

## Assessment of the students majored in Mechanical Engineering Technology in practical training programmes

Yueh-Ru Yang, Hsi-Hsun Tsai & Hui-Ping Feng

Ming Chi University of Technology  
Taipei, Taiwan

**ABSTRACT:** The learning assessment of a sandwich program adopted by a private university of technology in Taiwan is investigated in this article. All the junior students of the university take one year in cooperating companies for practical training in this programme. However, it is difficult to evaluate the learning achievements of the students placed in different factories or companies. For evaluating the intellectual skills of the students, four abilities defined by the Florida assessment project system are used: concept, rules, problem-solving and cognitive strategy, and then, five examination papers based on Constructivism are developed. Through five stage examinations, the performance of the students can be assessed. From the score results, it can be found that the students' performance is directly related to their placement factories or companies. Therefore, the students' scores in the five-stage examinations can be regarded as an important index. That is, the five stage examinations developed in this study can be used to supervise the implementation of the sandwich programme and choosing the cooperating companies.

### INTRODUCTION

Learning assessment for students highlights the achievement of each course. Through the assessment, the students will be aware of their current standard and will then improve more once they understand the aim of their learning. This understanding is where they are in relation to this aim and how they can achieve the aim. Bransford, Brown and Cocking reveal that an effective teaching environment can be established by way of an assessment-centred scheme for pupils [1]. Besides, Bransford et al further indicate that within the effective teaching environment of the assessment-centred scheme, the feedback from the students are responded to by the teacher through formative assessment during the teaching process [1]. The ongoing feedback by monitoring the learning status of students reflects the linkage between the course and the general information about students. Brown and Knight [2] and William and Black [3] also stated that the purpose of the formative assessment is the learning feedback for students, which closes the gap between actual and desired levels of performance. Brown and Knight further indicated the timely feedback of the formative assessment is much more important in increasing the learners' knowledge and skill, because of the clear information that allows the learners to understand what must be done [2].

It is a belief that one constructs knowledge from one's experiences, mental structures, and beliefs that are used to interpret objects and events. Jonassen stated that the mind is instrumental and essential in interpreting events, objects, and perspectives on the base that is personal and individualistic [4]. Hence, the independent learners have the ability to seek out and gain new knowledge and new skills. They can engage in self-reflection, and can identify the next steps in their learning. Teachers and/or the teaching institute should design the learning environment to help the learners to construct their skills, knowledge and the ability to solve problems. In addition, the learning environment should be authentic and interactive. The students studying in technical universities of Taiwan receive vocational training, which differs from the ordinary university. Constructing the learning environment for practical training is therefore very important.

Many schools have been adopting sandwich programmes containing of the practical training to help their students to learn the professional know-how. Obviously, sandwich programmes are profitable for designing the practical learning environment and minimising the gap between theories and practices [5]. The implementation of university sandwich programmes may require spending a half or full year in a private corporation during the tertiary education. Therefore, learning alternates between school and the factory. No matter how diverse the sandwich programs are, seeking an appropriate company for the students is the most important factor. Not all sandwich programmes can be naturally successful. Intrinsically, factory practice is a process of *learning by doing*. If cooperating companies cannot provide an instructive learning environment, the students on placement maybe become low-cost labourers. Therefore, *how to grade the student's achievements and be discriminate about the suitability of factories* is the principal concern of the faculty administering the sandwich programme.

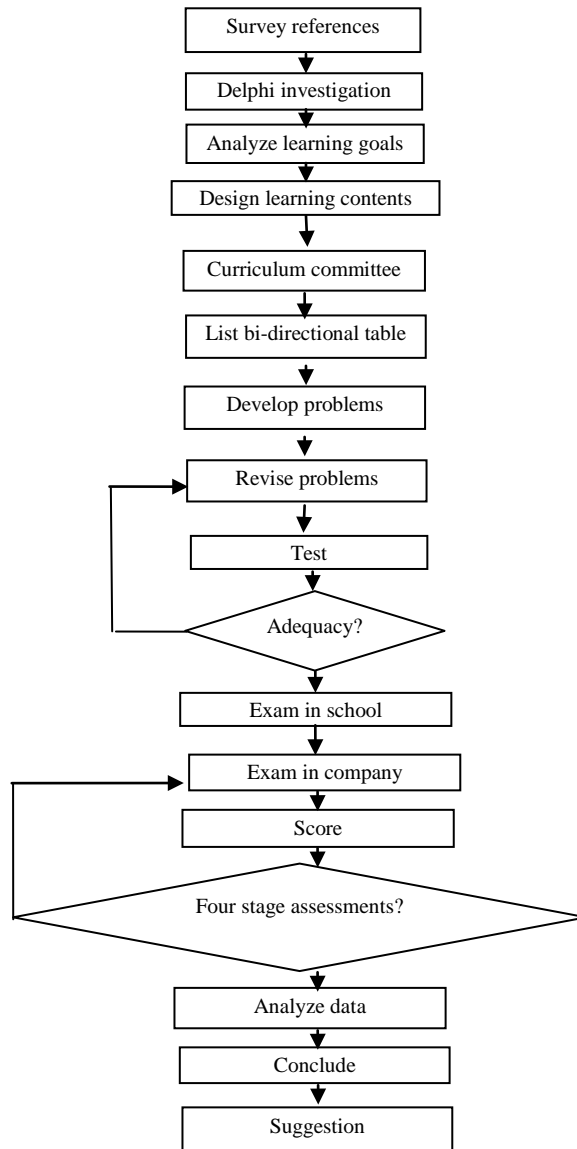


Figure1: Assessment flowchart.

Ming Chi University of Technology (MCUT), funded by the Formosa Plastic Group, has been offering a sandwich programme for more than forty years in Taiwan. The students graduated from the school must complete one-year of factory practical training. During the year, the faculty guide and grade the students by students' reports. However, it is not easy to assess the students' achievements only by the seasonal reports because the students' learning is a process based on Constructivism [6][7].

Furthermore, due to the changing industrial structure, the university sandwich programme needed to be revised in order to adapt to changes in society. Moreover, as a part of engineering education accreditation, the faculty also need a standardised procedure to supervise the implementation of the sandwich programme and assess the learning achievement of students. Assessment for learning should be used to enhance all learners' opportunities to learn in all areas of educational activity, especially of the practical training of sandwich programme. In this way, one can ensure that all learners will achieve their best, and have their efforts recognised.

Accordingly, the Mechanical Engineering Technology (MET) department of the university conducts a study to build a standard procedure for assessing the students' performance and for evaluating the participating companies. Based on Constructivism, the construction process of intellectual skills is the main concern. Therefore, the student's growth in problem-solving and cognitive strategy, before and after the sandwich programme, is observed and analysed.

This article summarises the test results of the MET students. By examining the previous background of the practical sandwich programme training, the purpose of this study is to use serial assessments during the one full-year practical training to assess the learning of each student that majored in the MET. Based on the curriculum standard and the core abilities of the students, Delphi investigation was used to analyse the assessment. By assessing the results of every student, one is able to evaluate the training position provided by the participating company, to see if it is suitable for increasing the professional skills and knowledge of students in the sandwich programme.

## METHODS AND IMPLEMENTATION

In the sandwich programme, all junior students are given placements in companies, factories and academic institutions. In this problem-oriented investigation, a class of thirty-eight students of the department of MET, MCUT, were assessed before proceeding to the practical training of sandwich program. Figure 1 illustrates the procedures adopted for this study. The procedures are briefly depicted as following. First, an initial reference survey was conducted where the survey included the curriculum standard and the core abilities of the student in the field of MET. Then, the Delphi investigation is a consultative process. Some scholars and experts in the fields of industrial education and mechanical engineering were consulted to clarify the educational targets and administrative procedures for the investigation. As the investigation was completed, the learning goals and contents in the field of MET were analysed and drafted. While the curriculum committee of the department passed the draft of the learning goals and contents, a more detailed instruction objectives and contents were listed in a bidirectional table. As shown in Table 1, the instruction objectives items are arranged in columns and the items of learning assessment are listed in rows.

Table 1: The Florida assessment project system [4].

Intellectual Skills	Learning Outcome (Action Word)	Human Performance	Assessment Example
Motor chain	Manipulates	Executes a skilled motor performance	Weighs substance on a balance
Verbal chain	Recalls	States fact, generalisation or descriptions	Lists minerals in Moh's scale of hardness
Discriminates	Discriminates	Distinguished objects or object features as same or different	Tells whether photographs of galaxies are same or different
Concept	Identifies or classifies	Classifies an object or situation in accordance with a definition	Classifies granite as an igneous rock
Rules	Demonstrates	Applies a rule, law or concept to specific example	Determines density of a mineral
Problem solving	Generates	Generates a solution to a novel problem	Determines effect of velocity on erosion in stream
Cognitive strategy	Originates	Originates a novel problem and solution	Gets an answer to <i>I wonder what would happen if...</i>
Attitude	Chooses	Chooses a course of action, expresses a feeling toward a person, object or event	Writes a letter to congressional representative supporting air quality standards

Table 2: Bi-directional table.

Field	Items	Concept	Rules	Problem-solving	Cognitive strategy	Total
Materials	Objective 1	2	1	1	1	5
	Objective 2	1	1	0	1	3
	:					
Dynamics	Objective 1	1	1	0	1	3
	Objective 2	2	0	1	1	4
	:					
Manufacturing	Objective 1	3	0	1	1	5
	Objective 2	0	2	2	1	5
	:					
Mechanical Design	Objective 1	2	1	1	1	5
	Objective 2	2	1	1	1	5
	:					

To assess the students' intellectual skills, the Florida assessment project system was adopted [8]. The Florida assessment system includes eight intellectual skills, motor chain, verbal chain, discriminates, concepts, rules, problem-solving, cognitive strategy and attitude. Table 1 shows the Florida assessment system and illustrates the corresponding learning outcomes, human performance and assessment example. In this investigation, four intellectual skills were selected from the Florida assessment system and used to evaluate the students' learning achievements. The four items selected were concept, rules, problem -solving and cognitive strategy, as listed in Table 2. Based on Constructivism, the students were placed in factories, companies and academic institutions should be able to learn actively and construct

their knowledge with their formal experiences. Basically, the four assessment items are stratified. First, the concept can be regarded as a basic knowledge requirement for the practical experience. Second, be able to apply the rules learned from school to practice is viewed as a higher performance level. Third, if the students can apply their knowledge and rules to solve the problems they encounter, it is seen as a promotion over second grade rules. Finally, if there are several methods that may be used to solve the problems encountered, and the students can choose an adequate method, then the learning objectives of incubating the ability of cognitive strategy will be achieved.

According to the selected four assessment items, many problems in MET are designed and categorised into five examination papers. To test the growth of the intellectual skills acquired by the students during their placement in the partner factories and companies, all five examination papers are designed to be of equivalent difficulty and having similar assessment effects. Each examination paper contains fifty multiple choice questions and five broader questions. Selected problems and questions both include the four assessment items, concept, rules, problem-solving and cognitive strategy. The numbers shown in the bi-directional Table 2 are just examples. The numbers in rows show the problem quantities designed in the four assessment items.

In Figure 1, the procedure of the problem design is shown as a three-step loop consisting of revision, test and accreditation. In the loop, the problems are tested by junior student samples. The circulating loop runs continuously until the developed problems behave with adequate difficulty. After finishing the problem design, a guidebook for learning assessment is prepared. The guidebook is used to help the faculty to conduct the stage examinations as they visit their students in factories and companies. While the five examination papers are prepared, the first examination is held at school, and the other four examinations are held at the companies and factories every three month. In the sandwich programme adopted by the university, the students' learning process in companies is divided into four stages. Each stage lasts for three months. While each stage ends, the faculty holds a stage examination to assess the student's performance. According to the students' examination results, the faculty can objectively improve their instruction strategies and select more instructive factories and companies for students.

In the investigation, thirteen companies, factories and academic institutions cooperated with the department of MET. Here, the cooperating companies, factories or institutes are designated as A to M. The main features of the thirteen companies cooperating with the university are briefly described as follows:

- Company A is an enterprise group for production of petrochemical products.
- Company B is a metal-sheet folding and pressing factory.
- Company C is a company involved in mock-up manufacturing.
- Company D is a metal-sheet stamping factory.
- Company E is a trading company for building and maintaining of the high class and measuring instruments and systems.
- Company F is an industrial technology research institute of Taiwan focused on the development of energy and resource.
- Company G is an enterprise for PC chassis, server chassis, power supply cases and server barebones.
- Company H is a company mastered in the technique of mechanical and electrical system integration.
- Company I is a private university of technology.
- Company J is a machine design company mastered in reverse engineering, CAD/CAM, CNC, RP and prototype.
- Company K is the maintaining management department of a plastic enterprise group in Taiwan.
- Company L and M are the branch companies belonging to the previous same plastic enterprise group.

## RESULTS AND DISCUSSIONS

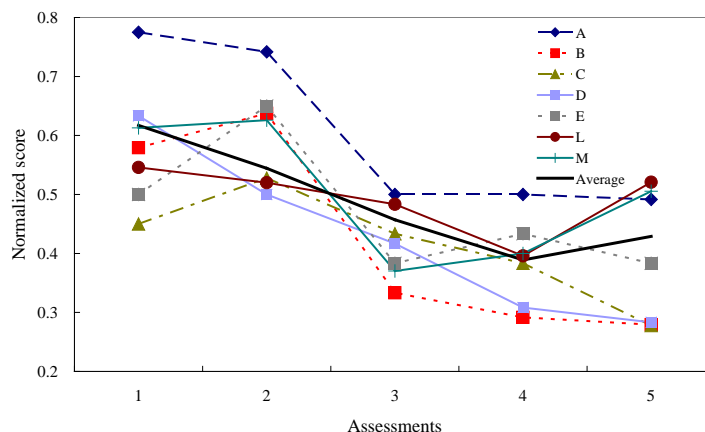


Figure 2: The assessment trend of Group I on the multiple choice questions.

The students' scores are analysed after the five-stage examinations are completed. For clarity, the students' scores in the thirteen companies are divided into two groups and shown in respective charts. The first group consisting of companies A, B, C, D, E, L and M has been designated as Group I, as shown in Figure 2. The second group contains companies F, G, H, I, J and K, as shown in Figure 3. In the two charts, the score line of each company has been compared to the black average line. The average line shows the average score of the thirty-eight students.

All the scores of the students are normalised. The first-stage score is the score tested at school and the next four-stage scores are the scores tested at the companies. As shown in Figures 2 and 3, the overall score trend on the multiple choice questions is descending. On the contrary, the score trend on the broader questions is ascending as shown in Figures 4 and 5. Figures 4 and 5 show the score trend on catechetical questions. Because the first stage examination held at school had no broad question, the two figures show only four stages.

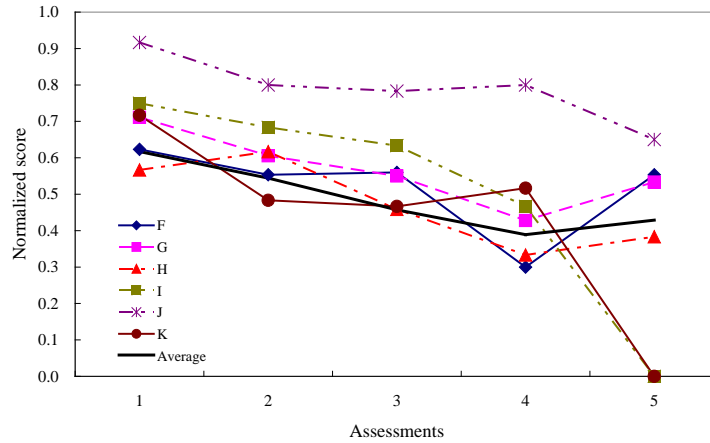


Figure 3: The assessment trend of Group II on the multiple choice questions.

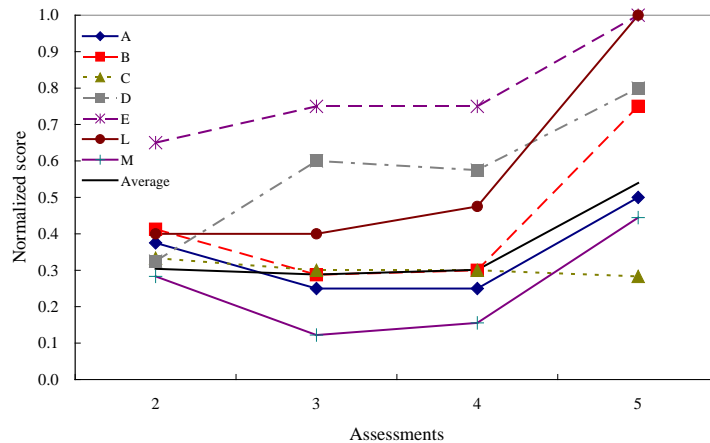


Figure 4: The assessment trend of Group I on the Catechetical questions.

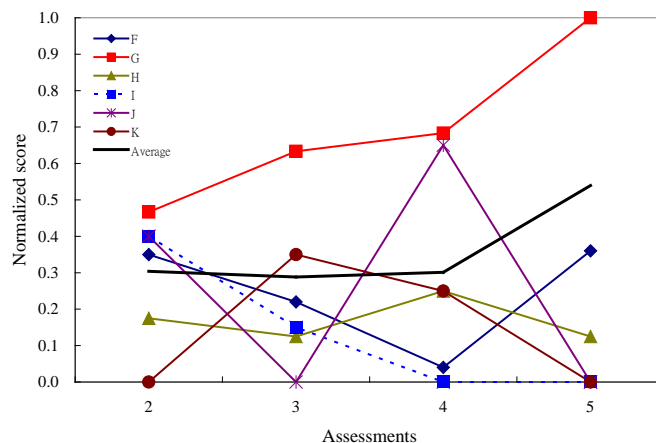


Figure 5: The assessment trend of Group II on the Catechetical questions.

Figures 6 to 8 are the typical test results that illustrate the individual differences of the students on placement in companies B, C and G, respectively. Since each company could have more than two students, the individual differences in mental growth should be treated with care.

Figure 6 depicts the different intellectual skill growth of the four students in company B. They have the same descending trend on the multiple choice questions, but three students grow in the broad questions.

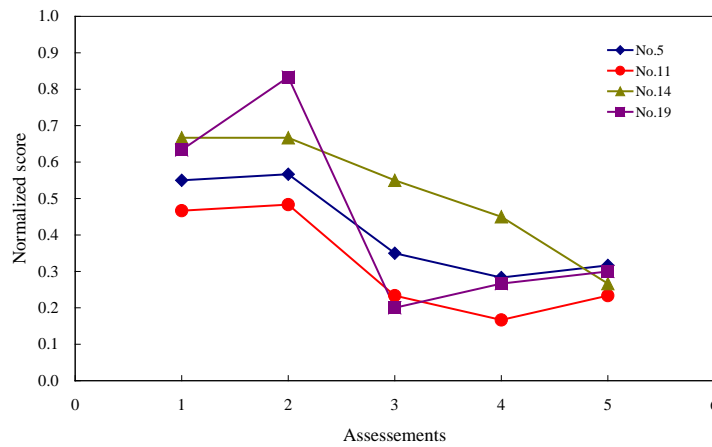


Figure 6a: The assessment score of students by the multiple choice questions (the assessments of students' scores in company B).

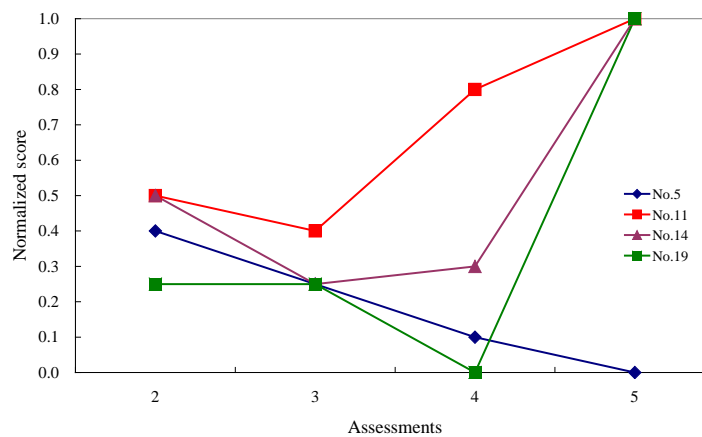


Figure 6b: The assessment score of students by the Catechetical questions (the assessments of students' scores in company B).

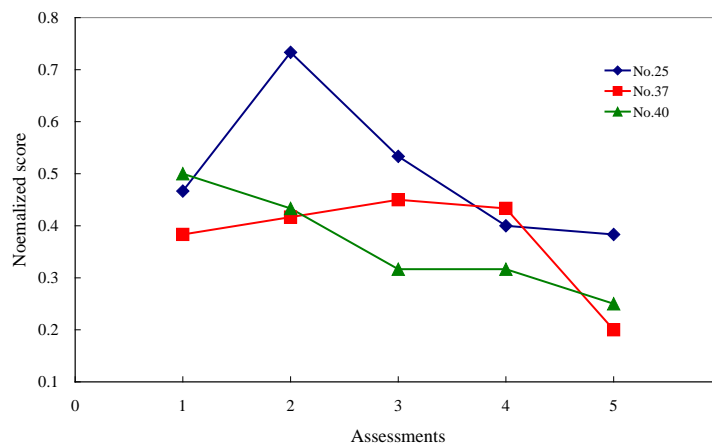


Figure7a: The assessment score of students by the multiple choice questions (the assessments of students' scores in company C).

Figure 7 shows the trend of company C. It is similar to Figure 6. The trend on the multiple choice questions is descending but is ascending on the broad questions. Moreover, even though the overall trend on the broad questions is ascending, it still has student drop-outs. Compared to Figure 6 and 7, Figure 8 is a better case. Figure 8 illustrates that the individual differences in company G are small. The students on placement in company G showed better performance.

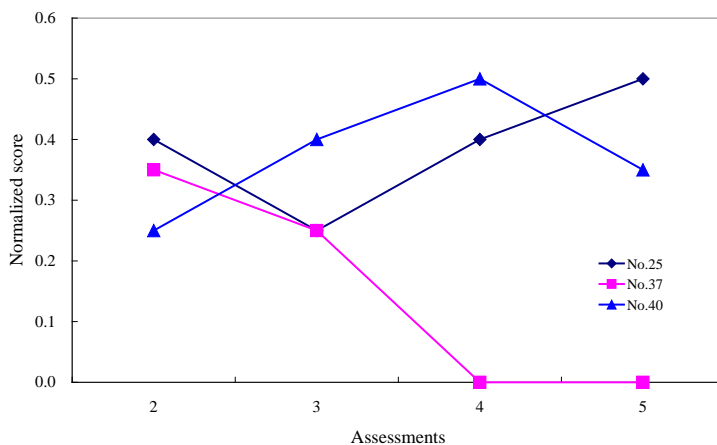


Figure 7b: The assessment score of students by the Catechetical questions (the assessments of students' scores in company C).

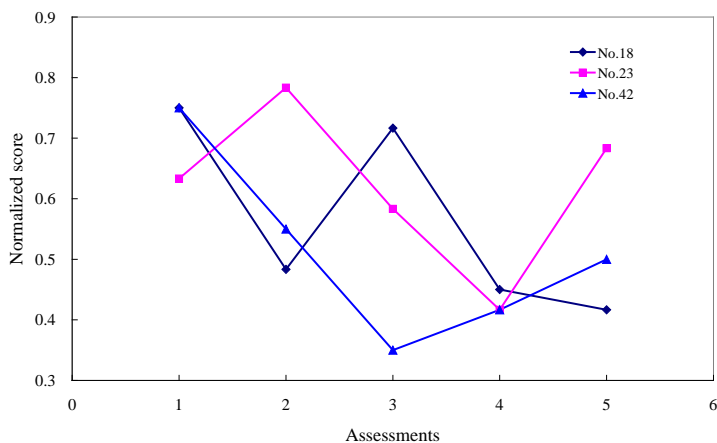


Figure 8a: The assessment score of students by the multiple choice questions (the assessments of students' scores in company G).

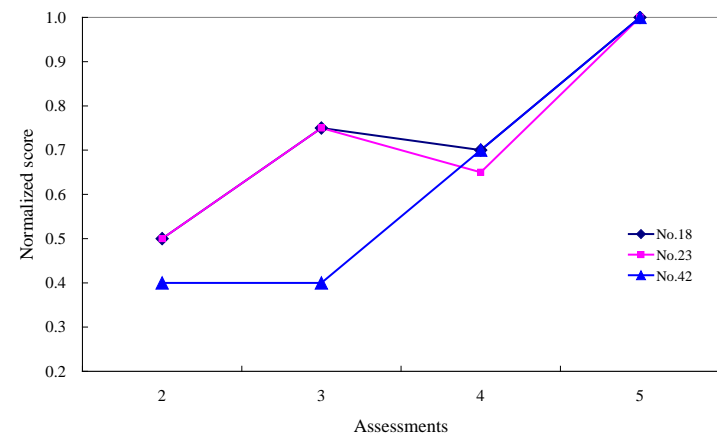


Figure 8b: The assessment score of students by the Catechetical questions (the assessments of students' scores in company G).

Obviously, Group-II has better performance than Group-I. This phenomenon can be regarded as a normal situation, because Group-II has more design and study works than Group-I. Therefore, the students on placement at companies in Group-II can naturally achieve higher learning achievements and such a result coincides with the anticipation of the faculty. Accordingly, the faculty of the university can check the students' scores to improve the administration of the

sandwich programme. That is, the scores could help the faculty to accredit the cooperating companies, whether the companies are qualified or not. The institute should find a suitable position for students taking the practical training to increase or construct the practical professional skill and knowledge. By their previous skill and knowledge, the learners could have the ability to solve professional problems. However, in this study, a few of the positions provided by the cooperating companies are not qualified for matching the goals of this practical training of the sandwich programme.

## CONCLUSIONS

This paper provides a case study of learning assessment to improve the administration of a sandwich programme. The test results of the five-stage assessment show that the intellectual skill growth of students is mostly related to the factories or companies. The growth of problem-solving ability is an important index while the learning acquired through a sandwich programme is assessed. For evaluating the students' learning achievement, the designed examination problems could be based on the intellectual skills defined by the Florida assessment project system. In this article, concept, rules, problem-solving and cognitive strategy were chosen as learning assessment items. The test results coincide with those anticipated by the authors.

## ACKNOWLEDGEMENT

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