Structured Assessment on Learning Progress

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Abstract

This paper presented a novel technique and practice of the assessment of learning progress of university students in an engineering discipline. Instead of measuring the effectiveness of accumulation of specific knowledge, the newly developed assessment technique evaluates the development of the intelligence of the students. The key components of the proposed technique are a performance-based method for the estimation of the intelligence level and a cognitive mental faculty-oriented decomposition method to determine the intelligence contribution factors for learning subjects and exam questions. The proposed technique was applied to assess the learning progress of a group of university students in the field of automation, and the results from test agreed with the expectation well.

Keywords: contribution factors; learning progress; mental faculties; structured assessment

1. Introduction

As we are in the process of building an innovation-oriented country, there is ever increasing huge demand for better students from various of social sectors. The effectiveness of teaching in higher education is critical to meet the demand. The conventional higher education system, especially in China, assess the quality of the teaching in universities based on the effectiveness of accumulation of the knowledge. The amount of knowledge that students obtained is obviously important, but is certainly not all that the students should gain in their university study.

1.1 The necessity of assessment

In many previously reported researches, it has been generally agreed that the criteria of the assessment of transfer of learning should be determined by the characteristics of different types of social sectors, more precisely the end users of university graduates. The criteria for being a good student could be very different from place to place, however, among various criteria the intelligence is always included.

The critical development of the students in university, except for the accumulation of knowledge in a specific area, should be the development of their intelligence. Since the intelligence level of the university graduates determines the innovation capability of our society to a large extend, the critical assessment criteria for the university education should emphasize on the intelligence to reflect the needs of current social development.

1.2 The objective

The objective of the research reported in this paper is to investigate how the students' intelligence are

developed as the learning subjects are arranged through the course of their university study in a specific discipline.

This paper is not attempting to cover all the disciplines in university education but a typical one, namely automation, as an example in the field of engineering. There are some typical characteristics of the student group in this research. Some engineering students are trained to be engineers in automation-related area. However, a large proportion of the students are willing to pursue further education at post-graduate level. The particular interests in our research are to investigate how the intelligence of the students has been developed with respect to the subjects learned during the university study. We proposed in this paper that the intelligence of the students should be measured using a performance-based technique to reflect the real effect of the intelligence in its application, and as the principal type of tasks of university students, to learn a specific subject was chosen as the task to reflect the nature of university study.

2. Theory and technique applied

The meaning of intelligence may be defined in many ways, however this paper takes the definition as "the ability to acquire and apply knowledge and skills" to specifically fit to the purpose of the research.

2.1 Designated definition of intelligence

Although there are no universally agreed assessment techniques for intelligence that should be used, it is generally accepted that the four important basic ideas about the assessment of intelligence should be embedded in any of the techniques [1][2]. Intelligence, if it is defined as mental ability, could be measured by objective tests, in which each question has only one "correct" answer. Differences in intelligence are quantifiable in terms of degree of intelligence. In this sense, numerical values could be assigned to distinguish levels of intelligence of people. Differences among people form a bell-shaped curve, or normal distribution. In a bell-shaped curve, a majority of scores cluster in the middle, and fewer are found reaching the two extremes of genius and mental deficiency. The precise extent to which two sets of test scores were related could be determined by a statistical procedure (correlation).

As the defined intelligence shall consist of various of abilities to achieve the objective, we propose in this paper that the intelligence could be decomposed according to the modules in the mental faculty. In general, the mental faculty has been regarded as the inherent cognitive powers of human mind, which could be grouped into modules [2][4], and through which the mind performs various functions and tasks [3]. However, there has been no globally agreed model to define the modules that describe the mental faculty comprehensively, or in other words, researchers intended to choose or to place their particular interests in certain modules of the mental faculty to suit their specific areas of researches [5][6].

Taking into account the particular interests in this research, we define the following modules of mental faculty for the measure of intelligence.

Table 1. Modules of mental faculty

Perception	The faculty of apprehending the external world through different sense channels.
Reason	The faculty of forming conclusions, judgments, or inferences from facts or premises through rational thought.
Volition	The faculty of making conscious choice, decision, and intention, and keeping them as a particular mental image "fixed" in the mind.
Memory	The faculty of retaining and reviving facts, events, impressions, etc., for recalling and recognizing previous experiences.

Imagination	The faculty of forming mental images to match up a particular thought or idea.
Attention	The faculty of distributing mental resource.

2.2 Technique of assessment

The intelligence, as defined in this paper, cannot be measured directly. This paper proposed to measure the performance of the students as the estimation of intelligence level. Since the quality of the performance is very much task-related measurement, the absolute measurement of the performance will not lead to any certain information. The proposed technique uses a relative comparison of the performance measurement between two groups of students who have taken different number of subjects to reveal how the intelligence development is related to the subjects learned.

Apart from of pure accumulation of knowledge in the discipline, we believe that all the subjects will contribute to the development of the intelligence of the students. More specifically, the contribution will be made according to the contents of the course to the modules of the mental faculty. According to the nature of knowledge, each learned subject will make different impact on different module of mental faculty, and all the subjects that students learned will make a general impact on the development of the students' intelligence. The impact on each module of the mental faculty will be valued as contribution factors (CF) respectively.

Due to the fact that there is no unified measure for intelligence, the absolute intelligence values of the students are not associated with any particular meaning. However, the comparisons between the scores of different groups from the same task would be a clear indication of the differences in the intelligence between the students of comparing groups.

3. The case study

The typical task of university students is to learn a subject, and the performance of learning can be measured by a well-structured examination which is accepted in general. The well-structured examination covers the knowledge of the subject comprehensively and has a clear indication on how the teaching materials and exam questions are related to the mental faculty modules respectively.

3.1 Participants

The chosen subject for performance measurement should not be sensitive to the difference in the learned subjects of compared student groups in terms of the knowledge contained in those subjects.

All the subjects were decomposed into the possible contribution factors (CF) to each mental faculty modules according to the nature of the subjects. The accumulation of the contribution factors of the total subjects learned provide an estimation of the development of the student's mental faculty which was considered as the estimation of the intelligence level of the student.

The 180 participants are divided into two groups, with each group 90 students. The first group are senior students in the major of automation, while the second group are junior students from the same department. The students from both groups took exactly the same subjects in their early two years' study. The subject for the performance measurement is Engineering Psychology, and it has no specific relationship with the subjects that Group No.2 missed. Both groups were combined into a joint class in order to eliminate the influencing aspects from teaching task. Four examinations were given during the course.

3.2 Data Process and Analysis

All the courses learned are decomposed according to the cognitive facilities, and the accumulated

contribution of two groups of students are shown in Table 2. Where group one, the senior students are better in the six factors.

Table 2. The contribution factors (CF) from learned subjects

C F	Perception	Reason	Volition	Memory	Imagination	Attention
Group 1	24	36	32	26	28	26
Group 2	22	26	28	21	19	20

All these six contribution factors are based on the courses that the students have attended. Where the contribution factor is assigned to **Perception** if the knowledge learned related to information resources, data acquisition; and to **Reason** if the knowledge learned helps form conclusions, judgments, or inferences from facts or premises through rational thoughts. The knowledge is likely related to signal/information processing and analysis. The data to **Volition** if the learned knowledge supports to make conscious choice, decision, and intention, and keep them as a particular mental image "fixed" in the mind. The knowledge was normally associated with fundamental theory. The contribution factor is assigned to **Memory** according to the size of the learned knowledge that required to remember; to **Imagination** if the knowledge learned helps to form students' mental images to match up a particular thought or idea. The knowledge was normally associated with advanced technologies; to **Attention** if the learned knowledge that requires interdisciplinary information to understand.

3.2.1 The performance measurement

During the semester, there are four tests that are carried out without advance notification to students. It means that the tests show the actual status of the students' level of understanding the contents. There are 3 major questions in each exam. Question one (Q1) is to fill three blankets a, b, and c. Question 2 is an explanation of some concept, and Question 3 is about the application, which needs to analyze and solve practical problems with the knowledge. The score of each exam was carefully recorded and evaluated.
In the first exam, the questions are designed including the six contribution factors. The contribution factors are calculated as Table 3.

Table 3. The contribution factors of the questions in exam I

C F	Perception	Reason	Volition	Memory	Imagination	Attention
Q1(a)				●		
Q1(b)				●		
Q1(c)			●	●		
Q2		●	●		●	●
Q3	●	●	●			●
Ratio	1/30	2/30	3/30	3/30	1/30	2/30

The scores of all the students in the two groups were analyzed, and the results show the mean scores of Group 1 senior students in the factors of Reason, Attention and Imagination are higher than group 2 junior students.

Table 4. Results of the first exam:

Mean scores	Perception	Reason	Volition	Memory	Imagination	Attention
Group 1	1.82	3.91	5.92	5.43	0.94	3.85
Group 2	1.84	3.65	5.91	5.44	0.82	3.24
G1 vs. G2		0.26			0.12	0.61

The questions in the second exam link the contribution factors as Table 5. And the results are shown in Table 6.

Table 5. The contribution factors in exam II

C F	Perception	Reason	Volition	Memory	Imagination	Attention
Q1(a)				●		
Q1(b)				●	●	
Q1(c)		●	●	●		
Q2	●	●	●		●	●
Q3	●	●	●	●		●
Ratio	2/30	2/30	3/30	4/30	2/30	2/30

Table 6. Results of the second exam:

Mean scores	Perception	Reason	Volition	Memory	Imagination	Attention
Group 1	3.72	5.81	7.42	7.25	1.85	3.75
Group 2	3.74	5.29	7.41	7.32	1.66	3.54
G1 vs. G2		0.52			0.19	0.21

From the above data, it shows that Group 1 performs better in the factors of Reason, Attention and Imagination.

In the third exam, the contribution factors are shown as Table 7. And the comparison of the results is shown in Table 8. Group one has better scores in the aspects of Reason and Attention, especially.

Table 7. The contribution factors in exam III

C F	Perception	Reason	Volition	Memory	Imagination	Attention
Q1(a)						●
Q1(b)	●				●	
Q1(c)		●	●	●		
Q2	●	●	●		●	●
Q3	●	●	●	●		●
	3/30	3/30	3/30	2/30	2/30	3/30

Table 8. Results of the 3rd exam:

Mean scores	Perception	Reason	Volition	Memory	Imagination	Attention
Group 1	5.61	5.71	7.42	7.25	3.87	5.40
Group 2	5.71	5.39	7.41	7.32	3.70	5.11
G1 vs. G2	0.1	0.32			0.17	0.29

In the fourth exam, the contribution factors are indicated in Table 9, afterwards, the scores are calculated and the results are shown in Table 10. Group 1 students are better in the aspects of Reason and Imagination.

Table 9. The contribution factors of exam IV

C F	Perception	Reason	Volition	Memory	Imagination	Attention
Q1(a)			●			●
Q1(b)		●			●	
Q1(c)		●	●	●		
Q2	●	●			●	●
Q3	●	●	●	●		●
	2/30	4/30	3/30	2/30	2/30	3/30

Table 10. Results of the 4th exam:

Mean scores	Perception	Reason	Volition	Memory	Imagination	Attention
Group 1	3.82	7.25	5.40	3.25	1.82	5.45
Group 2	3.79	7.11	5.32	3.32	1.67	5.51
G1 vs. G2		0.14			0.15	

4 Conclusion

From the results obtained, we could reach the following conclusions. The proposed performance measurement produces basic sensitivity to distinguish the intelligence level between two groups of students with essential salience. And the development of intelligence appears to have salient positive correlation with the subjects learned.

The basic features of proposed assessment could be checked from the aspect of reliability and validity. The assessment produced consistent outcomes from the four exams and proved to be reliable. The validity of assessment was demonstrated by the analysis results matching with the theoretical expectation. The assessment could cover all modules of the mental faculty.

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