CHEMICAL ENGINEERING TRANSACTIONS
VOL. 63, 2018
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Jeng Shiun Lim, Wai Shin Ho, Jiří J. Klemeš

ISBN 978-88-95608-61-7; **ISSN** 2283-9216
DOI: 10.3303/CET1863133

The Analysis of Determinant Factors in Selecting Laboratory Equipment in Chemistry Education Experiment

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Learning chemistry is a learning process that simultaneously develops the cognitive, affective, and psychomotor aspects. Developing affective and psychomotor aspects, however, need learning support conducted in the laboratory in terms of practice and or practical work. Learning pattern in the laboratory requires good equipment selection. This study aims to set the determinant factors in laboratory equipment selection in chemistry education. The analysis method used in this study is Analytic Hierarchy Process, in which setting modeling decisions are made by developing the logical relationship between criteria in the form of decision hierarchy, and then calculating the interest value between these factors based on respondent/ expert preferences. The result of this research showed the value of key factors relating to laboratory equipment selection in chemistry education. Here are the importance sequences of these factors in chemistry laboratory equipment selection, namely: safety, improvement of practitioner's understanding, ease of use, the accuracy level of equipment, and cost. This study provides a contribution in setting determination of the criteria/ factors which can be used as the analysis unit in selecting chemistry laboratory equipment. The characteristic of these criteria is more permanent, while the interest factor of each criterion is dynamic in accordance with education level, student's skills, experimental need, and the others.

1. Introduction

Learning natural science particularly chemistry is a learning process that develops cognitive, affective, psychomotor domains simultaneously. Therefore, the lesson plan of chemistry should be able to cover the development of three domains above. To develop the affective, and psychomotor realms do not rely only on learning in the classroom, but it needs to be supported by learning outside the classroom, either in the form of project activity or purposeful activity such as practical and experimental activities; or self-learning supported by multi-media devices. Learning by using devices based on multi-media is believed will improve learning achievement (Irwansyah et al., 2017). It is better for the concept of learning science to employ the inquiry concept, not the concept of memorizing formulas, rules, and postulates. Learning from direct experience is the best learning process (Anwar, 2016). Learning from experience, generally in learning chemistry, is performed in a laboratory. The laboratory is a center of learning science, especially chemistry. The laboratory is the place to see, try, test and assess the scientific concepts learned so that students can gain a better understanding of science. It is not a perfect instruction to learn science only through reading books, and listening to a teacher's explanation, without scientific activities mostly conducted in the laboratory. Through laboratory activity, students can assess the truth of concepts theoretically studied through critical analysis based on intellectual ability (Wiratma and Subagia, 2014). There are some main objectives of learning activity in the laboratory. The principal objectives are developing the concept and explaining the various natural scientific phenomena that occur to students and overcoming students' misconception because they gain a concept based on real experience (Anwar, 2016). A good learning process requires well-prepared planning. Some points that need attention in the lesson plan of laboratory experiment are planning the utilization of equipment and chemistry material that include: the types of experiment to be carried out, an understanding of the equipment and material to be purchased, the electrical power available, the details of equipment and materials to be purchased, the procedure of purchase, and the execution of purchase (Wiratma and Subagia, 2014). The use

Please cite this article as: Ferli Septi Irwansyah, Cepy Slamet, Muhammad Ali Ramdhani, 2018, The analysis of determinant factors in selecting laboratory equipment in chemistry education experiment, Chemical Engineering Transactions, 63, 793-798
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of methodology, equipment, and the material is an important point in the laboratory learning process. There are many considerations to be taken in selecting methodology, equipment, and material, namely: safety, learning effectiveness, use ease, materials availability, equipment accuracy, cost, and others. To facilitate this election, it is necessary to do a careful analysis of the criteria, so that the election result is the best decision. This study aims to provide the weighting of the criteria used in the selection of equipment in chemistry experiment performed in the laboratory.

2. Methodology

The systematics of troubleshooting is adapted to AHP based-need analysis (Saaty, 1988). The analysis systematic employed in this study is a modification of the systematic of AHP model-based research (Ramdhani and Wulan, 2012), that research systematics groove as shown in Figure 1.

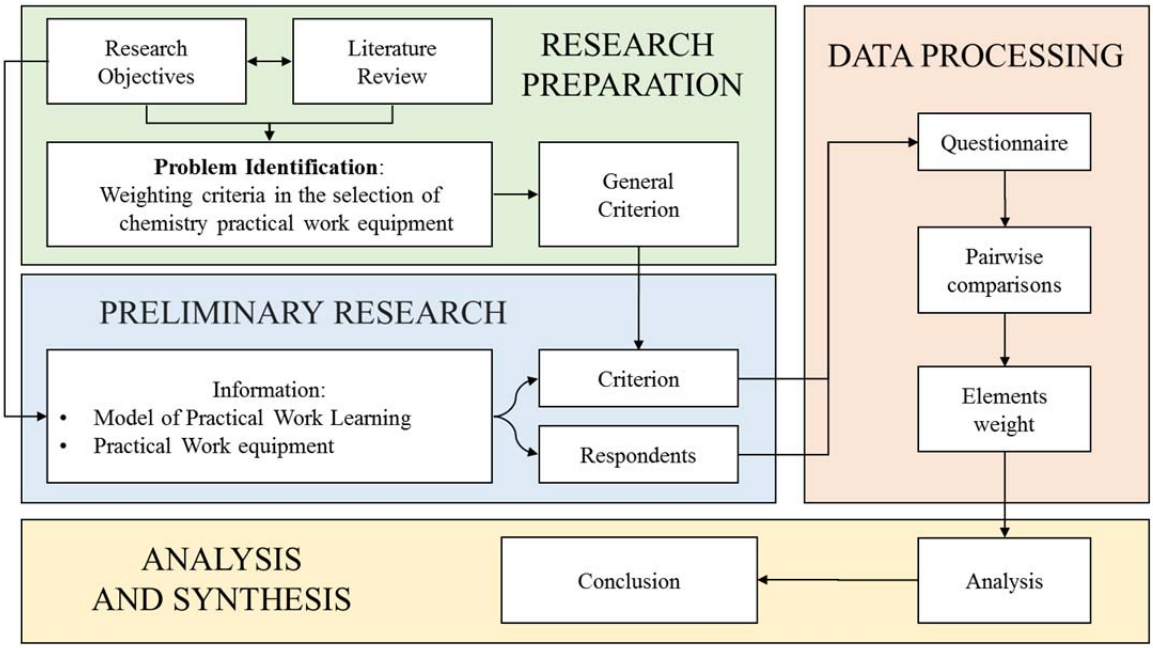

Figure 1: Analysis systematic and study synthesis of weighting criteria used in the selection of chemistry experiment equipment

The problems limitation in this study was weighting criteria used in the selection of chemistry experiment equipment applied in the learning process of chemistry at the university level. The data used in determining the criteria derived from the literature review and weight assessment of the data obtained from Focus Group Discussion specifically held for this study, with 6 respondents from the lecturers of Chemistry Education Department, UIN Sunan Gunung Djati Bandung.

3. Results and discussion

In learning chemistry, laboratory functions to be a supporting site of classroom activity. It is even possible that the main factor functions in learning chemistry are an experiment in the laboratory (Anwar, 2016).

3.1 Decision hierarchy

The approach in designing the hierarchy of AHP analysis in this study employed literature review and FGD process conducted in this study. Here are some factors identified to be the criteria in selecting chemistry laboratory equipment as presented below:

3.1.1 Safety

Work safety is the protection of the individual welfare from an injury related to work (Danial et al., 2017). Chemistry laboratory must be a safe place for its users. It is secure from any possibility of fatal accidents, and health problem. Only in a safe laboratory, someone can work productively and efficiently, and get free from

accident and poisoning. A secure condition in the laboratory can be created if there is a will from each user to maintain and protect himself. It is necessary to grow awareness that accidents can happen to its users, other people and the surrounding environment. It seems to be a moral responsibility that work safety plays an important role in preventing accidents. In addition, the discipline of each individual to obey regulations mostly contributed to work safety. The purpose of laboratory safety is to make the laboratory a safe site for learning science. One of the ways to meet the purpose is broadening the knowledge of science practitioners (lecturer, laboratory assistant, students) about safety, recognizing potential dangers and handling them. Understanding the name and equipment and how to use them is very important. For example, glass equipment must be checked prior to using it, whether it is cracked, broken, or not able to function properly (Hill and Finster, 2016). The use of laboratory glass equipment that does not comply with its right function and use may cause the risk of a work accident. For example: pouring the acid into a buret without using the glass funnel or by climbing the workbench can cause a risk of chemistry splash to the face or hands. A glass equipment that has lost some of its functions and uses, as there is a part of it has missed, cracked or broken it should no longer be used. The un-proper instruments are nor used, such as a damaged balance that causes weighing errors, resulting in errors in manufacturing material or reaction mixture. A damaged Centrifuge should not be used (Lasia et al., 2017).

3.1.2 Effectiveness of learning process

Provides the opportunity to examine and test directly, theory and concept will be more significant in the cognitive structure of students. Experiment provides laboratory experience for students will practice using equipment and chemistry. In addition, experiment can improve the process of psychomotor, cognitive, and affective skills. So far, experiment has not provided an opportunity for students to construct their own knowledge. This will affect the students' competence such as the students' lack of understanding of the concepts and skills. Therefore, it is necessary to employ a laboratory activity that provides the opportunity for students to develop a scientific attitude in acquiring knowledge and be actively involved in it so that the learning objective and process works well. Learning can work well when students are actively involved in it. By using the right equipment, an experiment will make learning more effective and efficient so that the target learning outcomes expected can be fulfilled optimally (Widayanti and Saptorini, 2014).

3.1.3 Ease of use

The ease of using an equipment in chemistry experiment is an aspect directly related to technological development. In general, it can be seen that the more sophisticated an equipment or instrument is, the easier it is to use. In addition, the more sophisticated and easier equipment to use can reduce the students' work time and a number of laboratory materials such as the volume and concentration of substance. For example, in determining the enthalpy of a certain substance neutralization by using a more practical or easier equipment to use, the enthalpy value can be determined directly in a shorter and accurate time (Barlag et al., 2014). The use of the laboratory equipment should be easily adapted for use by the student. Adaptability is an important aspect in the utilization of the laboratory equipment (Ramdhani et al., 2017).

3.1.4 Accuracy of equipment

The accuracy of equipment is the measurement precision level of a using equipment parameter or the smallest value that can be measured accurately by such a device that approaches the true value. A good student will try to get an accurate measurement, and then process it in the right way in order to obtain meaningful data. A measurement system can be accurate and precise, or accurate but not precise, or precise but inaccurate or incorrect and inaccurate. An accuracy indicates the proximity of measurement result to the true value while precision indicates how close the value difference at the time of measurement repetition. At the work time in a laboratory, the precision and accuracy of the examination must be considered well. Precision has defined a suitability of laboratory results obtained when the examination is repeated. Accuracy has interpreted a conformity of laboratory result with the respective value. In an examination, it is generally revealed inaccuracy than accuracy. Inaccuracy means the difference between the value obtained and the true value. The accuracy of examination is mainly influenced by the specificity of the examination method and the quality of the standard solution. In order that the examination has the true value, then it should have an examination method that has a high analytical specificity (Day and Underwood, 1991).

3.1.5 Cost

Cost is the amount of money charged for a product or the amount of value the consumers exchanged for the benefits of having or using the product (Maskur et al., 2017). The cost of an equipment or instrument in a chemistry laboratory generally varies, the cost will be comparable to the technology it uses, including the function and use of the equipment, and some of them require expensive treatment costs. A laboratory will

adjust its material to the equipment that will be used as a budget efficiency to its conformity to the cost of laboratory equipment (Barlag et al., 2014). Based on the explanation above, as adjusted to the main topic of the criteria employed in selecting chemistry experiment equipment, the hierarchical model is developed as shown in Figure 2.

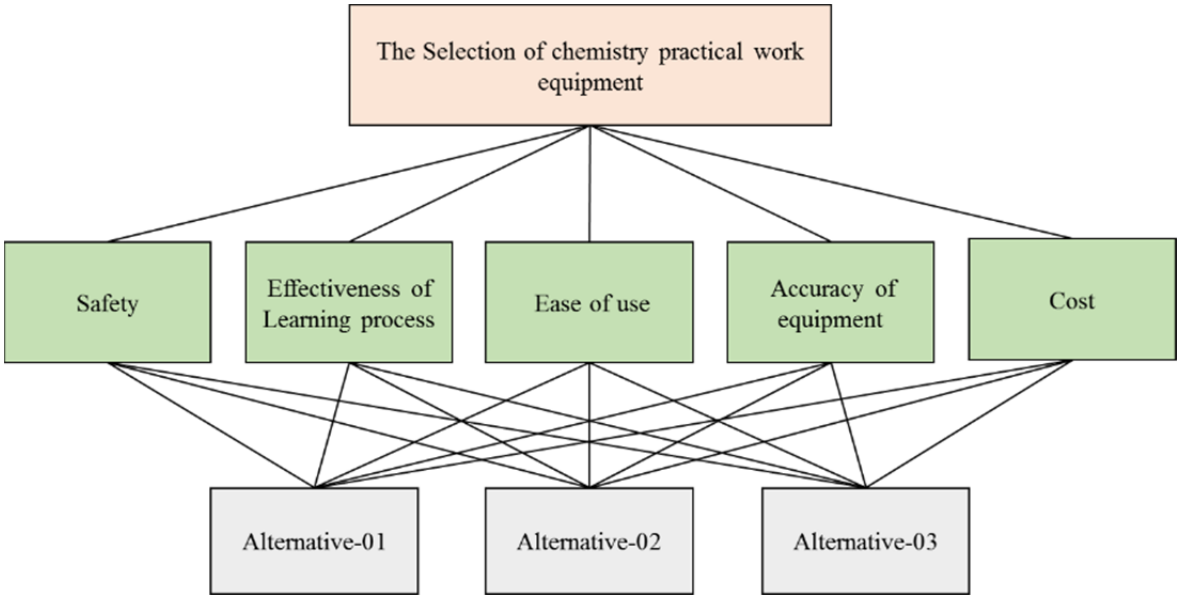

Figure 2: Decision hierarchy

3.2 Analysis and synthesis

Analysis and synthesis are intended to gain criteria weight used in the selection of chemistry experiment equipment. This process is measuring the weight of the relative importance of hierarchy based on AHP model. After fulfilling the requirement of consistency index, the calculation result of the weight of each element is presented in Table 1.

Table 1: The result of weighting criteria used in the selection of chemistry experiment equipment

S/No	Criteria	Weight
1	Safety	0.502
2	Effectiveness of Learning Process	0.236
3	Ease of Use	0.140
4	Accuracy of Equipment	0.072
5	Cost	0.050
	Total Weight	1.000

Based on the result of weighting calculation of each criterion, it can be seen that each of the elements have different weight. This means that the greater the weight value of an element is, the greater the element's influence on the selection of chemistry experiment equipment in the laboratory will be. Considering one of the axioms used in this study that the criteria were fully set out, the total weight fixed was valued 1:00. Furthermore, based on the result of the study, there was performed the synthesis or the discussion of the weight of each following criterion:

3.2.1 Safety

The safety of laboratory work is a criterion with the high weight, i.e. 0.502 in the criteria for selecting chemistry experiment equipment. This is in line with the opinion (Lasia et al., 2017), which states that safety is an important aspect that must be considered in the selection of laboratory equipment. It has been known that experiment or experiment employed using a variety of chemistries, glassware, and the special instrument can lead to an accident if done in an improper way. Accidents can happen because of negligence or carelessness

in work. Accidents happen not only to students but also the people around them. Work safety in the laboratory is a hope for every person aware of the importance of the work health, safety, and comfort (Lasia et al., 2017). The equipment that requires special attention in term of safety is an equipment that needs the other dangerous components such as gas, fire, or electric. Introducing the use direction of this equipment to the students is a primary priority so that they understand the urgency of this safety in the laboratory. Because the safety factor has the highest weight in the selection criteria for experiment equipment, the laboratory will look for another equipment alternative when there is found an equipment whose use is risky to the safety of students and the surrounding environment.

3.2.2 Effectiveness of learning process

The effectiveness of learning process has a weight of 0.236. This indicates that one of the important criteria in selecting the use of laboratory equipment is a strength consideration of the chemistry experiment equipment toward the increase of students' ability to understand the material. The effective utilization of chemistry laboratory will improve the success of chemistry learning activity. Utilizing the laboratory involves the ability to use and select an appropriate equipment to meet the target learning outcomes. Laboratory utilization will work well if supported by good attitude and acceptance of students to the learning pattern of a chemistry laboratory. This is in line with the result of previous study (Rahmiyati, 2008) which stated that the effectiveness of laboratory management including the selection of experiment equipment used accurately showed a good category with a percentage of 33 % and students' support for the learning in laboratory showed very good category with a percentage of 57.39 %, so the use of the laboratory was said to be effective for achieving learning targets with a good category. This is also supported by an observation indicating that the frequency of experiment implementation has shown an achievement of 100 % with the support the selection accuracy of laboratory equipment.

3.2.3 Ease of use

The ease criterion of experiment equipment has a weight of 0.140. this criterion was under the criterion of the effectiveness of the learning process in determining the selection of laboratory equipment. This criterion is closely related to the availability of guidance books of the laboratory instruments usage because when an equipment has a guidebook, it will make students use the equipment better rather than a simple equipment with no instructions for use. Therefore, the perception of the ease of using this equipment will be strongly influenced by the availability of the instructions for use of the equipment.

3.2.4 Accuracy of equipment

The accuracy criterion of the experiment equipment has a weight of 0.072. This showed that the equipment in chemistry experiment not only must be easy to use but also must have a good accuracy. There are two groups of measuring equipment used especially in the field of chemical analysis, namely: quantitative equipment and qualitative equipment. The quantitative equipment consists of the burette, volumetric flask, measurement pipette. As for the qualitative equipment consists of measuring cup, flask, and others. The use of such glass equipment must fit their function so that the job can work properly and appropriately. If an error or mistake happens in its use, it will affect the result obtained (Sakyi et al., 2015). Therefore, not all equipment in chemistry experiment requires a high accuracy as the equipment categorized as qualitative equipment. Their use emphasizes more on the function rather than accuracy. This shows the reason why the criteria of the equipment accuracy are under the criteria of safety and ease of use in selecting the use of chemistry laboratory equipment.

3.2.5 Cost

In selecting laboratory equipment, the cost is a criterion that has the lowest weight, equal to 0.050. This indicates that in the financing efficiency of chemistry practical work, cost criterion of laboratory equipment is considered in selecting the equipment, although its priority level is the last criterion compared with the factors of safety, the effectiveness of learning process, ease of equipment use and equipment accuracy. In the process of laboratory management, procurement procedure begins with the preparation of equipment and materials to be purchased and collected from the proposals of each experiment in coordination with the laboratory assistant. Before the purchase, it is better to determine a company or supplier of laboratory equipment in advance. In addition, the laboratory should have made cooperation with a company of chemistry experiment equipment, so that it will obtain low cost and at many times the laboratory needs equipment it can easily contact the company beyond procurement schedule. Procurement mechanism of such equipment may be one solution to make efficiency in financing the procurement of laboratory equipment (Salirawati, 2009). Another consideration that makes the cost criterion at last rank in the selection of laboratory equipment is the equipment substitution aspect which uses the modified equipment or equipment created by students from

scrap materials or even computer technology. For example, an experiment employing a virtual model of the laboratory, this model is considered as an effort to suppress the cost of the chemistry laboratory equipment (Totiana et al., 2013).

4. Conclusions

The key factors related to the selection of laboratory equipment in chemistry education, respectively, are based on the gradation value of importance, ranging from the most important factors, namely: safety, the effectiveness of learning process, ease of use, the accuracy level of equipment, and cost.

Acknowledgments

Thank you for the support of research fund assistance from PUSLIT UIN Sunan Gunung Djati Bandung and research cooperation with Chemical Education Laboratory UIN Sunan Gunung Djati Bandung

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