colour, dyestuff structure, and the process of making it be able to solve the problems encountered. Natural dyes have been used since ancient times to colour vegetable and animal fibers [1]. Nowadays natural dyes are preferred because they are safer and more environmentally friendly than synthetic dyes [2]. Textile waste is hazardous and accounts for one-third of the world’s waste [3]. Some research reviews have discussed in detail the source and chemical properties of the natural dyes, including green walnut [4] Clitoriaternatea, Targeteserecta Linn and Punica granatum [3]. Onions skin [1], Hibiscus Rosa Sinesis and Marigold [5] and secang [6] [7]. Natural dyes can produce basic colors (red, yellow, and blue) and color combinations. In Indonesia the secang grows in Java, at an altitude of 1-1700 dpl, planted as a barrier, or grows wild locally. Compounds that contained in the secang is brazilein which gives red color and changes color direction along with pH change. The optimum extraction conditions used water at a temperature of 80°C for 2 hours [7], and the condition of dyeing on cotton or silk was at room temperature for 30 minutes [6]. Temperature parameters at the time of extraction may cause changes in functional groups of brazilein [7].
In practice, experiment activities can be performed using several models. Experiments in the field of science are identical to scientific research or research study [8] which is also called the inquiry learning model. The learning model with scientific inquiry has five stages: 1) finding the problem, 2) getting the data, 3) collecting the data experiment, 4) formulating the explanation, 5) analyzing of the data of investigation process [9]. In the inquiry model, one of the approaches that can be applied is the Skills Process of Science (SPS), that includes stages: 1) defining problems, 2) formulating hypothesis/estimation, 3) determining the variables, 4) adequate testing, 5) collecting data, 6) display data, and 7) describing the results. With the application of SPS, it was found that student creativity increased significantly compared to students who did not using the SPS approach [10]. SPS has also been shown to improve students' ability doing chemistry lab activity [11].

In addition to the scientific inquiry model, the mini project chemistry lab activity model on natural material chemistry makes the students acquire more conceptual understanding than using verification laboratories [12]. Implementation of the project is also able to increase students' understanding of the chemistry of natural materials [13]. Project-based learning can not only improve students' learning motivation in vocational schools but also facilitate their problem-solving skills [14]. This model is able to improve soft skills and improve student data collection and analysis [15]. The laboratory project allows students to understand that plants around the world are the primary source of colour before synthetic dyes are available [1]. Model Project Based Learning (PBL) has several stages/syntax that is 1) determine the fundamental questions; 2) make project design; 3) arrange scheduling; 4) monitoring project progress; 5) assessment of results; and 6) evaluation of experience [16]. Project-Based Learning has a fundamental characteristic that distinguishes it from other models, including, the project-based learning model always begins by finding out what the fundamental question [16]. The lack of this PBL model is a lot of times [17].

Based on the presentation of the literature study, it is necessary to design the learning that can answer the outcome of the dye laboratory especially using dyestuff of secang. The learning design is to cover the entire process carried out on a systems approach consisting of analysis, design, development, implementation and evaluation [18].

2. Method
This study used descriptive study [19] on students majoring in textile chemistry as much as 32 people (divided into 8 groups) in one of Polytechnic in Bandung. The students were enrolled on the dye chemistry laboratory course in the third semester. The research data was obtained through observation of the lab activity, daily scores (performance of practicum and journal), mid term test of the concept dyestuff of secang, unstructured interview with lecturer and student, and questionnaire for students. The study was conducted for 8 meetings (half semester) on the implementation of dye practice secang. The practice design that is done in the table 1.

| Extract used      | Group | Dyeing parameters | Extract used      | Group | Dyeing Parameters |
|-------------------|-------|-------------------|-------------------|-------|-------------------|
| liquid dye extract| 1     | pH                | powder dye extract| 5     | pH                |
|                   | 2     | NaCl (g/L)        |                   | 6     | NaCl (g/L)        |
|                   | 3     | Temp (°C)         |                   | 7     | Temp (°C)         |
|                   | 4     | Time (min)        |                   | 8     | Time (min)        |
3. Results and discussion

3.1. Experiment design

From the observation result during lab activity, the implementation of natural dye laboratory is carried out by stages: 1) Determination of natural materials to be used, the lecturer determines the source of natural dye in the form of secang (*Caesalpinia Sappan linn*) This election is based on the optimum condition of the dye extraction secang [7], 2). The project design proposed consisted of two large groups of 4 groups using liquid extract from secang, while 4 groups from extracts of powder with different variables [10]. 3). Each group presented proposals from extraction, dye analysis, dyeing process and immersion analysis results, 4). Collected data / lab work, students took data from each practicum performed [9]. 5). Monitoring the progress of the project, monitoring is done by lecturers and two assistants, every meeting is done daily / performance appraisal for each student 6). Reporting, after the practicum is finished, the students make the report in writing and presentation. 7). Assessment of results, done when the project has been completed in the form of reports and presentations are also a matter of understanding the concept consisting of the design of dye making at each stage.

From the experimental results show that students are able to create dye extract from secang and apply it to viscose fabric along with optimization on the dying process. The use of liquid dye extracts gives better dyeing results when compared with powdered dye extracts. The optimization obtained from dye secang can be adjusted to the desired colour requirement [7]. The model involves students working in teams to solve real problems by using theory in practice. Furthermore, they must also learn to relate what they learn with their future professions [15]; The assessment stage to be one of the important aspects of an experiment is how teachers can confirm the findings and provide feedback to students in the form of reflection activities [20]. Assessment of the report focuses on the depth of the discussion, the linkage between the results and the theory also on the delivery of a coherent final product to the initial problem [15].

The stages of lab activities that have been done by students. Lab activities design was undertaken is a collaboration between the model of scientific inquiry and project based learning. Stages performed as many as 7 stages.

3.2. Conceptual understanding of textile chemistry students

Conceptual understanding that must be owned by textile students is about natural dyes, dyestuff structure, and the process of making it. By using collaborative designs above the students’ conception of natural dyes, the manufacturing process undergoes changes. The change of understanding of student concept of each group is depicted in the figure 1.

![Figure 1](image-url)  
**Figure 1.** Graph of enhancement improvement of students concept of chemistry of textiles.
Figure 1 shows that there is an increase in student conceptual understanding after the application of instructional design. Based on statistical calculations using SPSS 20 with Pearson 2-tailed correlation between daily value and overall mid-term test obtained (r: 0.131), this indicates a weak relationship between daily activities with mid-term test (concept master test). The weakness of the relationship between the value of daily activities and the mastery of concepts may be due to the lack of time at the lab [18]. This is reinforced by the results of student questionnaires which states less time laboratory. The calculation using t-test between daily values and mid-term test indicates a significant value change is indicated by the sig value. 0.00 (daily mean / Mid term test is 68.72 / 76.41).

3.3. Materials of chemical practice of natural color substances

Practical topics include the basic introduction of the dyestuff phyto-chemicals, dyestuff extraction, powder dye preparation, dyeing process, and evaluation of dyeing fabrics using secang. Secang is a plant that produces a red colour like Gambier, and bixarollena, which is commonly used for batik staining. The synthesized red dye from the secang is derived from a chemical compound called brazilein (C_{16}H_{14}O_{5}) [7], while the yellow colour is produced from the brazillin compound. Both of these components are tetracyclic with two aromatic rings, one pyron, and five carbon rings. The yellow color of brazillin turns red to brazilein due to the increase of electron delocalization by the presence of the carbonyl group [7]. In fact, the acidity (pH) has a major effect on the resulting colour, so the dye extract may be red, purple or yellow.

![A. Brazilin](image1.png) ![B. Brazilein](image2.png)

Figure 2. Structure of Brazilin (A) and structure of Brazilein (B).

Silk fabric when compared with more successful cotton colored with secang extract. Secang gives an old and vague shade of colour [6]. This is due to the phenolic compounds in the dye bound to the carboxyl of the protein fibers. Furthermore, the anionic charge in the phenolic group forms an ionic bond with a cation of the substrate protein [6].

Rayon fabric which is a medium in immersion is a fabric made from fiber regeneration of cellulose. The fibers used as rayon yarns come from organic wood pulp polymers, natural, cellulosic-based feedstocks [21]. The semi synthetic fibers naming because they can not be classified as true synthetic fibers or natural fibers. In the textile industry, rayon fabric is known by the name of viscous rayon or artificial silk. These fabrics usually look shiny and not tangled easily. Rayon fiber has a chemical element of carbon, hydrogen, and oxygen. In Indonesia rayon fabric is a raw material for the fabric industry and batik clothes silk fabric when compared with more successful cotton coloured with secang extract. Secang gives an old and vague shade of colour [6]. This is due to the phenolic compounds in the dye bound to the carboxyl of the protein fibers. Furthermore, the anionic charge in the phenolic group forms an ionic bond with a cation of the substrate protein [6].

4. Conclusion

Implementation of experiment dyestuff of secang can improve the conceptual understanding of textile students, covering the concept of making secang dye, extraction, and application. But it still needs a lot of improvements in the implementation of the lab activity, so that the time spent is limited enough to conduct a complete series of research.
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