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Creativity of Engineering Students as Perceived by Faculty: a Case Study*

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The fostering of creative students has become a crucial issue in engineering education in recent decades. This paper examines staff members' perceptions of creativity in Taiwanese engineering students. Several studies have reported how teachers perceive the nature of creativity. However, the studies have produced varying results because the samples have been drawn from different educational groups, academic disciplines, and geographical areas. The present study investigated the characteristics of creativity as perceived by 175 academic staff members from two Taiwanese universities. The perceptions of creativity by university academic staff were found to be different from those of primary or secondary school teachers. Rather than emphasizing extrinsic characteristics, such as questioning and responding (as had been done by primary school teachers in previous studies), engineering academic staff members paid more attention to intrinsic characteristics, such as logical thinking. In all, 21 important characteristics of creativity are identified in this study, and these are categorized into five dimensions.

Keywords: creative characteristics; perception of creativity; creativity survey

INTRODUCTION

WITH THE ADVENT of knowledge-based economies in the 21st century, creativity has become a crucial issue for human-resource management in both academic research and industry. It is increasingly recognized that creativity and innovation are required to deal with changing circumstances in education and society as a whole [1–5]. There has therefore been increasing concern about how teachers can foster creativity in students to meet the current and future needs of society. Several studies have demonstrated that such creativity is fostered by instructors who understand the nature of creativity and who believe that most students can exhibit such creativity [6–11].

It is thus apparent that an important issue is how teachers perceive the nature of creativity. Several studies have addressed this topic [12–16], but the findings have varied according to the particular educational groups, academic disciplines, and geographical areas studied. Moreover, there appears to have been no research in engineering education directly related to this topic. Because creative ability is an important aspect of engineering, a better understanding of creativity in engineering students is needed. In this respect, a report from Australia is worth noting in suggesting that engineering education must be more outward looking, and must be able to produce graduates who are capable of leading the engineering profession in its involvement with the great social, environmental, and cultural challenges of modern times [17]. Many researches have also reported that understanding creativity and the creative process in the context of engineering is essential for an instructor to be able to foster creativity in engineering students [18, 19].

The present study examines perceptions of creativity in engineering education. More specifically, the purposes of this study is: (i) to explore the characteristics of creativity required for engineering students (as perceived by academic staff); and (ii) to compare and contrast these perceived characteristics with previous studies.

LITERATURE REVIEW

Four major aspects of studying creativity can be identified in the literature: (i) the creative process; (ii) the creative person; (iii) the creative product; and (iv) the creative situation [20]. A review of recent literature reveals that research in this area is gradually shifting from psychometric perspectives to postmodern approaches [21–23], or from explicit theories of creativity to implicit theories of psychological constructs. According to Plucker and Renzulli [24] '. . . implicit theories are generally defined as the conceptions that laypeople hold about certain constructs'. Modern researchers argue that an understanding of such implicit theories of creativity can bridge the gap between research and educators, and help educators to develop feasible plans to foster students' creativity.

Studies that use such implicit theories have tended to describe a creative person in terms of: (i) cognitive characteristics; (ii) personality and motivational qualities; and (iii) environmental

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Table 1. A summary of major characteristics of creative people

Characteristics	Authors					
	1	2	3	4	5	6
Originality	×	×		×		
Imagination	×			×	×	×
Curiosity or inquisitiveness	×	×		×		×
Novelty	×	×				×
Intellectuality	×			×	×	
Aesthetic taste (artistic sense)	×	×		×	×	×
Risk taking (enterprising or challenging)	×	×		×		
Less conventional	×		×	×		
Flexibility	×		×	×		
Personal energy (energetic)		×		×		×
Open mindedness		×		×		×
Drive accomplishment and recognition	×		×			×
Independence		×	×	×	×	×
Self-confident	×		×	×	×	×
Open to new experience	×		×			×

1: Tardif and Sternberg [26, pp. 434].
2: Davis [16, pp. 69–72].
3: Feist [14].
4: Chan and Chan [13].
5: Diakidoy and Kanari [12].
6: Montgomery and Bull [15].

variables [25–26]. The cognitive approach has placed emphasis on exploring the mental representations and processes underlying creative thought. These can be grouped as traits, abilities, and processing styles [27]. The personality approach has focused on personality variables—including internal motivation, self-confidence, non-conformity, independence of judgment, risk taking, and so on [25]. The environmental approach has included consideration of political, religious, cultural, socio-economic, and educational factors.

Table 1 presents a summary of the major characteristics of a creative person as identified in a literature performed for this study [12–16, 26].

Tardif and Sternberg [26] stated that there were four traits commonly associated with creative individuals: 'relatively high intelligence', 'originality', 'articulateness and verbal fluency', and 'a good imagination'. In studying implicit theories of creativity, wisdom, and intelligence in college students, Sternberg [28] found that creativity was characterized by 'nonentrenchment' (seeing things in novel ways), 'integration and intellectual ability', 'aesthetic taste and imagination', 'decision-making skill and flexibility', 'perspicacity', 'drive accomplishment and recognition', 'inquisitiveness', and 'intuition'. In analyzing the results of several related studies, Davis [16] concluded that the personality characteristics of creative people included 'awareness of their creativity', 'originality', 'independence', 'risk-taking', 'personal energy', 'curiosity', 'humor', 'attraction to complexity and novelty', 'artistic sense', 'open-mindedness', 'need for privacy', and 'heightened perception'.

Feist [14] separately reviewed studies of creativity in artists and scientists, and then discussed whether the distinguishing personality traits of artists applied to scientists. He concluded that creative people in both the arts and the sciences tended to be open to new experiences. In addition, compared with less creative people, creative people in both the arts and sciences were less conventional, less conscientious, more self-confident, more self-accepting, more driven, more ambitious, more dominant, more hostile, and more impulsive. However, Feist also indicated that creative people in the arts and sciences did not share all aspects of personality profiles. Artists were more affective, more emotionally unstable, less socialized than non-artists, and less accepting of group norms than scientists; whereas scientists were more conscientious than artists. This study implied that personality traits for creative persons differ according to the areas in which they work.

Several studies have explored implicit theories of creativity in different target groups using different approaches [12–13, 15]. Montgomery and Bull [15] attempted to identify the relevant characteristics of a creative person from several databases and a study of academic staff in colleges and universities. The most common descriptions of creative characteristics of academic staff were (in order): 'imagination', 'openness to experience', 'curiosity or inquisitiveness', 'intuition', 'tolerance for ambiguity', 'independence', 'idea finding', 'innovation', and 'insight'. The most common descriptions of creative characteristics from the databases were 'innovation', 'decision-making', 'imagination', 'critical thinking', 'creative problem-solving', 'preparation', 'divergent thinking', 'imagery', 'creative dramatics', and 'analogy/metaphor'. However, the researchers noted that the results of the study represented general aspects of creativity, and that they required careful assessment if applied to specific domains.

Diakidoy and Kanari [12] used a questionnaire to examine British student teachers' beliefs about creativity in their pupils. The results showed that

the creative characteristics most commonly identified by student teachers were (in order): 'imagination', 'ability to set own goals', 'self-confidence', 'divergent-thinking ability', 'independence', 'autonomy', 'critical-thinking ability', 'many interests', 'ability to set own rules', 'innate talent', 'artistic tendencies', and 'problem-finding ability'. In addition to these cognitive abilities, the study also found that 'self-management' was also considered important to creativity. The study also concluded that the student teachers did not identify 'intelligence' as a necessary characteristic for creativity. In addition, the student teachers tended to perceive creativity as a general ability.

In Chan and Chan's study [13], 204 Hong Kong primary and secondary school teachers were invited to list the characteristics of creative and non-creative students. In all, 42 creative and 33 non-creative attributes were identified. The most frequently mentioned creative attributes were 'always questioning', 'imaginative', 'quick in responding', 'active', and 'high intellectual ability'. If these characteristics are compared with those identified in other studies [15, 29–30], the common characteristics are 'artistic', 'curious', 'imaginative', 'independent', 'intelligent'/'clever', and 'unique'/'original'. In Chan and Chan's [13] study, some attributes were associated with intellectual functioning—such as 'quick in responding', 'high intellectual ability', 'good at observation', and 'willing to think'. It is of interest that some socially 'undesirable' characteristics (for example, 'rebelliousness' and 'self-centeredness') were listed as important traits of creativity—which were less likely to be reported in the Western studies [12, 15]. Chan and Chan [13] argued that this might have been due to cross-cultural differences.

The literature review reveals that, although certain common characteristics have been identified, there is no consensus on what constitutes a creative individual.

METHODOLOGY

The present study examined the characteristics of a creative person from the perspective of engineering education in Taiwan. A survey was used to collect the perceptions of a creative student among university academic staff.

Subjects

Academic staff members from the engineering departments of two Taiwan universities—Yuan-Ze University (YZU) and Oriental Institute of Technology (OIT)—were invited to participate in this survey. YZU is a research-oriented university, whereas OIT is an industrial application-oriented university. Respondents were drawn from the following subject areas: electrical engineering (EE1), electronic engineering (EE2), mechanical engineering (ME1), material engineering (ME2), chemical engineering (CE), computer science (CS), and industrial engineering (IE).

A total of 175 questionnaires was sent out. Of these, 154 questionnaires (88%) were completed and returned. These consisted of 61 from YZU and 93 from OIT. As shown in Table 2, 87.7% of the respondents were male, 58.4% held a PhD degree, and 37.0% held a master's degree. The average duration of teaching experience was 10.83 years.

Instrument

The questionnaire developed for the survey was based on the studies of Chan and Chan [13], Diakidoy and Kanari [12], and Montgomery and Bull [15]—all of whom studied creativity among students from the perspective of teachers—albeit from different educational levels.

The questionnaire consisted of three parts. The first part presented 47 creative characteristics (see Table 3). Subjects were asked to assess the characteristics, according to their perceived degree of importance, using a five-point Likert-type scale (from '5' = 'very important' to '1' = 'unimportant'). All response items were in Chinese.

The second part of the questionnaire included four questions—which were designed to collect general concepts of creativity among engineering academic staff. The questions were as follows:

1. Can a student improve his or her creativity ability by learning?
2. How often do you think teachers encounter creative students?

Table 2. The demographic information of samples ($n = 154$)

	Sex		Educational level			Years of teaching		
Department	Male	Female	Master	Ph.D.	Other	M	SD	Total
EE1	35	4	13	25	1	9.58	5.85	39
EE2	16	4	11	8	1	10.95	7.03	20
ME1	34	1	12	21	2	12.17	6.36	35
ME2	9	5	9	4	1	13.64	6.53	15
CE	9	1	1	9	0	8.9	3.81	10
CS	9	1	2	8	0	10.6	7.21	10
IE	23	3	9	15	2	10.15	6.18	27
Total	135	19	57	90	7	10.83	6.32	154
%	(87.7)	(12.3)	(37.0)	(58.4)	(4.6)			(100.0)

3. Is creativity a rare characteristic among human beings?
4. Are good students (in academic terms) more likely to be creative than average students?

A five-point Likert-type scale was used for responses (from '5' = 'totally agree' to '1' = 'totally disagree').

Part 3 of the questionnaire was an open question that requested the five most important characteristics for a creative person. Respondents were asked to write down the five most important characteristics (based on their own opinions), irrespective of whether their chosen characteristics were included in Part 1 of the questionnaire.

RESULTS

Perceptions of all engineering academic staff

Table 3 presents the characteristics of creativity as assessed in this study, and compares these characteristics with those of other studies.

Table 3. The important characteristics of creativity

	This study		1	2	3	4	5	6
Characteristics	Mean	Rank	Rank	Rank	Rank			
High intellectual ability	4.71	1	5			×		
Good at observation	4.69	2	7					
Innovative	4.67	3	36	7		×		
Likes or willing to think	4.55	4	10					
Exploratory	4.50	5	29			×		
Insight	4.48	6		8				
Sensitive	4.47	7	26					
Logical or clear thinking	4.47	8	36			×		
Curious	4.40	9	11	3		×	×	
Open or open-minded	4.36	10	24	9			×	
Initiative or spontaneous	4.36	10	11					
Enterprising or challenging	4.32	12	22				×	
Unique or original	4.30	13	6			×	×	
Always questioning	4.27	14	1			×		
Attentive	4.23	15	16					
Idea finding	4.19	16		11	8			
Nonconforming	4.14	17	16					
Likes reading	4.14	17	23					
Intelligent or clever	4.09	19	16		12			
Confident	4.08	20	16	25	3			×
Has a lot of ideas	4.01	21	29					
Interested in something new	3.98	22	29			×		
Flexible	3.97	23	36			×		×
Eager to learn	3.95	24	36					
Independent	3.94	25	11	6	5	×	×	
Quick in responding	3.94	25	3					
Imaginative	3.88	27	2	1	1	×		
Energetic	3.87	28	36	24			×	
Intuition	3.66	29		4		×		
Daring	3.56	30	29					
High expressive power	3.44	31	29			×		
Willing to express ideas or opinions	3.36	32	8					
Assertive	3.30	33	11					
High verbal ability	3.30	34	10					
Cheerful	3.24	35	9					
Openness to experience	3.20	36		2		×		×
Unconventional	3.19	37	29			×		×
Artistic	3.15	38	15	30	11		×	
Opinionated	3.03	38	16					
Tolerance for ambiguity	2.93	40		5		×		
Rebellious	2.83	41	26					
Active	2.83	41	4					
Talkative	2.78	43	21					
Outstanding	2.63	44	45					
Self-centered	2.44	45	26					
Attention seeking	2.44	46	36					
Arrogant	1.96	47	26					×

1: Chan's study; 2: Montgomery's study; 3: Daikidoy's study; 4: Sternberg's study; 5: Davis' study; 6: Feist's study.

Table 4. The important characteristics of creativity in Part 3

Characteristics	Rank in Part 3	Rank in Part 1	Rank in Chan's Study
High intellectual ability	1	1	5
Good at observation	2	2	7
Logical or clear thinking	3	8	36
Likes or willing to think	4	4	10
Curious	5	9	11
Enterprising or challenging	6	12	29
Exploratory	7	5	22
Innovative	8	3	36
Attentive	9	14	16
Nonconforming	10	17	16

In the present study, 21 items had an average score greater than 4 (see Table 3). The items thus identified were significantly different from those of Chan and Chan [13] ($\chi^2 = 273.58$, $p = 0.00$). Generally speaking, the engineering academic staff of the present study placed more emphasis on certain 'intrinsic characteristics' (such as 'intellect', 'thinking', 'observation', 'insight', and 'innovation') than did the school teachers of Chan and Chan's [13] study, who placed more emphasis on 'extrinsic' characteristics. In addition, the engineering academic staff perceived verbal abilities and social characteristics as relatively unimportant attributes for creativity.

Table 4 presents the 10 most important characteristics identified in Part 3 of this survey. The rankings in Part 3 were very similar to those in Part 1. The χ^2 statistics between the results of two parts were insignificant. However, some respondents did indicate characteristics that were not listed in the questionnaire. These characteristics included 'divergent thinking', 'knowledgeable', 'patience', 'teamwork', 'modesty', 'analytic capability', 'problem-solving skill', 'sharing problem', 'ability to correcting error', 'pragmatic attitude', 'perseverance', and a desire to pursue the truth. These characteristics appear to be related to creative problem solving.

Perceptions of male and female respondents

There were some statistically significant differences between male and female respondents. Male respondents considered the following characteristics to be more important than did female respondents: 'good at observation' ($\chi^2 = 7.84$, $p = 0.005$), 'innovative' ($\chi^2 = 7.88$, $p = 0.048$), 'likes to think' ($\chi^2 = 8.65$, $p = 0.034$), 'insight' ($\chi^2 = 8.30$, $p = 0.040$), 'sensitive' ($\chi^2 = 9.81$, $p = 0.044$), 'open-minded' ($\chi^2 = 9.30$, $p = 0.026$), 'always questioning' ($\chi^2 = 8.32$, $p = 0.004$), and 'independent' ($\chi^2 = 14.38$, $p = 0.006$). Female subjects considered 'arrogant' to be more important than did male respondents ($\chi^2 = 11.80$, $p = 0.019$).

Perceptions of staff from both universities

Although the present study included staff members from two universities that had different forms of engineering education, the academic staff in the two universities held generally similar perceptions with respect to creative students. The most important ten characteristics were similar (as listed in Table 4).

There were a few items (not among the top ten) in which there was a statistically significant

Table 5. Categorized important factors of creativity characteristics

Factor	Characteristics	Factor loadings	Extraction sums of squared loadings cumulative %	Cronbach α
1	Clear thinking	0.729	33.14%	0.82
	Innovative	0.691		
	Insightful	0.590		
	Sensitive in observation	0.583		
	Good at observation	0.478		
	Likes or willing to think	0.447		
2	Likes reading	0.712	40.47%	0.67
	Enterprising or challenging	0.644		
	Initiative or spontaneous	0.583		
3	Has a lot of ideas	0.753	46.52%	0.69
	Idea finding	0.634		
	Exploratory	0.599		
	Nonconforming	0.517		
	Open or open-minded	0.463		
4	Confident	0.709	51.94%	0.72
	Intelligent/clever	0.535		
	High intellectual ability	0.529		
	Attentive	0.522		
5	Unique or original	0.771	57.13%	0.55
	Always questioning	0.545		
	Curious	0.528		

Extraction method: Principal component analysis
Rotation method: Equamax with Kaiser normalization

difference between the two universities. Respondents from OIT considered that the following five attributes were more important than did respondents from YZU: 'confident' ($\chi^2 = 9.54$, $p = 0.049$), 'has a lot of ideas' ($\chi^2 = 9.661$, $p = 0.047$), 'interested in something new' ($\chi^2 = 10.663$, $p = 0.031$), 'attention-seeking' ($\chi^2 = 9.899$, $p = 0.042$), and 'unconventional' ($\chi^2 = 9.499$, $p = 0.050$).

Factor analysis

Factor analyses were conducted to explore the commonality of the identified characteristics and to reduce the dimensions. The 21 most important characteristics (those with average scores greater than 4.0) were included in this part of analysis.

Five factors are extracted by means of principal components analysis (see Table 5). The factor loadings of the 21 characteristics ranged from 0.463 to 0.771. The cumulative percentages of extraction sums of squared loading were 33.14% to 57.13%. Cronbach alphas were 0.55 to 0.82. The results showed that the five extracted factors were appropriate.

On the basis of factor analysis, six characteristics in factor 1 indicated 'an exploratory disposition'. Three characteristics in factor 2 indicated 'a problem-solving attitude'. Five characteristics in factor 3 indicated 'a problem-solving capability'. Four characteristics in factor 4 indicated 'personality traits'. Three characteristics in factor 5 indicated 'a problem-solving approach'.

General perceptions of creativity

Table 6 presents respondents' general perceptions of creativity in answering the questions posed in Part 2 of the survey. In response to Question 1, 97.4% of respondents agreed that students can improve their creative ability through learning. In response to Question 2, only 14.29% of respondents agreed that educators often encounter creative students. This result can be contrasted with Diakidoy and Kanari's [12] study, in which more than 70% of respondents agreed that educators encounter creative children often or very often. In response to Question 3, 23.37% of respondents agreed that creativity is a common characteristic of all people. This result is similar to that of Diakidoy and Kanari [12], who found that 75.5% of respondents believed that creativity is not a characteristic of all people. In response to Question 4, only 27.39% of respondents agreed that good students (in academic performance) are more likely to be creative.

DISCUSSION

Engineering academic staff perceptions of students' creativity

The results of the present study indicate that, in assessing creativity in students, academic staff members in Taiwanese engineering education emphasized:

- logical thinking and problem-solving capabilities—such as exploratory ideas, problem-finding capabilities, insight, observation skills, logic and clear thinking, questioning attitudes, flexibility, imagination, and so on;
- learning attitude—such as an enjoyment of reading, eagerness to learn, attentiveness, spontaneity, enterprise, and so on; and
- certain personality traits—such as energy, daring, and independence.

Although the respondents were from two universities with differing orientations, the perceptions of creativity were very similar. Most curricula in engineering educational institutions emphasize a pragmatic problem-solving approach, and teachers therefore favor particular characteristics in students—such as logical thinking and problem-solving capabilities. In recent years, students in engineering educational institutions have been encouraged to become problem-solvers and to equip themselves with such skills to meet the needs of manufacturing and service industries. This has led to a greater emphasis on creative problem solving and logical thinking. The findings of this study are consistent with this tendency.

Creativity among different groups and disciplines

Comparing this study with the studies of Chan and Chan [13], Montgomery and Bull [15], Diakidoy and Kanari [12], and Feist [14] reveals that perceptions of creative characteristics vary between different teachers' groups and academic disciplines.

In Chan and Chan's [13] study, primary or secondary teachers perceived extrinsic behaviors to be important characteristics of creativity, rather than intrinsic attributes—perhaps because it is relatively easy to identify creative students from

Table 6. The responses of Q2 to Q5 by respondents ($n = 154$)

	5		4		2		1	
Question	n	%	n	%	n	%	n	%
2	60	38.96	90	58.44	4	2.6	0	0
3	2	1.3	20	12.99	88	57.14	44	28.57
4	49	31.82	69	44.81	35	22.73	1	0.64
5	6	3.90	37	24.03	107	69.49	4	2.58

In question 2, 4, and 5: 5–totally agree, 4–agree, 2–disagree, 1–disagree at all
In question 3: 5–very often, 4–often, 2–sometimes, 1–rarely

verbal interactions in a school classroom. Although Chan and Chan [13] suggested that cultural factors might play a part, the findings of the present study suggest that teachers in different teaching groups have different perceptions of creativity. Teachers in universities are more likely to identify creative students by their logical thinking—perhaps because students in higher education have more opportunities to demonstrate their creative abilities in written format.

According to Montgomery and Bull [15], academic staff in American higher-education institutions emphasized cognitive skills. It seems that higher-education teachers in America and Taiwan had similar views on the attributes that are intrinsic to creativity.

Diakidoy and Kanari's [12] study and the present study shared certain characteristics—including 'imagination', 'self-confidence', 'thinking ability', 'artistic tendencies', 'problem-finding ability', and 'intelligence'. However, it is interesting to note that student teachers—who were the respondents in Diakidoy and Kanari's [12] study—perceived self-management to be important for a creative student. This characteristic was not found in the present study. It seems that different respondents have different perceptions of creativity.

According to Feist [14] '. . . creative scientists are generally more open and flexible, driven and ambitious, and although they tend to be more relatively asocial, when they do interact with others, they tend to be somewhat prone to arrogance, self-confidence, and hostility'. He also concluded that other social traits, such as autonomy, introversion, and independence, are important. Feist's [14] study and the present study share certain common traits for creative people—including openness to experience, flexibility, and independence. The characteristics that differed between the studies were 'arrogance', 'hostility', and 'ambition'. Feist suggested that creative scientists demonstrated 'dominance', 'arrogance', 'hostility', 'self-confidence', and 'achievement'. These characteristics seem to be related to management and leadership in the social sciences. However, teachers in engineering and applied science did not identify these characteristics in the present study.

Implications for engineering education

It is interesting to note that 97.4% of respondents agreed that students' creativity can be improved by learning. However, only 14.3% of respondents agreed that they were likely to meet creative students. Taken together, these findings suggest that the respondents recognized the importance of education in enhancing students' creativity, and the need for improvement in this area. In this regard, the previous studies have evidenced the enhancement of students' creative performance through the appropriate arrangement of their curricula. According to the studies, creativity was generated by making creativity a prerequisite for students in every assignment [10, 18–19, 31–32].

Based on the research findings, the present study has at least two implications for developing an engineering education program that fosters creativity. First, certain elements of creativity that are needed by engineers have been identified in this study—for example, observation and willingness to think. University teachers of engineering students should be encouraged to include these elements of creativity when designing their educational curricula.

Secondly, factor analysis of 21 creative characteristics produced five dimensions of creativity: (i) an exploratory disposition; (ii) a problem-solving attitude; (iii) a problem-solving capability; (iv) personality traits; and (v) a problem-solving approach. Of these, the second, third, and fifth are to do with learning and education, and can be improved by learning. They should be taken into account in the design of an engineering curriculum and in classroom interaction. The other dimensions noted above are essentially inherent, but they can be used in selecting or screening applicants in terms of engineering talent.

CONCLUSIONS

The conclusions of this study are as follows. First, academic staff from two different universities shared their perceptions of creativity in identifying 21 important characteristics.

Secondly, the perceptions of creativity among engineering academic staff were significantly different from those found in previous studies. Intrinsic characteristics were generally identified in this study as being more important than extrinsic characteristics. In particular, characteristics related to intellectual capacity (such as 'high intellectual ability', 'willingness to think', 'logical thinking', and so on) were emphasized. In contrast, previous studies had found that extrinsic characteristics (such as 'questioning', 'quick responses', and so on) have been identified as important attributes for a creative person by primary or secondary school teachers. Furthermore, the present study found that male respondents tended to place significantly more emphasis on these characteristics than did female respondents. It is interesting that both male and females respondents considered social traits (such as 'arrogance', 'attention-seeking', 'self-centeredness', and so on) as unimportant attributes.

Thirdly, the result of factor analyses demonstrated that the 21 items can be categorized into five dimensions: (i) an exploratory disposition; (ii) a problem-solving attitude; (iii) a problem-solving capability; (iv) personality traits; and (v) a problem-solving approach. Using these five dimensions, the present authors suggest that a model for fostering creativity in engineering education programs can be developed.

As with all research, the present study has certain limitations. First, the respondents came from two universities in Taiwan. A further study should be conducted using samples from other geographical areas to compare with the findings of the present study. Secondly, the study was restricted to engineering academic staff. Perspectives from other scientific disciplines would be worthy of further investigation.

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