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A STUDY OF LEARNING STYLES OF ENGINEERING STUDENTS IN VOCATIONAL EDUCATION IN HONG KONG

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Abstract

Students have different learning preferences of receiving, processing and internalizing knowledge and skills. If the learning environment is advantageous to the learning styles of the students, there is a higher chance that the students can achieve the intended learning outcomes. Previous research on understanding the learning styles of students suggests that the use of learning style models helped teachers design effective instruction and could help students better understand their own learning preferences. Felder and Silverman (1988) proposed a learning style model, which was designed to capture the important learning style differences among engineering students. The model categorised learning preferences into four dimensions, namely, active/reflective, sensing/intuitive, visual/verbal, and sequential/global (Felder and Spurlin, 2005). After identifying the learning styles of the students, corresponding teaching strategies can then be developed for more effective learning.

This research was an preliminary investigation of learning styles of engineering students studying vocationally oriented higher diploma programmes in Hong Kong. Data from over 140 students in two engineering programmes was collected and analysed to identify the learning characteristics of students. It was found that the sample students were marginally reflective, predominately sensing, visual, and sequential learners. Observations from the analysed data provided valuable information for teachers to design more effective teaching strategies.

Keywords: *Learning styles, learning characteristics, index of learning styles, engineering education, vocational education, Hong Kong.*

Introduction

Vocational education is a strategic development in the education system of Hong Kong. In the 2014 Policy Address, the Chief Executive of Hong Kong Special Administrative Region highlighted the importance of vocational education and announced a series of initiatives to promote vocational education and recognition of its value. It is advocated that vocational education plays an indispensable role in offering multiple pathways to young people with diverse abilities and aspirations to excel in their career. Vocational education is also crucial in nurturing the necessary manpower to support the sustainable development of the city.

While vocational education advocates a unique approach of enabling students with the expertise, skills and professional attitude to tackle real-world situations, the success of vocational education depends on how well the students fulfil the intended learning outcomes. Students have diverse ways of receiving, processing and internalizing the knowledge acquired in their studies. The higher level of awareness teachers have about the differences in their students, the better chance they have of meeting the diverse learning needs of all of their students, and, as a result, the higher likelihood the students have of achieving the intended learning outcomes.

Understanding the learning characteristics of students has been a continual focus in education research worldwide. Coffield et al. (2004) appealed to the idea that teachers and course designers should pay closer attention to students' learning styles: by diagnosing them, by encouraging students to reflect on them and by designing teaching and learning interventions around them. A systematic review of 13 major models of learning styles was done by Coffield et al. (2004).

In the context of engineering education, Felder and Silverman (1988) proposed a learning style model designed to capture the important learning style differences among engineering students. The model was later revised by Felder and Spurlin (2005), which categorised students' learning preferences into four dimensions, namely, processing (active/reflective learners), perception (sensing/intuitive learners), input (visual/verbal learners) and understanding (sequential/global learners). The index of Learning Styles (ILS) is an instrument designed to assess preferences on the four dimensions of the Felder-Silverman learning style model. The web-based version of ILS, developed by Soloman and Felder (1997), was taken hundreds of thousands of times per year.

The ILS was widely used in a quite number of published studies (Felder and Spurlin, 2005). Constant (1997) administrated ILS to Materials Engineering students in Iowa State University and suggested the use of multimedia techniques to address diverse learning styles of the students. Paterson (1999) explored the use of different internet-based learning tools to suit the diverse learning styles in the class of environmental engineering students. Dee et al. (2002) investigated the learning styles of biomedical engineering students at Tulane University. Compared to other engineering student populations, their sampled students contained the highest percentage of students preferring the global learning style. Zywno (2003) identified a mismatch between learning styles of the majority of the sampled students and the reported prevalent traditional teaching. The study suggested that students whose learning needs were not consistently supported by traditional instruction underachieved in such an environment. Improved academic achievement in the study was linked to an increased accommodation of student learning styles.

The research on learning styles was still active in the past decade. Alumran (2008) used ILS to study the relationships between learning styles in relation to gender, field of study, and academic achievement for students in University of Bahrain. Do et al. (2008) attempted to create a new perspective on assessing the effects of learning English in Hong Kong, which is a predominately Chinese-speaking country. The learning styles of multi-disciplinary students who studied the same English module were investigated. Kolmos and Holgaard (2008) used the Felder-Silverman ILS and found that the first year engineering students at Aalborg University were predominately active learners. The finding leaded to a discussion of whether reflection and conceptualization should be facilitated further in the curriculum to balance the learning style of the students. Direito et al. (2012) investigated engineering undergraduates' perceptions of soft skills by looking into the relations of self-efficacy and learning styles. Mohamad et al. (2014) studied the disparity of learning styles and cognitive abilities in vocational education. The ILS was given to building construction students from three Vocational Schools in Malaysia. Tee et al. (2015) explored the pattern of learning styles of Business students in a vocational college in Northern Malaysia.

After identifying the learning characteristics of the students, corresponding teaching strategies can then be developed for more effective learning. Studies have shown that better learning may occur when teaching styles of teachers match learning styles of students than when they are mismatched (Felder and Silverman, 1988 and Hayes and Allinson, 1996).

Methodology

Investigation of learning styles of engineering students in this study was conducted based on Index of Learning Styles (ILS) developed by Soloman and Felder (1997). The learning style dimensions and the notions

for the sub-scales in ILS are summarised in Table 1. The processing dimension measures the preference of how the student processes information, either actively through engagement of physical activity or discussion, or reflectively through introspection. The perception dimension measures what type of information the student preferentially perceives, either through external sensory, such as sights, sounds, and physical sensations, or internal intuitions, such as possibilities, insights and hunches. Input dimension concerns about the most effective sensory channel of the student to perceive external information, either through visual means such as pictures, diagrams, graphs and demonstrations, or through verbal means, such as words and sounds. The understanding dimension measures how the student progress toward understanding, either in a sequential manner in continual steps or in a global and holistic manner by large jumps. Detailed descriptions of the characteristics of these learning styles are given in Felder and Silverman (1988) and Felder (1993).

The ILS is a structured questionnaire of 44 questions. Each of the four dimensions in Table 1 is measured by 11 questions. Each question has two options, which represents a tendency toward either sub-scales in a dimension. For each dimension, the frequency of the two chosen sub-scales in the 11 questions are first counted. The sub-scale with the higher frequency is selected as the dominant scale for the dimension.

The score for each dimension is then calculated to represent the tendency of the student's learning on a dimension. The score is the net difference between the higher frequency of the sub-scale and the lower frequency of the other sub-scale. As a result, the score for a dimension is odd numbers ranged from 1 to 11. The score therefore represents the degree of preference of the student has for the dimension. If the score on a dimension is 9 or 11, the student has a very strong preference for the dimension. The student can learn very quickly in a teaching environment which favours the dimension. On the contrary, the student may have real difficulty in learning when the teaching environment is unfavourable to the dimension. If the score is 5 or 7, the student has a moderate preference for the dimension and will learn more easily in a favourable teaching environment. If the score is 1 or 3, the student is a fairly balanced on the learning dimension.

Table 1 Learning Style Dimensions

Dimension	Sub-scale	Notation
Processing	Active	ACT
	Reflective	REF
Perception	Sense	SEN
	Intuitive	INT
Input	Visual	VIS
	Verbal	VRB
Understanding	Sequential	SEQ
	Global	GLO

The questionnaire was developed for the engineering students in the Department of Construction in Tuen Mun campus of Institute of Vocational Education (IVE). IVE is one of the 13 member institutions of Vocational

Training Council, which was established in 1982 and now is the largest vocational education provider in Hong Kong. The department offers three full-time Higher Diploma programmes, namely, Higher Diploma in Civil Engineering (CE), Higher Diploma in Building Studies (BS) and Higher Diploma in Architectural Studies. This study focused on the first two programmes, which are more related to engineering. Both of the full-time programmes are delivered on a two-year duration.

The questionnaire was bilingual. Chinese translations of the original English questions were provided, so that the students could easily understand the questions and make appropriate selection of the options.

The questionnaire was disseminated to the students through a web link of a cloud internet platform. Students could access the questionnaire conveniently through mobile phones or any online computers. Their answers to the questionnaire were collected through their online devices and stored on the cloud storage. Whenever a student submits the questionnaire, the researcher will receive an email notification instantaneously. At the same time, the learning style index scores will then be calculated automatically by the script program in the cloud system and the scores will be sent to the student's email directly.

A total of 141 students completed the online questionnaire. Both first and second years of CE and BS students were invited to take part in the research. The students were given a short overview about the research, they could voluntarily participate in the research. The majority of the responses was from first year students, because some of the second year students were having industrial attachment during the research period. The numbers of completed questionnaires from CE students and from BS students were 75 and 66 respectively.

After all the participants had completed the questionnaire, the researcher provided a debriefing to the participants about different characteristics of learning styles. The students generally expressed that the learning style questionnaire was useful in helping them to be aware of their own learning characteristics.

Results and Discussion

The results of learning styles preferences of IVE students are given in Table 2, along with the reported Felder-Silverman learning styles preferences of various universities and vocational institutes. The samples were all engineering students, except sampled populations 7 and 9. In this study, of the total 141 sample completed the ILS, 48.2% were classified as active learners (and by implication 51.8% were reflective learners). 78.7% were sensing learners (so 21.3% were intuitive learners). 73.0% were visual learners and 68.8% were sequential learners.

With the given breakdown of the results of the two programmes in Table 2, the learning styles preferences of the CE students and the BS students could be compared. It was found that the students of the two programmes were relatively consistent in all the dimensions, except the first ACT/REF dimension. The net differences between the percentages of the two programmes in the SEN/INT, VIS/VRB and SEQ/GLO dimensions were 5.8%, 0.6% and 4.5% respectively. Nevertheless, substantial difference was noted in the ACT/REF dimension for the two programmes. 57.3% of CE students were reflective learners, whereas 54.5% of BS students were active learners.

Considering the preferences of the ACT/REF dimension in all sampled populations in Table 2, it was observed that only IVE and Hong Kong University of Science and Technology (HKUST) had the majority of sampled students as reflective learners. The percentage of reflective learners in IVE students was 51.8%, whereas the percentage in HKUST was 54%. Since the two sampled populations were both in Hong Kong with predominantly Chinese students, whereas other sampled populations were non-Chinese students. As previous research indicated (Biggs, 1991), Chinese students may have different learning styles, when compared to students in western countries.

With regard to the SEN/INT dimension, all the sampled populations in Table 2 had the majority of sensing learners. The IVE students had the highest percentage of sensing learners of 78.8%, which was about 12% higher than the second highest percentage reported in sampled populations 2 and 8.

Table 2 Comparison of Learning Styles Preferences

Sampled Population	ACT	SEN	VIS	SEQ	Size	Reference
1. Institute of Vocational Education (IVE) Results of the two engineering programmes	48.2%	78.7%	73.0%	68.8%	141	This study
Civil Engineering (CE) students	42.7%	76.0%	73.3%	66.7%	75	
Building Studies (BS) students	54.5%	81.8%	72.7%	71.2%	66	
2. Iowa State University, Materials Engr.	63%	67%	85%	58%	129	Constant (1997)
3. Michigan Tech. University, Env. Engr.	56%	63%	74%	53%	83	Paterson (1999)
4. Ryerson University, Elec. Engr. 2002 cohort	63%	63%	89%	58%	132	Zywno (2003)
5. Tulane University, Biomedical Engr.	66%	55%	88%	41%	128	Dee et al. (2002)
6. Aalborg University, Engr. students	73%	65%	87%	44%	493	Kolmos & Holgaard (2008)
7. Hong Kong University of Science and Technology, multi-disciplinary students	44%	57%	94%	50%	166	Do et al. (2008)
8. Three Vocational Schools in Malaysia	77%	67%	84%	56%	128	Mohamad et al. (2014)
9. Vocational College in Northern Malaysia	72%	55%	90%	72%	60	Tee et al. (2015)

In the VIS/VRB dimension, all the sampled populations had the majority of visual learners. It was found that the IVE students had the lowest percentage of visual learners of 73%, while the highest percentage of visual learners of 94% was reported in HKUST.

In the last SEQ/GLO dimension, 6 of the 9 sampled populations had the majority of sequential learners. It was observed the two vocational institutes, namely, IVE and the Malaysia's Vocational Collage, had the highest percentage of sequential learners of around 70%.

To further understand the distribution of the learning styles preferences of the CE and BS students, histograms of the two programmes in the four dimensions were given in Figures 1a, 1b to 4a and 4b respectively. The horizontal axis was the ILS score from the maximum score of the left sub-scale, i.e. 11, to the maximum scale of the opposite right sub-scale. The vertical axis was the frequency of the samples. By assignment of negative score to the left sub-scale, the mean (μ), standard derivation (σ), and skewness of the distribution were also given in the figures. The skewness measures the asymmetry of the frequency distribution and has a value of zero if the distribution is normal.

The distribution of active and reflective learners in the two programmes were compared in Figures 1a and 1b. The mean value of the CE distribution was 0.71 (balanced reflective), whereas that of the BS distribution was -0.88 (balanced active). Although the mean values were of opposite sides, the values were still close to zero, which suggested a fairly balanced preferences in the processing direction. The standard derivation of the two distributions was around 4.5. The skewness values of the two distributions were in opposite signs. The skewness of the BS distribution in Figure 1b had the minimum value of 0.05 among all calculated skewness values, suggesting the distribution was close to a normal distribution.

In the second SEN/INT dimension given in Figures 2a and 2b, the mean values of the two distributions were very consistent with a value of -3.8 (moderate sensing). It was observed that the standard derivation of the two distributions was the highest among all the four dimensions. In addition, the both distributions were asymmetrically skewed to the right, both with the highest skewness values of 0.6 among all the distributions in the four dimensions. The peak of the distributions coincided at SEN9. After all, a very strong preference to sensing sub-scale was observed in the perception dimension in both student groups.

In the third VIS/VRB dimension shown in Figures 3a and 3b, the mean value of the CE distribution was -2.63, whereas that of the BS distribution was -3.35, it was evident that both groups were visual-learner dominant. The standard derivation of the two distributions was around 4.5. Both distributions were asymmetrically skewed to the right, with a skewness value of around 0.3. As shown in Fig 3a, the peak of the CE distribution was VIS3. In Fig 3b, the BS distribution had two peaks at VIS5 and VRB1.

In the last SEQ/GLO dimension given in Figures 4a and 4b, while both distribution was dominant by sequential learners. The mean value of the CE distribution was -1.77, whereas that of the BS distribution was -2.45, it was evident that both groups were sequential-learner dominant. The standard derivation of the two distributions was around 4. Again, both distributions were asymmetrically skewed to the right, with a skewness value of around 0.3.

Given the close relationship between learning styles and teaching styles, it is favourable to minimise the mismatch between the learning styles and the teaching styles. In the processing dimension, the active and reflective learners were fairly evenly distributed. Active learners learn best through active experimentation, which involved discussing, explaining, or using information in the external world. On the other hand, reflective learners learn by reflective observations, which involved examining and manipulating the information introspectively. Active learners work well in groups; reflective learners work better by themselves or with at most one other person. When designing class activities for the IVE students, alternate activities for active and reflective learners should be arranged. Examples of activities for active leaners are group discussions, problem-solving activities, brief presentations, experiments, hands-on practices. Potential learning activities for reflective learners are lectures with occasional pauses for thought, exercises for fundamental understanding and pair discussions.

Nearly 80% of the IVE students were sensing learners, who like facts and data and solving problems by standard routine methods but dislike theories and abstract concepts. Sensing learners are slower in understanding symbols and words than intuitive learners (Felder and Silverman 1988). Vocational education and training is particularly suitable for sensing learners, where the theoretical knowledge and practical application is blended throughout the curriculum. Theories and concepts are often illustrated with practical examples and demonstrations.

73% of the IVE students were visual learners, who remember best what they see, therefore any graphic inputs, such as pictures, diagrams, flow charts, animations, and demonstrations, favour learning of the visual learners (Felder and Silverman 1988). It is recommended that more graphical materials should be provided in teaching and learning activities. Advanced computer techniques such as Building Information Modelling with 3D model visualization and augmented/virtual reality technology could be applied in teaching engineering skills and knowledge.

Around 70% of the IVE students were sequential learners, who learn best when material is presented in a steady progression of complexity and difficulty. Sequential learners follow linear reasoning processes when solving problems (Felder and Silverman 1988). In this regards, while the curricula, module syllabi, and learning materials of IVE were designed to be sequential, teachers could pay closer attention to the learning progress of the students. Regular formative assessments may be done to check on the students' mastery of subject knowledge and skills.
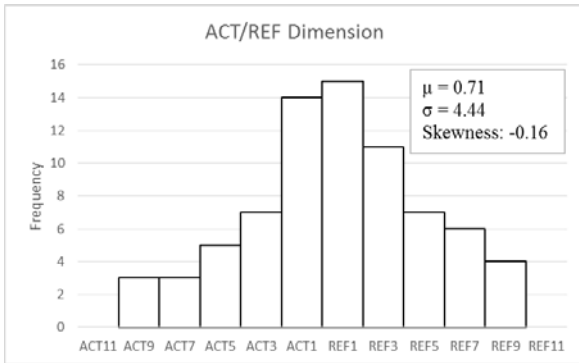
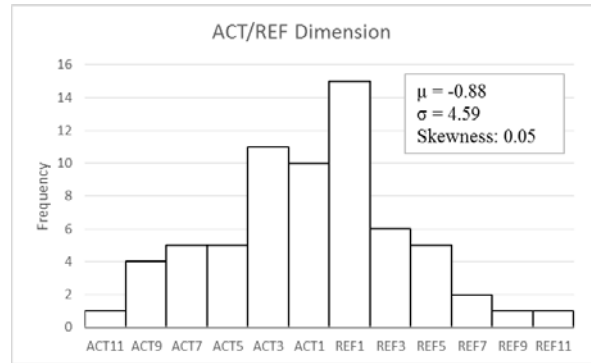Figure 1a ACT/REF Dimension for the CE Students

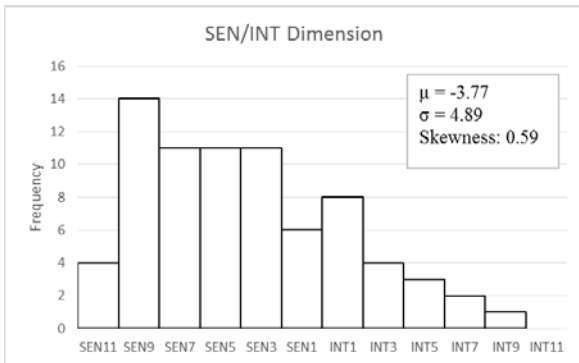Figure 1b ACT/REF Dimension for the BS Students

Figure 2a SEN/INT Dimension for the CE Students
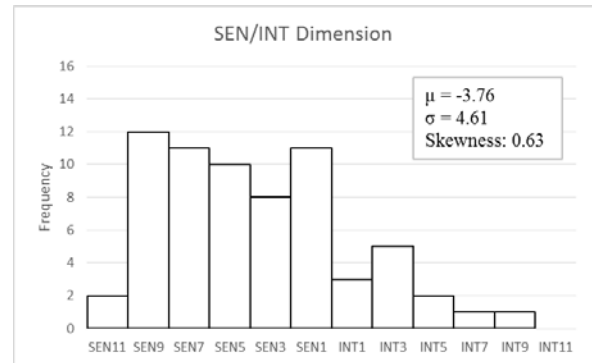

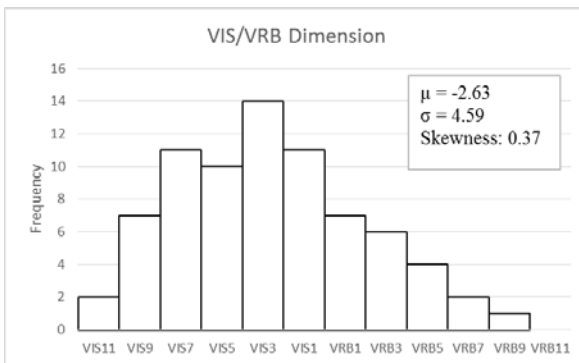Figure 2b SEN/INT Dimension for the BS students

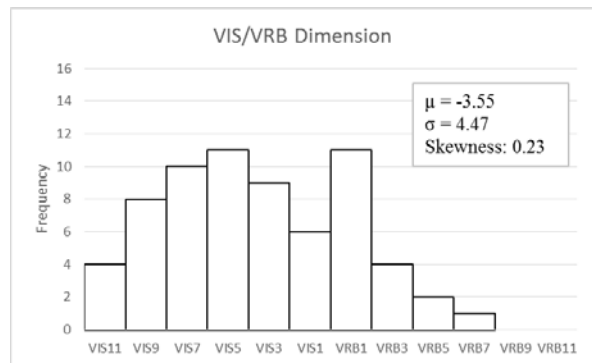Figure 3a VIS/VRB Dimension for the CE Students

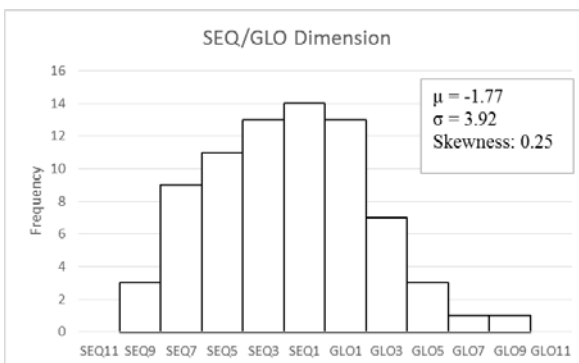Figure 3b VIS/VRB Dimension for the BS Students

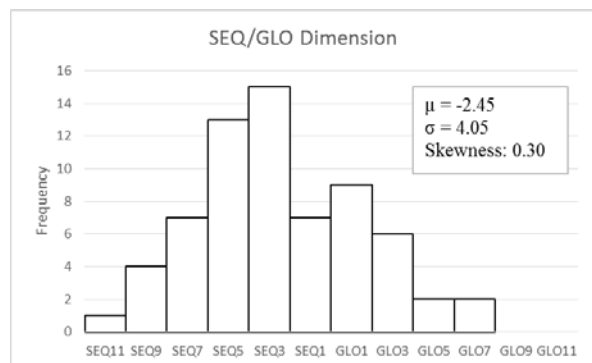Figure 4a SEQ/GLO Dimension for the CE Students

Figure 4b SEQ/GLO Dimension for the BS Students

Conclusions

A Chinese-English version based on Felder-Silverman learning style model was developed on a cloud platform and administrated to two groups of engineering students studying vocationally oriented programmes in Hong Kong. The results of the 141 samples were analysed and compared to ILS-based studies of engineering students in eight universities and vocational institutes. In general, the learning styles preferences of the IVE students were marginally reflective, predominately sensing, visual and sequential. The findings of this study offered valuable insights to inform more effective teaching and curriculum development in vocational education.

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