Dimensions of Learning Styles among Engineering Students

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Abstract. Current study is conducted to examine the types of learning styles among engineering students. Felder Silverman learning style model (FSLSM) was used to measure the types of learning styles represent engineering students. FSLSM contains four dimensions that intended to identify learning preferences of students with respect to process information, perceive information, input information and understand information. Each dimension consisted of two sub-dimensions such as in processing dimension learner can be either active learner or reflective learner, this pattern follows in all four dimensions, perceive dimension distinguishes sensing or intuitive learner, input dimension distinguishes visual learners or verbal learners, understand distinguishes sequential or global learners. This study applied survey research method. Index of learning styles (ILS) was used as a tool to collect data. A total of 315 engineering students participated from Universiti Tun Hussein Onn Malaysia. Finding revealed that engineering students are tending to be visual learners.

1. Introduction
Learning style plays an energetic role in engineering education that portrait the techniques in which learners generally obtain, retain and get back information. It helps students to increase their cognitive capacity and to deal with the learning difficulties which successively improves their academic performance [1]. Every student has different learning style preference depends on their likings and disliking. They acquire knowledge best by auditory, listening, observing, and doing [2]. Certain external environmental inputs like seeing, hearing, reflecting and acting helps students in learning. These inputs support students as learning process is a way of reflecting and acting, reasoning logically and intuitively, memorizing and visualizing [3].

Students gain knowledge well in a class when teaching styles matches to their preferred learning styles [4]. Such as, the learning styles are the preferences and characteristics by which individual receive and process information [5]. For instance, a classroom is comprised of dissimilarities in terms of educational background, preferred learning style, cultural influence and cognitive ability from a social perspective.

Furthermore, mismatches between teaching methods with students preferred learning styles may lead them towards poor academic performance [6]. Thus, to understand students learning preferences which accomplish their needs and enhance their academic achievements, it requires to determine the best feasible learning style. In higher education, third and fourth year students are supposed to be matured enough to deal with their ability of understanding assignments and subjects by own [7]. However, majority students who fails examination usually blame their failure to external stimulus such as mismatch teaching methods or lack of academic standards [8].

Teachers are main facilitating and guiding sources in classroom for that reason they must possess the ability to understand that how well students acquire information and what ways [9]. Therefore, it is necessary that educators must adjust their teaching methods according to students learning styles preferences as discrepancies in teaching and learning styles can create difficulties to understand subjects.
and assignments in class. Hence, there is a need to deliver an effective teaching that must be comprised of teaching style and preferred learning style in their teaching activities particularly taking cognitive and intellectual activities into consideration [10].

Moreover, a continuous process of learning styles may lead students’ higher performance [11]. Felder opinions that strong preference of any student for a particular learning style may trouble if teaching style do not match with student learning style [12]. Every student has different mental approach, learning styles, speed of pickup any information, passion, and motivation to learn however teaching methods and academic activities are different. So, the learning styles try to find out individual thinking skills, motivation, and preferred ways of acquiring knowledge to enhance students' performance. Thus, providing educational facilities in a classroom; educators must understand categories of students to enhance the learning abilities so that they can meet expected educational goals [13].

1.1 Defining learning styles
There are numerous definitions of learning styles can be found in literature. For instance, some definitions are mentioned below.
Dunn (1993) defined learning style as the technique in which each learner initiates to concentrate on, process and maintain new information [14].
Felder (1996) describes learning styles are individuals take in information by means of preferences and strengths in their preferred ways of learning [15].
Vermunt (1996) expresses learning style as a logical attention of learning activities that scholars generally employ in their educational orientation and intellectual learning activities [16].
Keefe (1985) defines learning style as the combined characteristic cognitive, affective and physiological behaviors that help as relatively constant signs of how students observe, interrelate with, and react to the educational environment [17].

1.2 Felder-Silverman Learning Style Model (FSLSM)
The Felder-Silverman Learning Styles Model (FSLSM) was developed by Richard Felder and Linda Silverman and was first published in 1988 [18]. The model was originally developed to address learning differences amongst engineering education. The model categorizes students into four dimensions. The first-dimension process information distinguishes learners into active learners and reflective learners. Active learners learn best by applying, trying things out and working with learning materials. Also, they tend to be more interested in communication with others and prefer to learn by working in groups where students can discuss the learned material. While reflective learners like better to think about materials and reflect on the materials. The second dimension of FSLSM model is perceive information that consisted of sensing and intuitive learners. Sensing learners prefer to learn facts and concrete material also they are considered more sensible and realistic.
Moreover, they like to relate the learned material with real world. While intuitive learners like better abstract learning resources for instance theories and their fundamental meanings. Intuitive learners like to discover relationships and possibilities and they have a tendency to be more innovative and creative than sensing learners. The third dimension is input information that differentiates learners into visual learners or verbal learners. Visual learners learn best by pictures, diagrams, flowcharts or by demonstrations while verbal learners learn best through written and spoken materials. The dimension of FSLSM model is understand information that categorized learners in two styles sequential and global learners. Sequential learners learn best by small incremental steps, step by step paths in finding solution and from small parts to whole. Whereas, global learners learn best by using holistic thinking process and learn in large leaps.

In addition, the main focus of Felder’s work is learning style preferences of students. To measure the learning style preferences based on FSLSM model, Index of Learning Styles (ILS) questionnaire was designed by Felder and Solomon [19]. Index of learning style questionnaire is based on Felder Silverman learning style model that consisted of 44 items. ILS items are divided according to FSLSM model dimensions, each dimension contains 11 items with two answers “a” and “b”. Where “a” denotes sub scales active, sensing, visual and sequential respectively and “b” denotes reflective, intuitive, verbal and global respectively. With regard to the psychometric qualities of instrument ILS, various studies illustrated that the ILS deals predictive value and more consistency than other normally used learning
style instruments [11]. The index of learning items was grouped based on semantic similarities as described in FSLSM model. Table 1 shows the ILS items grouped according to semantic similarities [7].

Table 1. Semantic groups of Index of learning style

| Learning Style | Semantic group | ILS questions (answer a) | Learning Style | Semantic group | ILS questions (answer b) |
|----------------|----------------|--------------------------|----------------|----------------|--------------------------|
| Active         | Trying something out | 1a 5a 9a 13a 17a 21a | Reflective     | Think about material | 1b 5b 9b 13b 17b 21a |
|                | Social oriented   | 25a 29a 33a 37a 41a    |                | Impersonal oriented | 2b 25b 29b 33b 37b 41b |
| Sensing        | Existing way      | 2a 6a 10a 14a 18a 22a  | Intuitive      | New ways Abstract material | 2b 6b 10b 14b 18b 22b |
|                | Concrete material | 26a 30a 34a 38a 42a    |                | Not careful with details | 26b 30b 34b 38b 42b |
|                | Careful with details | 1b 5b 9b 13b 17b 21b |                |                   |                           |
| Visual         | Pictures, diagram, graphs, flowchart, demos | 3a 7a 11a 15a 19a 23a 27a 31a 35a 39a 43a | Verbal         | Spoken & Written words | 3b 7b 11b 15b 19b 23b 27b 31b 35b 39b 43b |
|                |                   | 28a 32a 36a 40a 44a |                | Difficulty with visual style | 28b 32b 36b 40b 44b |
| Sequential     | Detail oriented   | 4a 8a 12a 16a 20a 24a  | Global         | Overall picture Relations or connections | 4b 8b 12b 16b 20b 24b 28b 32b 36b 40b 44b |
|                | From parts to the whole | 28a 32a 36a 40a 44a |                |                   |                           |

2. Problem Statement
Knowledge is refined when importance is given on learners learning style preferences as it helps in achieving necessary academic achievements rather also improves students’ cognitive ability. The learning process is a way of communication between students, teachers, and teaching resources. For better outcomes, students learning process should always be given importance [13]. Preferably, teacher’s teaching methods should be matched with learners’ preferred learning style. Mismatches in instruction and preferred learning style of students often leads them towards lower academic grades [20]. For instance, in education learning style is playing a major role, teachers must not neglect students learning preferences in classes to enhance their cognitive and academic performance.

2.1 Objective of study
- To identify the types of learning styles among engineering students.
- To identify the learning style differences among engineering courses.

3. Methodology
Present study adopted quantitative survey research as this method gives better accuracy and consistency of research findings [21]. Survey method delivers possible information regarding the population and data collection from respondents about their educational, financial, and social backgrounds [22]. The purpose of this research is to explore the types of learning styles of engineering students represent. There were 315 final year engineering students participated from three undergrad courses mechanical, electrical and civil at Universiti Tun Hussein Onn Malaysia. Random sampling method was applied in this study. The index of learning style questionnaire was distributed among participants for data collection. This study aimed to determine types of learning style represent engineering students and learning style differences among the courses. For the first objective, calculation method was adopted from Felder and Spurlin. And for second objective ANOVA (Analysis of variance) was applied to analyze the differences among the courses.

4. Results
- To identify the types of learning styles among engineering students
Index of learning styles by Felder and Solomon was used to categorize students based on their preferences. The following is the scoring method of index of learning style questionnaire was described by Felder and Spurlin [23]. Students learning style scores were calculated by allocating a value of one to each of the 11 questions in the four learning style dimensions. The smaller number was then subtracted from the larger one and the letter from the larger number was taken over, leading to a value between 1 and 11 as well as a letter for the learning style dimension. For example, if under Active/Reflective, the learner had 2 “a” and 9 “b” responses, the dominant learning style is 7b (9b-2a=7b). That means the learner is a reflective learner. For each dimension, if learner’s score on a scale
is 1-3, student has a mild preference for the one or other dimension. If the learner’s score on a scale is 5-7, learner has a moderate preference for one dimension of the scale and will learn more easily in a teaching environment which favors that dimension. If the score on a scale is 9-11 then student has a strong preference for one dimension of the scale and may have difficulty learning in an environment which does not support that preference. The learning style scores were transferred to an Excel spreadsheet to analyze the data.

Figure 1 reveals that respondents had a preference for the Active and reflective learning styles with mild, moderate and strong preferences, the 114 students are mild active with percentage of 36.19%, 91 students with percentage of 28.88% have moderate preference on active learning style and 16 learners with 5.07% percentage have strong preference on Active learning style. While on reflective dimension, 70 students with percentage of 22.22% are mild-reflective, 23 students with 7.30% percentage are categorized as moderate preference and only one student have strong preference on reflective dimension with percentage of 0.31%.

**Figure 1. Distribution of Active-Reflective Learning Styles**

Figure 2 shows the distribution of sensing and intuitive learning styles with mild, moderate and strong preferences. 116 (36.82%) students have mild preference on sensing dimension, 56 (17.77%) students are moderate on sensing information and 19 learners with percentage of 6.03% have strong preference on sensing dimension. While on Intuitive dimension, 89 (28.25%) students are mild-intuitive preference, 31 (9.84%) have moderately intuitive preference and 4 students with percentage of 1.26 have strong intuitive preference.

**Figure 2. Distribution of Sensing-Intuitive Learning Style Scores**

Figure 3 categorized visual learners and verbal learners with mild, moderate and strong preferences. 76 students with percentage of 24.12% have mild-visual preference, 113 (35.87%) students are moderately visual preference and 107 (33.96%) have strong visual preference. While on verbal dimension, 15 (4.76%) students are mild verbal learners, 4 students with percentage of 1.26%
moderately verbal learners and 0 student means no any students have strong preference on verbal dimension.

![Distribution of Learning preferences](image)

**Figure 3. Distribution of Visual-Verbal Learning Style Scores**

Figure 4 categorizes the sequential and global learning style preferences with mild, moderate and strong preferences. On this dimension 125 (39.68%) students have mild-Sequential preference, 57 (18.09%) students have moderate sequential preference and 14 students with percentage of 4.44% have strong preference on sequential dimension. While on global learning style there are 79 (25.07%) students are mild, 32 (10.15%) have moderate level preference and 8 students with 2.53% have strong level preference.

![Distribution of Learning preferences](image)

**Figure 4. Distribution of Sequential-Global Learning Style Scores**

- **To identify the learning style differences among engineering courses**

  The one way ANOVA (Analysis of Variance) was used to determine if any difference exists or not among the learning styles between electrical, mechanical and civil degree students. There is no any difference found between engineering courses mechanical, electrical and civil as the “p” value is greater than 0.05 that is 0.357. For the assumption statistically significant difference the “p” value must be less than 0.05. This shows that all three engineering students from mechanical, electrical and civil courses share similar learning style preferences. Furthermore the preferred learning styles of all engineering students was found visual learning style. The results of ANOVA analysis is shown below in Table 2.

**Table 2. Differences between learning styles among courses**

|                  | Sum of Squares | df  | Mean Square | F      | P (Sig.) |
|------------------|----------------|-----|-------------|--------|----------|
| Between Groups   | .969           | 2   | .484        | 1.033  | .357     |
| Within Groups    | 146.279        | 312 | .469        |        |          |
| Total            | 147.248        | 314 |             |        |          |
5. Discussion and Conclusion

Knowing the learners preferred learning styles may support to increase the quality of learning and teaching. As Sabine Graf mentioned that identifying preferred learning style of learners is road to improve learning and teaching in classroom [20]. The findings of this study are supported by many previous researches. Constant has conducted a study at Iowa State in educational field where respondents preferred learning style was visual preference with percentage of 85% [24]. Likewise, Sabine Graf has conducted a study on students of Engineering and Information Management from Massey University, New Zealand and the University of Vienna, Austria that resulted with 87% visual learning preference [20]. Furthermore, Tee in 2015 has found majority of students preferred visual learning with percentage of 90% in Business Management and Hospitality programs at Vocational college of Malaysia [25]. Most of learners in different social science, natural science, and engineering have visual preference, however, in every course the information presented is verbal, such as written texts on the board, spoken words in classroom lectures [23]. In this study majority of engineering students have strong preferred learning style found to be visual learning.

Besides, engineering courses mostly based on designs diagrams but some subjects are based on theories. Educators need to reform their teaching style based on students’ preferences so that better academic performance can be obtained. As in this study engineering students showed their strong preference on visual learning. This implies that institutes should focus more on visual learning environment so that learners can easily enhance their academic achievement. This shows a serious concern that mismatching teaching and learning can cause problem to students’ academic performance. Additionally, learning styles and teaching styles are closely connected to each other. Several studies found that when educators teach courses according to students preferred learning styles, students perform well, and they improve their academic achievements. Through this match between learning styles and teaching styles will give a good impact on learners’ academic achievements.

The findings of second objective of this study revealed that there is a no any difference exist between the engineering courses. This implies that engineering courses are different by nature but students’ preferences for learning is identical. Therefore, teaching methods should be made flexible so that better outputs can be gained. It argues that curriculum and teaching methods should be made according to courses. Based on study findings, the researcher suggests that lectures, teaching materials should practice more visual graphical tools such as demonstration, presentation using software PowerPoint etc. in classroom teachings. That will suit according to visual learning style preferences. Moreover, educators should also generate a mix teaching atmosphere to support active learning between the learners. Activities doings like discussion, cooperative learning, demonstration, brainstorming, problem based learning and project based learning are strongly suggested. By nature, mostly engineering subjects are involved in procedures. Due to this reason educators should deliver instructions systematically like from easy steps to difficult steps.

Finally, educators can start a lecture by highlighting on details then follow by hands on doings to support the learner’s view on new information. At the time, delivering examples will assist the learners to relate class work with real work condition outside the tutorial room.

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7. References

[1] Mohamad, M. M. B., Mei Heong, Y., & Tze Kiong, T. (2014). Conceptions of learning through learning styles and cognitive dimension in vocational education. *Journal of Technical Education and Training, 6*(1).

[2] Graf, S., & Kinshuk. (2008). *Learner modelling through analyzing cognitive skills and learning styles*. Handbook on Information Technologies for Education and Training, 179–194.

[3] Yee, M. H., Yunos, J. M., Othman, W., Hassan, R., Tee, T. K., & Mohamad, M. M. (2015). Disparity of Learning Styles and Higher Order Thinking Skills among Technical Students. *Procedia - Social and Behavioral Sciences, 204*(November), 143–152.
[4] Mohamad, M. M., Sulaiman, N. L., Sern, L. C., & Salleh, K. M. (2015). Global Journal of Business and Social Science Review the Composite of Students’ Characteristic and Cognitive Dimension in Vocational Education, 1(March), 164–175.

[5] Letele, M. J., G. Alexander, & Swanepoel, Z. I. (2013). Matching/Mismatching of Teaching and Learning Styles in Rural Learning Exologies of Lesotho: Does it Enhance Academic Achievement. Journal of Human Ecology, 41(3), 263–273.

[6] Graf, S., Viola, S. R., & Leo, T. (2007). In-Depth Analysis of the Felder-Silverman Learning Style Dimensions. Journal of Research on Technology in Education, 40(1), 79–93.

[7] Romanelli, F., Bird, E., & Ryan, M. (2009). Learning styles: A Review of theory, application, and best practices. American Journal of Pharmaceutical Education, 73(1).

[8] Mohamad, M. M., Yusof, Y., Muhammad Hanafi, N., Yee, M. H., & Tee, T. K. (2013). Connecting learning styles and cognitive dimension in building construction education. In Proceeding of the International Conference on Social Science Research, ICSSR (e-ISBN 978-967-11768-1-8). 4-5 June 2013, Penang, Malaysia.

[9] Koh, Y. Y., & Chua, Y. L. (2012). The Study of Learning Styles among Mechanical Engineering Students from Different Institutions in Malaysia. Procedia - Social and Behavioral Sciences, pp.636–642.

[10] Alias, N. A., and Zainuddin, A. M. (2005). Innovation for Better Teaching and Learning: Adopting the Learning Management System. Malaysian Online Journal of Instructional Technology, 2 (2), 27-40.

[11] Felder, R. M., Brent, R., & Prince, M. J. (2011). Engineering instructional development: Programs, best practices, and recommendations. Journal of Engineering Education, 100(1), 89–122.

[12] Felder, R. M., and Soloman, B. A. (1997). Index of Learning Styles Questionnaire. Retrieved 1st July 2016, from http://www.engr.ncsu.edu/learningstyles/ilsweb.html.

[13] Eishani, K. A., Saa’d, E. A., & Nami, Y. (2014). The Relationship between Learning Styles and Creativity. Procedia-Social and Behavioral Sciences, 114, 52-55.

[14] Dunn, R. (1993). Learning Styles of the Multiculturally Diverse. Emergency Librarian, 20(4), 24-32.

[15] Felder, R. M. (1996). Matters of style. ASEE Prism, 6(4), 18-23. Retrieved from: www4.ncsu.edu/unity/lockers/users/f/felder/public/PapersILS-Prism.htm.

[16] Vermunt, J. D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: A phenomenographic analysis. Higher education, 31(1), 25-50.

[17] Keeffe, J. W. (1985). Assessment of learning style variables: The NASSP task force model. Theory into practice, 24(2), 138-144.

[18] Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. Engineering Education, 78(7), 674–681.

[19] Felder, R. M., and Soloman, B. A. (1997). Index of Learning Styles Questionnaire. Retrieved from http://www.engr.ncsu.edu/learningstyles/ilsweb.html.

[20] Graf, S., Liu, T. C., Chen, N. S., & Yang, S. J. (2009). Learning styles and cognitive traits–Their relationship and its benefits in web-based educational systems. Computers in Human Behavior, 25(6), 1280-1289.

[21] Creswell, J. W. (2008). Educational research, planning, conducting, and evaluating quantitative and qualitative research (3rd Ed.). Upper Saddle River, NJ: Pearson Education.

[22] Krosnick, J. a. (2010). Survey Research. Research Design and Data Collection, 159–185.

[23] Felder, R. M., & Spurlin, J. (2005). A validation study of the Index of Learning Styles. International Journal of Engineering Education, 21(1), 103–112.

[24] Constant, K. P. (1997). Using Multimedia Techniques to Address Diverse Learning Styles in Materials Education, Journal of Materials Education, 19.

[25] Tee, T. K., Yunus, J. M., Kuppusamy, B., Yee, M. H., Mohamad, M. M., Othman, W., & Hanapi, Z. (2015). The Pattern of Learning Styles among Second Year Students in Business Management and Hospitality Programs at One of the vocational college in Northern Zone. Procedia-Social and Behavioral Sciences, 204, 62-72.