CLUSTER ANALYSIS FOR STUDENT GROUPING BASED ON INDEX OF LEARNING STYLES

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Abstract. This research aims to group students of Information and Computer Education, Universitas Sebelas Maret into classes based on the similarity of student's learning style, and to analyze the characteristics of each group. In this research we used Felder and Silverman learning style model (FSLSM) that includes four dimensions, which are (1) learning process; (2) learning perception; (3) information input; and (4) information understanding. We used a quantitative descriptive method combined with cluster analysis technique. The subject of this research were 58 2\textsuperscript{nd} year students of the Department of Computer and Informatics Education Universitas Sebelas Maret. Assessment of learning style characteristics was done by using the Index of Learning Styles (ILS) instrument developed by Felder and Soloman. We applied a hierarchical clustering method to the student’s ILS data for the cluster analysis. This research indicated that two dominant clusters were formed with different characteristics in the dimensions of learning styles. Cluster 1 has a reflective preference in the dimension of learning process with an average of -3.76; a sensing preference in the dimension of learning perception with an average of 4.24; a visual preference in the dimension of information input with an average of 5.21; and a global preference in the dimensions of information understanding with an average of -2.66. Whereas cluster 2 has an active preference in the dimension of learning process with an average of 2.52; a sensing preference in the dimension of learning perception with an average of 1.48; a visual preference in the dimension of information input with an average of 5.08, and a global tendency in the dimensions of understanding information with an average of -0.04. We either found some outliers with different characteristics of learning style outside the two clusters. The results of this research can be used by lecturers to determine the appropriate learning strategy for each class.

1. Introduction
Each individual has different optimizations in receiving information. The way to understand the characteristics of each individual in receiving information is by knowing their learning style. Porter dan Hernacki [1] stated that learning styles are keywords for developing performance in work, at school, and in interpersonal situations. Each individual has a different learning style according to individual characteristics in the learning process. Mulyono [2] explained that learning styles are closely related to each person's personality, which is influenced by their character, experience, education and history.
other words, individual characteristics are strongly influenced by various factors that cause each individual to have different learning styles.

Each individual's learning style can be assessed using a variety of guidelines. One of the guidelines for determining individual learning styles is by the Index of Learning Styles (ILS) score formulated by Felder and Solomon [3]. ILS classifies each individual's learning style into four learning style dimensions that were first created by Felder and Silverman [4]. Those are: 1) sensing (concrete, practical, fact and procedure-oriented thinkers) or intuitive (abstract, innovative, theory and meaning-oriented thinkers; 2) visual (prefers a presented visual representation of the material, such as pictures, diagrams and flowcharts) or verbal (prefers written and spoken explanations); 3) active (learns by trying various things, likes to work in groups) or reflective (learns by thinking about something, prefers to work alone or with a close partner); 4) sequential (linear thinking process, learning in small number of additional steps) or global (holistic thinking process, learning in big leaps).

So far, the division of study groups or student classes in the Department of Informatics and Computer Education is only based on the student numbers, whether even or odd. It isn’t based on the certain characteristics of the students such as learning styles. This causes lecturers couldn’t design and implement appropriate learning strategies optimally. Therefore, in this study we proposed a way to divide study groups based on learning styles using cluster analysis.

Hair, et. al in Fadliana dan Rozi [5] defines cluster analysis as a technique in multivariate statistical analysis that aims to group observational objects into several groups based on their characteristics. By conducting cluster analysis, it can be done to determine groups of student learning styles from one another based on the resulting homogeneity. The cluster analysis technique is carried out with the aim of developing the Informatics and Computer Engineering Study Program class into several classes based on the learning styles of each student.

2. **Felder and Silverman Learning Style.**
In the teaching and learning process, each individual has different learning tendencies. Felder and Silverman [4] develop the learning dimension into four aspects, namely active-reflective, sensing-intuitive, visual-verbal and sequential-global. Each dimension consists of some aspects that categorize individuals, based on their tendency to input, process, and understand an information

Active learning styles tend to retain and understand information very well by doing an active activity such as discussing, applying, and explaining this to others. Reflective learning styles are more likely to think about things silently. Active learners tend to like group learning, on the other hand, reflective learners tend to like learning alone.

Sensing learners tend to like to learn facts, while intuitive learning tends to find possibilities and relationships that occur. Sensing-type learners often solve problems with obvious methods and dislike obstacles and surprises; whereas intuitive learners like innovation and don't like to repeat things. Sensing learners find it easier to understand when presented with an example of a concept and procedure so that they can find out how the concept is applied in everyday life; meanwhile, intuitive type learners try to understand a concept and are often more comfortable than sensing learners in abstract and mathematical formulas. Sensing learners tend to be more practical and more cautious than intuitive learners; Intuitive learners work more quickly and are more innovative than sensing learners. Sensing learners do not like a lesson that has nothing to do with the real world; meanwhile, intuitive learners do not like learning in which there are a lot of mathematical calculations and memorizing.

Visual type learners remember many things they have seen such as pictures, diagrams, flowcharts, timelines, films, and demonstrations. Verbal type learners get more information about written or spoken explanations by others. Sequential type learners gain understanding through linear steps, in which each step is sequential and structured in relation to the previous step. Whereas global type learners tend to learn something in general and understand each material randomly without paying attention to connections or continuous steps.
Felder and Solomon [3] developed an instrument that can be used to measure Felder and Silverman learning style scores called the Index of Learning Styles in 1993. Index of Learning Styles (ILS) is a learning style assessment questionnaire consisting of 44 items to identify learning styles according to Felder and Silverman's (1988) model. Each preference is indicated by a value between +11 and -11. The range of scores was calculated based on 11 questions, each of which was active-reflective, sensing-intuitive, visual-verbal, and sequential-global dimensions.

3. Cluster Analysis
Romesburg [6] defines that cluster analysis is a general term in a mathematical method, numbering hundreds of data, which can be used to determine similar objects. In various kinds of research objectives, researchers include grouping various objects and dividing them into similar and dissimilar objects.

Setyawan [7] explains that in cluster analysis there are two types of analysis, namely hierarchical cluster analysis (Hierarchical Clustering) and non-hierarchical cluster analysis (Non Hierarchical Clustering). Hierarchical clustering analysis is carried out by starting a grouping with two or more objects that have the closest similarity. Then, the process is passed on to another object that has a second closeness. And so on so that the cluster will form a kind of 'tree' in which there is a clear hierarchy (level) between objects, from most similar to least similar. All objects will eventually form a cluster (Santoso, [8]). The hierarchical clustering method has a structure similar to a branched tree. The hierarchical cluster method is a method of grouping that is carried out if the number of groups is unknown.

4. Research Method
This research is a quantitative descriptive research. The sample in this study were 58 second semester students of the Department of Computer and Informatics Education Universitas Sebelas Maret. Sample were selected using purposive sampling technique. Assessment of learning style characteristics was done by using the Index of Learning Styles (ILS) instrument developed by Felder and Soloman. After the ILS questionnaire was given to the students, we applied a hierarchical clustering method to the student’s ILS data. This clustering technique will group the students into some classes based on the similarity of the student's learning style. The final step of this research was analyzing the characteristics of each class that was formed, based on the dimensions of ILS.

5. Result and Discussion
Respondents to the Index of Learning Styles questionnaire consisted of 58 2nd year students of the Department of Informatics and Computer Education, Universitas Sebelas Maret. The overall results of the ILS learning styles questionnaire are shown in Table 1.

|                         | N   | Minimum | Maximum | Mean  | Std. Deviation |
|-------------------------|-----|---------|---------|-------|----------------|
| **Active-Reflective**   | 58  | -9      | 11      | -55   | 4.418          |
| **Sensing-Intuitive**   | 58  | -5      | 11      | 3.31  | 3.724          |
| **Visual-Verbal**       | 58  | -7      | 11      | 4.97  | 4.312          |
| **Sequential-Global**   | 58  | -9      | 11      | -1.21 | 3.741          |

5.1. Clustering Result
By using hierarchical clustering in SPSS software, we get a dendrogram as shown in Figure 2, which shows the ILS learning style index among the students.
Figure 1 Average Linkage Dendrogram of ILS learning style index
Based on Figure 1, we can conclude that there are two big clusters that can be identified as shown in Figure 2 and some objects identified as outliers.

![Figure 2. Determining the cluster](image)

The clustering process is carried out with SPSS software which automatically provides information output in the form of cluster membership which is summarized in Table 2.

| Cluster 1 | 1, 3, 7, 9, 10, 11, 12, 13, 15, 16, 19, 20, 22, 23, 28, 29, 31, 37, 38, 39, 42, 43, 44, 45, 47, 50, 56, 57, 58 |
|-----------|------------------------------------------------------------------------------------------------------------------|
| Cluster 2 | 2, 4, 5, 6, 8, 14, 17, 18, 21, 24, 25, 26, 30, 32, 34, 35, 36, 41, 46, 48, 51, 52, 53, 54, 55 |
| Outlier (cluster 3 & 4) | 27, 49, 33, 40 |

Table 2 *Cluster membership of student’s ID*
5.2. Clustering Analysis

Next, we analyze the characteristics of each cluster. Statistical summary of the dimensions of learning styles in the two largest clusters can be seen in Table 3.

| Cluster | Dimension         | Mean  | Standard deviation | Preference |
|---------|-------------------|-------|--------------------|------------|
| 1       | Active-Reflective | -3.76 | 2.474              | Reflective |
|         | Sensing-Intuitive | 4.24  | 3.642              | Sensing    |
|         | Visual-Verbal     | 5.21  | 3.478              | Visual     |
|         | Sequential-Global | -2.66 | 2.882              | Global     |
| 2       | Active-Reflective | 2.52  | 2.6                | Active     |
|         | Sensing-Intuitive | 1.48  | 3.016              | Sensing    |
|         | Visual-Verbal     | 5.08  | 4.102              | Visual     |
|         | Sequential-Global | -0.04 | 3.47               | (Balance)  |

5.2.1. Analysis of Learning Styles in the Dimension of Learning Process (Active-Reflective) between cluster

In this dimension there is a significant difference between clusters 1 and 2. Students in cluster 1 tend to have a learning style with a fairly strong reflective type, with a score of -3.76. Reflective type learners have a passive tendency in learning. They are more comfortable studying on their own than as a group. Meanwhile, cluster 2 tends to be active, with a score of 2.52. Students in cluster 2 prefer to have discussions or group work and are more active in expressing opinions than studying alone. (Wang, [10]).

5.2.2. Analysis of Learning Styles in the Dimension of Learning Perception (Sensing-Intuitive) between cluster

In the dimension of learning perception, students in clusters 1 and 2 have the same preference which is sensing type. Wang [10] defines that sensing types in learning perception tend to be more patient with details and skilled at remembering facts, and they are able to solve problems using tested methods. Basically, sensing type learners prefer to learn everything that has been applied in the real world. In cluster 1 it can be seen that the tendency of sensing type is higher than in cluster 2, but commonly the two clusters have the same characteristics in learning perception.

5.2.3. Analysis of Learning Styles in the Dimension of Information Input (Visual-verbal) between cluster

In the dimension of information input, both have a visual preference. Students find it easier to capture visual information (pictures) than verbal, words or writing. So that learning that displays graphics, pictures, diagrams become an appropriate learning strategy for them.

5.2.4. Analysis of Learning Styles in the Dimension of Information Understanding (Sequential-Global) between cluster

This dimension is related to how individuals understand information. Sequential type means that individuals learn by linear, step-by-step or sequential methods clearly starting from the earliest stages and continuing sequentially. Meanwhile, global understanding means that the individual understands everything in outline. Usually, individuals have a preference to learn information randomly without sequencing, then sort it after getting enough information. Based on clustering result, it can be concluded that both clusters have global type scores. In cluster 1, it shows that respondents have a higher global
tendency than cluster 2. And cluster 2 shows that respondents with a small global score tend to show a balance in the dimension of understanding information.

6. Conclusion
By using hierarchical clustering, we can group students based on their learning styles into two clusters. The difference between the two clusters formed is that in the learning process dimension, students in cluster 1 tend to have passive type, while students in cluster 2 tend to be active type. However in three other dimensions, both clusters have almost same preferences. Students in both clusters have sensing type in the dimension of learning perception, visual type in the dimension of information input and global type in the dimension of information understanding. Based on this result, we can form two learning classes and implement teaching and learning strategy that are in accordance with student's learning styles.

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