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Assessment of students' problem-solving abilities at a technological university in Taiwan

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ABSTRACT: The ability to solve problems should be important to students. High-level cognitive skills may help students to face the future complicated development of society. A problem-solving ability is, thus, at the forefront of educational goals. The actual enhancement of the students' abilities at a technological university was the aim of this study. The circle of pre-testing, statistical analysis, expert consulting and assessing is well implemented for all of the students. Analysis with SPSS software gives the reliability of the students' problem-solving ability as 0.934, while total cumulative variance is 100%. The background variables of the performance ranking in last semester, with part-work experience and student leadership experience in a university, show a significant difference by correlation testing. The previous variables are further indicated as correlated with the problem-solving ability of students.

INTRODUCTION

Engineering technology education research suggests that post-secondary education should evolve from traditional lecture style instruction to models involving active learning (or student-centred) techniques, such as collaborative, inquiry, internship and problem-based learning [1]. The type of activity employed will likely dictate the degree of critical thinking and problem-solving skill development [2]. Thus, one of the most influential models of learning, Kolb's experiential learning model has been widely used by educators for a variety of different purposes in higher and in professional education [3]. Since the primary responsibility of any engineer is to solve problems, the absence of repeated opportunities to explicitly learn the procedural knowledge of the discipline can hinder the development of competent engineers [4]. As the majority of the participants explained, theoretical and practical knowledge are important elements of problem-solving, but just as important is procedural knowledge to solve problems. Following the engineering education accreditation, the assessments for learning achievement of students should be used to enhance all learners' opportunities to learn in all areas of educational activity. By the assessments, one can ensure all learners achieve their best and have their efforts recognised.

Students studying at technological universities in Taiwan receive vocational training that differs from the general university curriculum. Constructing the learning environment for practical training on the basis of Kolb's experiential learning model is, therefore, very important. Many schools have been adopting internship programmes containing practical training to help their students acquire professional *know-how*. Obviously, internship programmes are profitable for designing the practical learning environment and minimising the gap between theories and practices. The implementation of internship programmes at a university may be diverse, comprising a half year or a full year within a private corporation during tertiary education. Basically, learning alternates between school and factory. No matter how diverse the internship programme, seeking an instructive company for students is most important.

Therefore, problem-solving ability is at the forefront of educational goals. Especially in this decade, most senior high school students are accepted easily into a university in Taiwan. The curriculum of each department in the university can be formulated and, as a consequence, help students to achieve their career goals once they graduate. Assessing the students will enable them to know and improve their skills once they understand the aim of their learning. This understanding is in terms of where they are in relation to this aim and how they can achieve the aim. Learning assessment for students raises the achievement of each course. An effective teaching environment is by way of the assessment-centred scheme for pupils [5]. In the effective teaching environment of the assessment-centred scheme, the feedback from students is responded to by the teacher via formative assessment during the teaching process. The ongoing feedback by monitoring of the learning status of students would reflect the linkage between the course and students' general information.

Generally, the student constructs knowledge from his or her experiences, mental structures and beliefs that are used to interpret objects and events. The higher cognitive ability of problem-solving is the most important of all educational goals. The assessment of the trained ability of the student is, therefore, vital due to the actual enhancement of the ability, to which the student at college should give more attention. By studying the educational approach, the problem-solving inventory is constructed by which to assess the problem-solving ability of the senior student of higher technological education. Accordingly, the university conducted a study to build a standard procedure for assessment of students' performance. Based on the problem-solving ability inventory developed in the previous study, the assessment of all of the students at a technological university in Taiwan is the main aim in this article [6].

RESEARCH QUESTION

The circle of pre-testing, statistical analysis, expert consulting and assessing would derive the norm of the problem-solving abilities of the students, which may provide feedback on the abilities acquired during the fundamental science and technology courses studied and can be used to construct the proper teaching modules. Little is known about how these background variables influence the problem-solving abilities of students. The current study moves beyond previous research by answering the following research question: How do students' problem-solving abilities compare with each background variable in a technological university?

METHODS AND IMPLEMENTATION

Many of the students did not have all the domain knowledge needed to solve the ill-structured and poorly expressed problem. However, instead of refraining from the task, because they lacked the knowledge, they proceeded with the exercise by relying on their problem-solving skills to solve the problem (i.e. defining the engineering problems, identifying critical variables, information and/or relationship involved in a problem, breaking down complex problems to simpler ones).

Table 1: Descriptive statistics of effective samples.

Background variables	Levels of the variable	Number	Percentage (%)
Grade	freshman	495	28.1
	sophomore	430	24.4
	junior	456	25.9
	senior	380	21.6
Major	Mechanical	234	13.3
	Vehicle	126	7.2
	Electronic	146	8.3
	Electrical	172	9.8
	Chemical	261	14.8
	Environment	134	7.6
	Material	123	7.0
	Industrial Engineering	132	7.5
	Industrial Design	137	7.8
	Business Administration	152	8.6
	Visual Communication	143	8.1
Part time job (period)	null	141	8.0
	< 1 month	440	25.0
	1-2 months	193	11.0
	2-6 months	274	15.6
	>6 months	304	17.3
Postponed to get permission	Yes	85	4.8
	No	1525	86.6
Leadership experience in university in semester	null	137	7.8
	1	739	42.0
	2	528	30.0
	3	242	13.7
	4	61	3.5
	5	36	2.0
	>=6	6	0.3
Rank in last semester in percentage	Top 10%	186	10.6
	Top 30%	415	23.6
	Top 50%	421	23.9
	Top 70%	471	26.7
	The others	242	13.7

To compensate for their lack of subject matter knowledge, students utilised their procedural knowledge to develop a process to solve the ill-structured and poorly expressed problems. All 2,231 students of a technological university were assessed by the previous constructed inventory [6]. The tasks included: 1) developing a procedure for identifying the mental processes as they were used by students; 2) creating an inventory to analyse the mental processes used by students; and 3) proving the inventory for consistency and reliability.

It is relevant to note that, although the term assessment is often used within a context, where a value judgment is made and one thing is determined to be better than another, the process described in this study uses the term operationally to describe procedures for identifying particular activities, determining how long these activities last, and how frequently activities are repeated in practice. The procedure would enable an observer to determine whether a learning activity accomplished objectives related to the use of mental processes in problem-solving. It was not, however, designed to directly measure the products or outcomes of the activities involved. Preliminary testing of the observation procedure was done using a timer to record the duration and frequency of each mental process observed. The field-testing phase demonstrated that agreement could be achieved between observers independently viewing videotaped technology education activities.

RESULTS AND DISCUSSIONS

The effective feedback inventories of 1,761 students were analysed in this study. The descriptive statistics are shown in Table 1, and show that each of the eleven major disciplines had at least 123 students for assessment. The Cronbach's alpha coefficient is 0.696 and the standardised Cronbach's alpha coefficient is 0.773. The proposed inventory for the three dimensions of the total of 76 items showed the reliability test as 0.773, which demonstrated good validity.

Table 2: Distribution of 1,761 undergraduate responses on the items of attitude, approach, quality and total in the problem-solving abilities scale.

	No Ability	Some Ability	Adequate Ability	>Adequate Ability	High Ability
Students	347 (19.7%)	365 (20.7%)	338 (19.2%)	364 (20.7%)	347 (19.7%)
Average of problem-solving ability	216.7	249.3	269.7	288.5	320.9

According to the distribution list of different background variables, in the 1,761 valid samples, no part-time work experience accounted for 8.0% of those with part-time work experience, of those with less than one month, the rating was 25%. However, between 2 and 6 months, the part-time working experience was rated 15.6%. Most of the students had leadership experiences in university but 7.8% did not have.

Analyses show that the students' problem-solving skills reveal an insignificant variability across gender and department variables. It is concluded that no significant difference was present in terms of classroom variables. As a result of the *t*-test conducted, it is concluded that problem-solving ability scores of students from the groups showed significant differences in part-time work experience, learning achievement ranking in the class in last semester and leadership experience during tertiary education.

All the effective feedback inventories were examined to find the previous correlation factors. The problem-solving ability of the feedback inventories were further rated on a five-point scale (where 1 = No Ability; 2 = Some Ability; 3 = Adequate Ability; 4 = More than Adequate Ability; and 5 = High Ability) as shown in Table 2. This table displays the distributions of participants' answers on the problem-solving abilities scale. By Chi-square testing, the five-point scale problem-solving ability of this assessment was strongly statistically significant. The Chi coefficient of contingency for these results was 0.139, which indicates a positive correlation (Table 3).

Leadership experience in a university from the feedback inventories is significant at an alpha of 0.05 and Pearson r of 0.124 gives a positive correlation with problem-solving ability. As well, the part-time job experience of the feedback inventories was significant at an alpha of 0.05 and Pearson r of 0.09 gave a positive lower correlation to problem-solving ability. The more time spent in a part-time job, the more likely a student is to rate more highly their ability to understand essential aspects of problem-solving ability, as compared to students who spend less time in part-time jobs. The main effects for the following variables are not significant, including the grade, major, postponements of permission to enter university or not, and the learning performance rank in their class.

Table 3: Chi-square testing of effective samples.

Measures of association	Value	Significance
Pearson r (d.f.=12)	34.8	0.000
Coefficient of contingency	0.139	0.000

Figure 1 indicates that the numbers for the raw score category of problem-solving ability is normally distributed, while the mean of the problem-solving ability of all of the university students was 269.02. The standard deviation is also depicted in this figure being 38.321.

According to the results obtained at the end of the research, it is proposed that tertiary education students have variations in terms of problem-solving skills according to a number of variables, which differ statistically. As well, it has been observed that the education received has caused differences in sub-dimensional levels of problem-solving. It was concluded that the students' levels of problem-solving abilities in terms of attitude, approach and quality show significant differences as a result of part-time working experience, learning achievement ranking in the class and service experience during tertiary education.

Table 4: Problem-solving abilities of effective samples correlated with background variables.

Background Variables	Pearson *r*	Significance (2 tails)
Grade	0.011	0.633
Major	-0.023	0.330
Part-time job experience	0.090	0.004
Postponed gaining of permission	0.031	0.209
Leadership experience in university in semester	0.124	0.000
Rank in last semester in percentage	-0.041	0.090

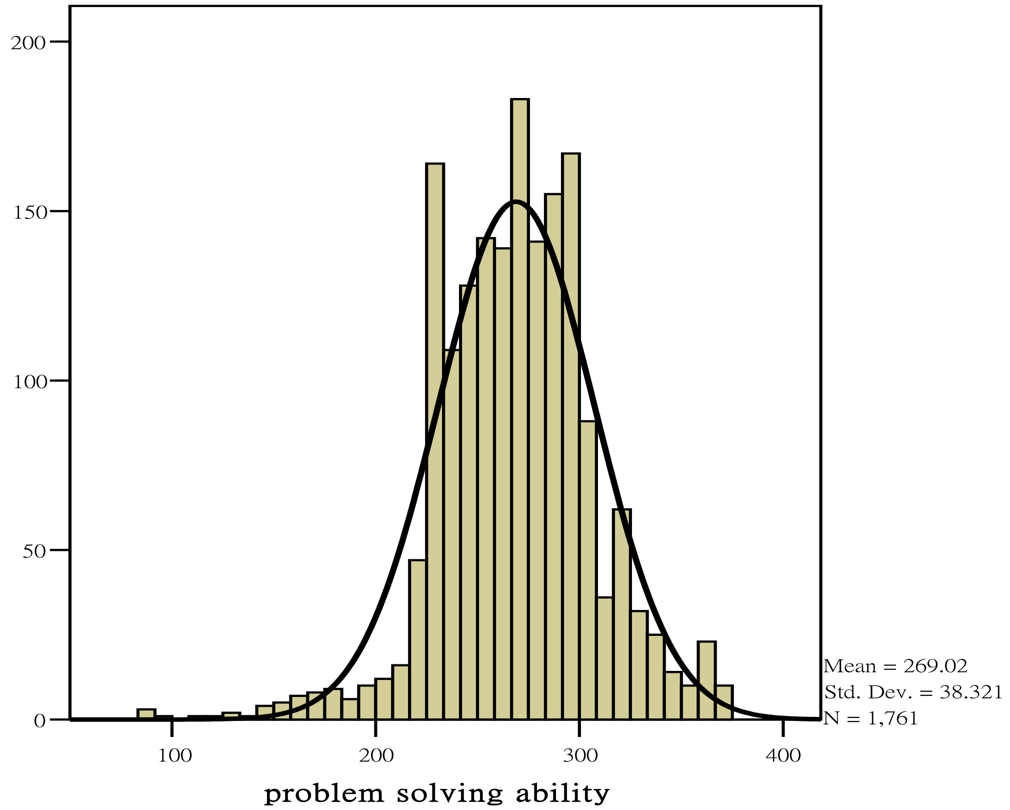

Figure 1: The problem-solving ability of all students in a technological university.

CONCLUSIONS

The relative homogeneity of students' self-ratings in this sample suggests that engineering programmes are preparing students to be fairly competent problem-solvers. Research though should focus on how and why the part-time job experience and the leadership experience in the university allow engineering students to have a higher perception of their problem-solving abilities than those with no part-time work or leadership experiences. One hypothesis is that the experience gained may provide the context needed for students to understand and apply engineering concepts, laws and relevant equations, possibly making them competent problem-solvers.

Analysis by the SPSS software gives the reliability tests on the students' problem-solving ability, of 0.934 while the total cumulative variance is 100%. The background variables of performance ranking in last semester, part-work experience and leadership experience of students in university show significant difference by correlation testing. The previous variables further indicated correlations with the problem-solving ability of students. Suggestions are provided at the end of the study for the reference of the assessment processers and future research. The feedback from the ability assessments of each student provided the concerned teachers with the possibility to improve teaching modules that are useful for higher technical and vocational education.

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