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Critical creativity criteria for students in higher education: taking the interrelationship effect among dimensions into account

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Abstract It is known that the overall competitive advantages enjoyed by the Taiwanese higher education system have been decreasing in recent years relative to the educational systems of other countries. In light of aiming to become a kingdom of innovation, how to regain its competitive advantages over the very short term has become a critical issue requiring immediate attention. Based on previous research indicating that improving innovation is among the primary ways of enhancing an education system's competitive advantages, that creativity is the foundation of innovation, that organizations that truly understand human creativity and are committed to nurturing it and living with the consequences of doing so are those that are most likely to succeed, and that students are a major group to be regarded as the backbone of a nation's future development, the aim of this study is to explore critical criteria for creativity, which could significantly improve the creativity of college students. Although related studies can be found today, these studies seem to ignore the different effects of different dimensions of creativity evaluation, leading to results that are irrational and not completely suitable for real practice. In this regard, a perception of interrelationships among these dimensions is thus taken into account while calculating weights of evaluation creativity dimensions and criteria. In accordance with the result, the top six explored critical creativity criteria are shown to help enhance today's college students' creativity.

Keywords Creativity · Interrelationship effect · Multiple-criteria decision-making · Decision making trial and evaluation laboratory · Analytic network process

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1 Introduction

Today's high risks and ruthless competition found among areas of modern economic life are producing a future marked by uncertainty, complexity and high-speed change. Each industry is facing intense domestic and global competition in such a highly turbulent and uncertain environment (McCloskey 1995). When one must seek survival in such a competitive atmosphere, not only academia but businesses as well have found that continuous innovation is a key approach (Mumford 2000; Weiner 2000; DiPietro and Anoruo 2006), especially knowledge base development (Gardiner 1993). Additionally, since creativity is the foundation of innovation (Dewett and Gruys 2007), it has been confirmed that organizations that truly understand human creativity and are committed to nurturing it and living with the consequences of doing so are the ones most likely to succeed (Williamson 2001). This is because that members' creativity can be used as building blocks for organizational innovation, change, and competitiveness (Mumford 2000; Williamson 2001; Zhou and George 2003; DiPietro and Anoruo 2006), as an individual is always regarded as the source of a novel idea of an organization (Gilad 1984; Whiting 1988; Mumford 2000) which is the basic element of the organization's innovation.

Human creativity is important not only for an organization's innovation but also for an individual's work performance (Williamson 2001). To date, the most cited approach to improve creativity is to continually build member capacity in order to generate new knowledge, discover applications, and maintain the knowledge for future applications (Gardiner 1993; Chen and Chen 2009a,b,c,d). Due to this phenomenon, the higher education system is currently is a main issue for both government and academia, as it represents the basis of fostering high-tech talent, the key driver of rising national development quality and the main method of enhancing a country's competitive ability (Fairweather 2000; Meek 2000; Chen and Chen 2010). In Taiwan, the higher education system is especially important, as half of the country's overall GDP comes from the high-tech industry (Chen and Chen 2009a,b,c,d). This also derives from Taiwan's general goal of becoming a kingdom of innovation (CNA 2009a,b).

Unfortunately, Taiwan's higher education system is currently undergoing a difficult period caused by not only today's global dynamic competitive environment but also several domestic issues such as a decrease in the birth rate, economic depression, the country's joining the WTO, and an increase in the country's interaction with China, based on the report of Taiwan Assessment and Evaluation Association in 2006 (Chen and Chen 2009a). To recover from such difficulties and further regain competitive advantages, a number of studies advocate putting more effort into total quality management and innovation. While numerous measurement models for total quality management have been proposed, relatively few studies focus on innovation, especially from the perspective of evaluating student creativity, a major constituency that has already been deemed the backbone of the country's future development, though there are innovation-related studies that can be found (Gilbert et al. 1996; Driver 2001; Allison 2004; Hervani and Helms 2004; Wynder 2004).

Although creativity has been measured in many ways (Kaufman et al. 2007), studies that involve creativity criteria are highly encouraged and needed (Wolfradt and Pretz 2001) because there is surprisingly high agreement on individual-differences correlates of creativity (Batey 2007). In light of the above, the aim of this study is to explore critical criteria of creativity, highlighting factors that could significantly improve students' creativity. Although related studies can be found, these studies still seem to ignore the different effects of different dimensions of creativity evaluation, leading to irrational results that are not completely suitable for practical application. To conquer such a technical problem, the interrelatedness of the dimensions is thus taken into account during computation. In sum, owing to several

critical factors taken into account in constructing the research framework and the proposed perception taken into account during the computation process, such a problem can be handled by multiple-criteria decision-making (MCDM). This study used an integrated MCDM model based on decision making trial and evaluation laboratory (DEMATEL) and analytic network processes (ANP). The DEMATEL method is utilized to develop the interrelations between the evaluation dimensions to form an impact relations map (IRM), and the ANP is adopted to release the restriction of hierarchical structure (Yang et al. 2008). A considerable number of studies have proven the advantages and reliability of both methods for their purposes (Momoh and Zhu 2003; Lin and Wu 2008). In this study, the DEMATEL is used to explore causal relationships and different impacts among creativity evaluation dimensions. In other words, the IRM of the creativity evaluation dimensions constructed by DEMATEL then becomes a network evaluation structure for ANP analysis, which is employed to determine the relative weights of creativity evaluation criteria.

The remainder of this study is organized as follows. A literature review on creativity is illustrated in Sect. 2. The integrated MCDM model is introduced in Sect. 3. A numerical study is conducted in Sect. 4. Discussions and implications are in Sect. 5 and finally, the conclusion is presented.

2 Literature review on creativity

2.1 What is creativity

Creativity is dynamic and varies between studies or disciplines due to its diversify and multi-faceted nature (Sternberg 1988, 1999). For instance, one can find over 60 definitions of creativity within the field of psychology (Taylor 1988).

The understanding of creativity continues to improve and evolve (Weiner 2000). Creativity can be deemed the production of novel and useful ideas or solutions (Amabile 1988; Oldham and Cummings 1996; Shalley 1991; Zhou and George 2001). Allison suggests that creativity is a combination of novelty, knowledge, intelligence and personality characteristics (Allison 2004). In addition, creativity can be seen as the interrelationships between individuals and their environment that determine whether they exhibit creativity (George and Zhou 2001; Oldham and Cummings 1996; Woodman et al. 1993; Zhou 2003). One may also consider the cognitive and individualistic perspective with regard to learning and education, and more specifically, with regard to problem solving (Guilford 1977; Flowers and Hayes 1981; Sternberg and Davidson 1985; Walberg 1988; Mokyr 2002). Williamson advocates that creativity is a learned skill and atrophies when it is not practiced; that is, it is something that can be taught and learned when individuals are given appropriate support, encouragement and reward (Williamson 2001). It can also be the constant recycling and recombination of a finite stock of ideas (Magee 2005). Mumford claims that creativity is an activity that requires time for one to think before work begins (Mumford 2000). In sum, according to Chen and Chen, who in 2009 summarize related studies, creativity can be seen as a complex human perception-action process that turns not just a novel but also useful idea into a practical action that others have not yet figured out or done.

2.2 Creativity evaluation criteria summarization

Because the meaning of creativity varies between disciplines, to date, there is no confirmed way of precisely evaluating creativity (Furnham et al. 2008). As mentioned previously, studies

that highly involve different evaluation criteria are encouraged because there is surprisingly high agreement on individual differences correlates of creativity (Batey 2007); this approach is believed to be necessary to try and could capture the many nuances of creativity (Wolfradt and Pretz 2001). In consideration of the characteristics of creativity, unique and complex concepts, and dynamic meaning (Chen and Chen 2009a,b,c,d), as well as the aim of this study, related creativity evaluation criteria are summarized in Table 1. Owing to a lack of studies on higher education (Chen and Chen 2009a,b,c,d), the hierarchical structure of creativity, proposed by Wu et al. (2009), is also adopted, which will be explained in detail in a later section.

2.3 Creativity, innovation, and higher education

In the past 10 years, there has not been as much emphasis placed on knowledge-oriented measurement among organizations and industries as there is today, especially among public organizations such as higher education institutes (Sanchez and Elena 2006). However, owing to globalization's having made today's world highly competitive, each organization and industry has no choice but to face this competition and seek new ways to survive. As previously mentioned, innovation plays a key role in helping organizations to gain competitive advantages. Because innovation comes from human creativity and human creativity comes from knowledge generalization, the responsibility of higher education has thus increased greatly in recent years.

In Taiwan, despite the above-mentioned domestic and international competitive pressures, due to an increasing number of universities, the government has each year decreased its funding of education. Additionally, having been given greater authority in enrolling new students, increasing various departments and fundraising through channels, universities in Taiwan have called for building closer relationships with industrial circles and markets for raising administrative funds. At the same time, universities also need to reward them by providing innovative techniques and research findings. Taiwanese universities can no longer maintain their academic freedom or preserve their independent roles as in the past. On the contrary, they have to resort to an effective solution such as improving innovation that can strengthen academic competition in the future (Wu et al. 2010).

Unfortunately, Taiwanese students usually lack the motivation to explore and pursue innovative activities because there is pressure coming from examinations, which has existed since their first semester as elementary school students. Accompanying the social consciousness of the importance of student creativity today, how to foster future students with creativity and to enhance current students' creativity have become urgent issues for the Taiwanese education system, especially the higher education system, due to creativity's critical roles such as fostering high-tech talent, the key driver of national development quality and the country's competitive standing (Fairweather 2000; Meek 2000; Chen and Chen 2010). Additionally, Taiwanese Ministry of Education recently proposed creativity-related policies to make Taiwan become the Republic of Creativity (ROC) so as not only to foster continuous learning, engender creative lifestyles, provide differentiation in students and lively learning environments, and shape an innovative and diverse cultural climate but also to meet the country's goal of becoming the kingdom of innovation (Ministry of Education 2002).

Although such a policy is at first glance full of considerable foresight, more precise indications for guiding universities to engender creativity are still lacking and needed. Hence, the aim of this study is to explore critical creativity criteria that could significantly improve students' creativity. Creativity evaluation criteria, summarized in Table 1, and the hierarchical

Table 1 Creativity evaluation criteria summarization

Authors	Creativity factors
Guilford (1950)	Intelligence or personality
Barron (1955) and Mumford (2003)	The production of an idea or product that is both novel and useful
Ghiselin (1963) and Mumford and Gustafson (1988)	The production of useful new ideas, or ideas that can be implemented to solve some significant novel problem
Owens (1969)	Skill in combining and reorganizing concepts
Amabile (1983, 1996), Eysenck (1993), Guilford (1950), Woodman and Schoenfeldt (1989), Runco and Chand (1994), Dodds et al. (2002) and Moss (2002)	1. Cognitive ability, personality factors, cognitive style, motivation, stimulation, evaluation knowledge and the environment (based on individual domain)
	2. Organizational encouragement (e.g., an organizational culture that supports creativity), supervisor encouragement, workgroup support (e.g., a diverse and open workgroup), sufficient resources, challenging work, and freedom
Weisburg (1986), Kulkarni and Simon (1990), Qin and Simon (1990), Redmond et al. (1993), Erickson and Charness (1994) and Baer (1998)	Expertise or knowledge acquired with experience that influences peoples' ability to generate viable, original solutions to novel problems
Amabile (1988), Shin and Zhou (2003), Tierney et al. (1999), George and Zhou (2001), Oldham and Cummings (1996), Tierney et al. (1999) and Zhou (2003)	Leadership, supervisory behaviors, organizational systems, procedures, and processes
Mumford and Gustafson (1988)	Cognition and information processing
Simonton (1988)	Experience or time working in a field
Tardif and Sternberg (1988)	1. Use of existing knowledge as base for new ideas
	2. Relatively high intelligence, originality, verbal fluency and a good imagination
Martindale (1989)	Extraversion as a characteristic
Qin and Simon (1990) and Zuckerman and Cole (1994)	The availability of relevant information along with access to strategic sites and strategic materials
Shalley (1991)	Production goals and low discretion lead to limited innovation
Mumford et al. (1994)	The systematic screening and manipulation of applicable representations to identify relevant goals, procedures, key information, and restrictions
James (1995)	Conflict among task goals
Scott (1995)	Managing by directing process and approach rather than specifying a single desired outcome
Baughman and Mumford (1995)	The use of diverse concepts, multiple features, and multiple strategies for linking features as well as elaborative exercises focusing on the ability of new concepts to account for anomalies within a broader pattern of observations
Davidson (1995)	People actively search for key relevant facts, seek to identify anomalies or inconsistent observations, and examine a variety of different concepts, particularly concepts relevant to long-term goals that might be used to organize this information
Amabile (1996) Sternberg (2003) and Lubart and Guignard (2004)	Abilities, knowledge, thinking styles, personality, attitude, motivation, and environment

Table 1 continued

Authors	Creativity factors
Kasoff (1997) and Brophy (1998)	Usefulness, impact, originality, others' likely reactions, and the source of the idea, among other considerations
Leonard (1998)	Knowledge management and knowledge-building activities
Williamson (1998)	Learning
Zhou (1998)	Positive, informative feedback provided under conditions of high autonomy
Cropley (1999)	Phases for planning and preparation, ideation, verification and communication
Ripple (1999)	Suitable forms of teaching
Fagerberg (1999) and DiPietro and Anoruo (2006)	Innovation, technology, technology transfer, and startups
Bharadwaj and Menon (2000)	Intelligence, motivation to innovate, and creative skills
Mumford (2000)	1. The combination and reorganization of information and concepts to advance new understandings or new conceptual systems 2. Selecting people for skill in combining concepts
Williamson (2001)	1. Companies employ and develop flexible, innovative employees and a trust-based organization 2. Organizational culture 3. Sound foundations of training, education and understanding and emerges as people, within a particular domain of knowledge practice high-level skills of problem-solving, communication and analysis
Gelade (2002)	Personality
Mokyr (2002)	A limited number of 'tight' analogies drawn from the inventor's existing epistemic base, that collection of principles and techniques that form the basis of his or her expertise
Mody and Yilmaz (2002)	The transfer of knowledge
Zhou and George (2003)	Identifying a problem or an opportunity; gathering information and resources; generating ideas; evaluating, modifying, and communicating ideas; and implementing ideas
Sternberg (2005)	Domain specific; involves the time and effort needed to invest

Sources Authors developed

structure of creativity, proposed by Wu et al. (2009), are adopted to be the basis of the research structure of this study. In the following section, the integrated MCDM model which is based on decision making trial and evaluation laboratory (DEMATEL) and the analytic network process (ANP) is introduced so as to better explain how the importance ranking of creativity evaluation criteria is confirmed and how critical creativity evaluation criteria are identified in the later computation.

3 The integrated MCDM model

3.1 Decision making trial and evaluation laboratory

The DEMATEL was adopted to develop the interrelations between evaluation criteria to form an IRM (Yang et al. 2008). The calculation steps can be described as follows (Yu and Tseng 2006; Liou et al. 2007; Yang et al. 2008):

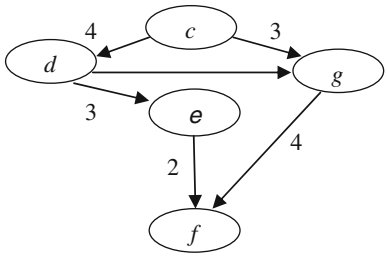


Fig. 1 An influential map

Step 1: Calculate the initial average matrix by scores.

This study assumed that a group of sample experts are asked to indicate the direct effect among elements (evaluation criteria) in accordance with their perception of the degree to which each element i exerts on each other element j, as presented by $a_i\,j$, by utilizing a scale ranging from 0 (no influence) to 5 (very high influence). On the basis of groups of direct matrices from samples of experts, an average matrix $\boldsymbol{A}$, in which each element is the mean of the corresponding elements in the experts' direct matrices, can then be generated.

Step 2: Calculate the initial influence matrix.

While completing the normalization of the average matrix $\boldsymbol{A}$, the initial influence matrix $\boldsymbol{D}$, $[d_{ij}]_{n\times n}$, is calculated so that all principal diagonal elements equal zero. In accordance with $\boldsymbol{D}$, the initial effect that an element exerts and/or acquires from each other element is given. The map, as shown in Fig. 1, illustrates a contextual relationship among the elements within a complex system; each matrix entry can be seen as the strength of its influence. In Fig. 1, an arrow from d to g means that d influences g with an influence score of 1. Therefore, it can then translate the relationship between the causes and effects of various measurement criteria into a comprehensible structural model of the system based on the degree of influence.

Step 3: Create the full direct/indirect influence matrix.

The indirect effects of problems decrease when the powers of $\boldsymbol{D}$ increase, e.g., $\boldsymbol{D}^2, \boldsymbol{D}^3, \ldots, \boldsymbol{D}^4$, which guarantees convergent solutions for the inverted matrix. As shown by Fig. 1, the effect of c on d is greater than that of c on g. Based on this, an infinite series of both direct and indirect effects is derived. Let the (i, j) element of matrix $\boldsymbol{A}$ be presented by a_{ij}; the direct/indirect matrix can then be acquired through Eqs. 1–4 as follows:

$$\boldsymbol{D} = s * A, \quad s > 0 \tag{1}$$

or

$$[d_{ij}]_{n\times n} = s[a_{ij}]_{n\times n}, \quad s > 0, \quad i, j \in \{1, 2, \ldots, n\}, \tag{2}$$

Where

$$s = \text{Min}\left[\frac{1}{\max_{1\leqslant i\leqslant n}\sum_{j=1}^{n}|a_{ij}|}\,\frac{1}{\max_{1\leqslant i\leqslant n}\sum_{i=1}^{n}|a_{ij}|}\right] \tag{3}$$

and

$$\lim_{m\to\infty}\boldsymbol{D}^m = [0]_{n\times n} \text{ where } \boldsymbol{D} = [d_{ij}]_{n\times n}, \quad 0 \leqslant d_{ij} < 1. \tag{4}$$

Then, the total-influence matrix $\boldsymbol{T}$ can be obtained by utilizing Eq. 5. Here, $\boldsymbol{I}$ is the identity matrix.

$$\boldsymbol{T} = \boldsymbol{D} + \boldsymbol{D}^2 + \cdots + \boldsymbol{D}^m = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1} \quad \text{when } m \to \infty. \tag{5}$$

If the sum of rows and the sum of columns are represented by vectors r and c, respectively, in the total-influence matrix $\boldsymbol{T}$, then

$$\boldsymbol{T} = [t_{ij}], \quad i, j = 1, 2, \ldots, n, \tag{6}$$

$$r = [r_i]_{n\times 1} = \left(\sum_{j=1}^{n} t_{ij} \right)_{n\times 1}, \tag{7}$$

$$c = [c_j]'_{1\times n} = \left(\sum_{i=1}^{n} t_{ij} \right)'_{1\times n}, \tag{8}$$

where the superscript apostrophe denotes transposition.

If r_i represents the sum of the ith row of matrix $\boldsymbol{T}$, then r_i represents the sum of both direct and indirect effects of factor i on all other criteria. In addition, if c_j represents the sum of the jth column of matrix $\boldsymbol{T}$, then c_j represents the sum of both direct and indirect effects that all other factors have on j. Furthermore, when $j = i$, the value produced by the row and column aggregates, $(r_i + c_i)$, provides an indicator of influential strength that is given and received. That is, if $(r_i + c_i)$ is positive, then factor i affects other factors, and if it is negative, then factor i is affected by other factors (Tzeng et al. 2007; Liou et al. 2007; Yang et al. 2008).

Step 4: Confirm the threshold value (α) and generate the IRM.

Last, a threshold value, α, should be set by taking into account the sample experts' opinions in order to ignore minor effects presented in matrix $\boldsymbol{T}$'s elements (Yang et al. 2008). That is, decreasing the complexity of the IRM requires a threshold value determined by the decision-maker for the influence degree of each factor. If the influence level of an element in matrix $\boldsymbol{T}$ is higher than the threshold value, then this element is included in the final IRM (Liou et al. 2007; Yang et al. 2008).

In the following section, the ANP and its calculation steps are introduced to overcome the problem of interdependence and feedback among each measurement criterion generated by the DEMATEL.

3.2 Analytic network process

The ANP is utilized in MCDM to release the restriction of a hierarchical structure (Yang et al. 2008); its steps for calculation can be illustrated as follows (Huang et al. 2005; Yang et al. 2008).

Step 5: Form a supermatrix by using criteria comparison in the system

This can be accomplished using pair-wise comparisons. The relative importance-values of pair-wise comparisons can be categorized from 1 (equal importance) to 9 (extreme inequality in importance) (Saaty 1980). The following is the general form of the supermatrix (Fig. 2) (Yu and Tseng 2006; Liou et al. 2007), where C_m represents the mth cluster, e_{mn} represents the nth element in the mth cluster, and W_{ij} is the principal eigenvector of the effect of the elements compared in the jth cluster to the ith cluster. If the jth cluster has no impact on the ith cluster, then $W_{ij} = [0]$ (Huang et al. 2005; Yu and Tseng 2006).

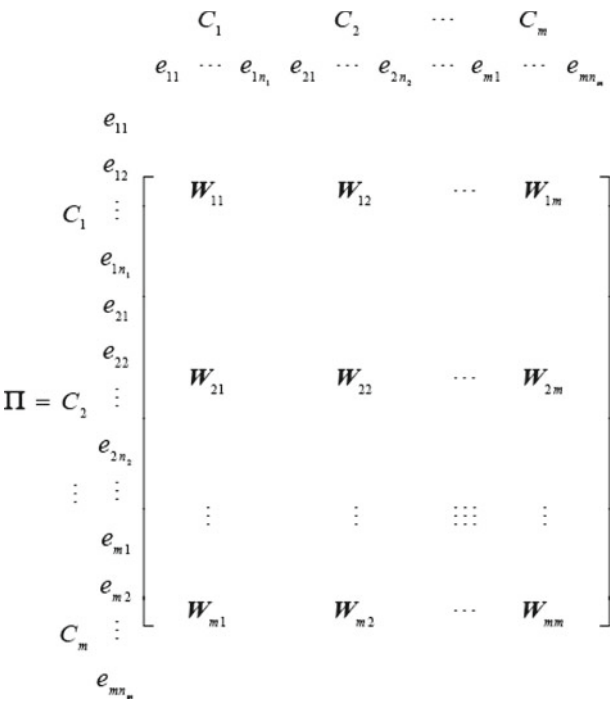
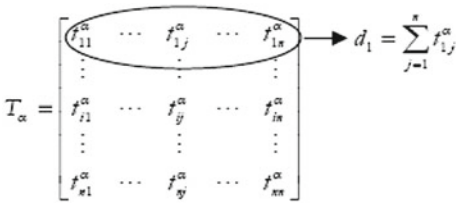


Fig. 2 The general form of the supermatrix

Step 6: Acquire the weighted supermatrix by multiplying the normalized matrix based on the result of the DEMATEL (Yang et al. 2008)

Traditionally, the way used to derive the weighted supermatrix is to transform each column to sum to unity. As elements in columns where they belong are divided by the number of clusters, columns will sum to unity. Such a normalization method traditionally assumes that influences among clusters have equal weights, which may not suit the real world, as there may exist different effect levels between clusters. Therefore, to overcome such an irrational problem, Yang et al. (2008) propose a novel hybrid model to combine DEMATEL with ANP, which we demonstrate as follows.

IRM is first developed by DEMATEL, as stated previously; then, using total-influence matrix $\boldsymbol{T}$ and a threshold value, α, a new matrix is developed. In matrix $\boldsymbol{T}$, the value of each cluster is set to zero if its value is less than α, and this new matrix is named an α-cut total-influence matrix $\boldsymbol{T}_\alpha$ (as Eq. 9).



if $t_{ij} < \alpha$, then $t_{ij}^{\alpha} = 0$; Otherwise, $t_{ij}^{\alpha} = t_{ij}$. After that, α-cut total-influence matrix T_{α} is next normalized by using Eq. 10 below and is renamed as $\boldsymbol{T_s}$ (as Eq. 11 presented).

$$d_i = \sum_{j=1}^{n} t_{ij}^{\alpha}, \tag{10}$$

$$\boldsymbol{T_s} = \begin{bmatrix} t_{11}^{\alpha}/d_1 & \cdots & t_{1j}^{\alpha}/d_1 & \cdots & t_{1n}^{\alpha}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\alpha}/d_i & \cdots & t_{ij}^{\alpha}/d_i & \cdots & t_{in}^{\alpha}/d_i \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{\alpha}/d_3 & \cdots & t_{nj}^{\alpha}/d_3 & \cdots & t_{nn}^{\alpha}/d_3 \end{bmatrix}. \tag{11}$$

Then, the weighted supermatrix (W_w) can be derived by Eq. 12 using the normalized α-cut total-influence matrix $\boldsymbol{T_s}$.

$$W_w = \begin{bmatrix} t_{11}^{s} \times W_{11} & t_{21}^{s} \times W_{12} & \cdots & \cdots & t_{n1}^{s} \times W_{1n} \\ t_{12}^{s} \times W_{21} & t_{22}^{s} \times W_{22} & \vdots & & \vdots \\ \vdots & \cdots & t_{ji}^{s} \times W_{ij} & \cdots & t_{ni}^{s} \times W_{in} \\ \vdots & & \vdots & & \vdots \\ t_{1n}^{s} \times W_{n1} & t_{2n}^{s} \times W_{n2} & \cdots & \cdots & t_{nn}^{s} \times W_{nn} \end{bmatrix} \tag{12}$$

where $t_{ij}^{s} = t_{ij}^{\alpha}/d_i$

Step 7: Limiting the weighted supermatrix by raising it to a sufficiently large power k.

This can be done by using Eq. 13 until the weighted supermatrix (W_w) becomes convergent and sufficiently stable to acquire global priority vectors (weight).

$$\lim_{k \to \infty} W_w^k \tag{13}$$

4 A numerical study

Develop the research structure of this study is sophisticated and must be suitable for practical application. For acquiring precise results, the creativity evaluation criteria, summarized in Table 1, and a hierarchical structure of creativity, which is proposed by Wu et al. (2009), are adopted to be the basis of this study's research structure. The final research structure is provided as Table 2.

In this section, we aim to explore critical creativity criteria that could significantly improve students' creativity, adopting the integrated MCDM model of DEMATEL and ANP. Typically, DEMATEL procedures are initially used to develop the network structure, and ANP procedures are then utilized to compute the limited supermatrix to explore the weights of evaluation criteria in the network structure. A total of 60 expert questionnaires sent to university faculties. Of them, 34 were returned, after discarding 1 questionnaire for statistical reasons. The overall response rate was 55% or a total of 33 expert questionnaires for analysis. Among them, 19 (58%) were male and 14 (42%) were female. The background groups are professors (30%), associate professors (24%), assistant professors (39%), and lecturers (7%). Additionally, 10% of respondents were from research-intensive universities, 30%

Table 2 The research structure of this study

Goal	Evaluation dimensions	Evaluation criteria
To identified critical creativity criteria for college students	Personality Trait (D1)	Knowledge Learning (C1)
		Self-Motivation (C2)
		Personal Characteristics (C3)
	University Effect (D2)	University Climate (C4)
		Interaction between Student and Faculty (C5)
		Student Interaction (C6)
	Family Influence (D3)	Family Living Style (C7)
		Parents' Ways of Fostering Children (C8)
		Children's Recognition of Learning Model (C9)
	Society Education and Interaction (D4)	Culture-level Influence (C10)
		Educational-level Enhancement (C11)

Table 3 The average initial direct-relation 4*4 matrix $\boldsymbol{A}$

	D1	D2	D3	D4
D1	0	1.03	1.11	0.47
D2	3.61	0	0.19	1.53
D3	4.59	0.06	0	0.17
D4	3.91	2.03	1.33	0

of respondents were from professional-intensive universities, 35% respondents were from research and teaching-intensive universities; 21% respondents were from teaching-intensive universities, and 14% respondents were from education-in-practical-intensive universities. Their weightings with regard to the impact effect between each creativity evaluation dimension, a scale ranging from 0 (no influence) to 5 (very high influence) were utilized. With respect to the importance of creativity evaluation dimensions and criteria, the 5-point scale used ranged from 1 (equal importance) to 9 (extreme inequality in importance) based on the senior experts' professional experiences.

The interrelationships among the creativity evaluation dimensions then needed to be determined. A total of 33 senior experts were asked to provide the level of influence of relationships among the creativity evaluation dimensions. Based on the senior experts' ratings, the average initial direct-relation 4*4 matrix $\boldsymbol{A}$ was constructed, as shown in Table 3.

Next, adopting *steps* (Eqs. 1–6) of the section of DEMATEL, the total-influence 4*4 matrix $\boldsymbol{T}$, which is given as Table 4, was obtained. Further, for maintaining the prominence of important relationships, the threshold value was set to 0.2311 after discussion with senior experts and reaching an agreement. The α-cut total-influence 4*4 matrix $\boldsymbol{T}_\alpha$ is presented as Table 5.

The results of DEMATEL show different impact levels among creativity evaluation dimensions, and the traditional normalized method is thus irrational (Yang et al. 2008). In this study, an integrated MCDM model in accordance with DEMATEL and ANP was utilized. The DEMATEL was to compute the α-cut total influence 4*4 matrix $\boldsymbol{T}_\alpha$, as provided in

Table 4 Total influence 4*4 matrix $\boldsymbol{T}$

	D1	D2	D3	D4
D1	0.3396	0.2311	0.2363	0.1408
D2	0.9283	0.2236	0.2328	0.3230
D3	0.8801	0.1676	0.1606	0.1193
D4	1.1407	0.4966	0.4044	0.1877

Table 5 α-cut total influence 4*4 matrix $\boldsymbol{T}_{\alpha}$

	D1	D2	D3	D4
D1	0.3396	0.0000	0.2363	0.0000
D2	0.9283	0.0000	0.2328	0.3230
D3	0.8801	0.0000	0.0000	0.0000
D4	1.1407	0.4966	0.4044	0.0000

Table 6 The normalized α-cut total influence 4*4 matrix $\boldsymbol{T}_{\boldsymbol{s}}$

	D1	D2	D3	D4
D1	0.5897	0.0000	0.4103	0.0000
D2	0.6255	0.0000	0.1569	0.2176
D3	1.0000	0.0000	0.0000	0.0000
D4	0.5587	0.2432	0.1981	0.0000

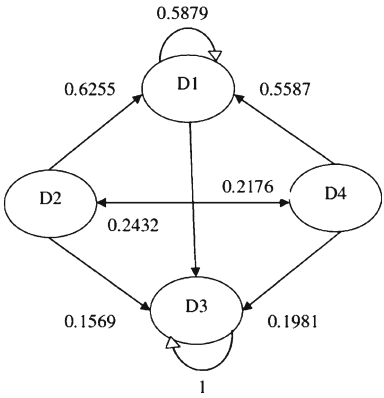


Fig. 3 The IRM and network evaluation structure of creativity

Table 6. Through Eqs. 9–12, the IRM (i.e., the network evaluation structure of ANP) is further constructed to accurately reflect the complicated causal relationships among creativity evaluation dimensions. Referring to Table 6, the network evaluation structure of ANP is provided in Fig. 3.

Based on the interrelationship and the influence levels between creativity evaluation dimensions (as Fig. 3), the unweighted 11*11 supermatrix of creativity evaluation criteria $\boldsymbol{W}$ was obtained as shown in Table 7 after using the perspectives of 33 senior educational experts and *Step 5*. After that, the weighted 11*11 supermatrix of creativity evaluation criteria $\boldsymbol{W}_{\boldsymbol{w}}$, revealed as Table 8, was computed by Eq. 12. To confirm the global weights of creativity evaluation criteria, Eq. 13 was utilized to determine the limiting supermatrix ($\boldsymbol{W}_{\boldsymbol{final}}$). The

Table 7 The unweighted 11*11 matrix of creativity evaluation criteria $\boldsymbol{W}$

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	1.000	0.000	0.000	0.180	0.270	0.180	0.270	0.150	0.160	0.040	0.160
C2	0.000	1.000	0.000	0.390	0.320	0.290	0.350	0.360	0.410	0.390	0.410
C3	0.000	0.000	1.000	0.430	0.410	0.530	0.380	0.490	0.430	0.570	0.430
C4	0.140	0.030	0.210	1.000	0.000	0.000	0.120	0.140	0.040	0.020	0.210
C5	0.470	0.590	0.430	0.000	1.000	0.000	0.540	0.470	0.550	0.510	0.460
C6	0.390	0.380	0.360	0.000	0.000	1.000	0.340	0.390	0.410	0.470	0.330
C7	0.410	0.330	0.430	0.330	0.370	0.360	1.000	0.000	0.000	0.290	0.330
C8	0.510	0.460	0.530	0.500	0.490	0.380	0.000	1.000	0.000	0.460	0.500
C9	0.080	0.210	0.040	0.170	0.140	0.260	0.000	0.000	1.000	0.250	0.170
C10	0.310	0.430	0.370	0.510	0.470	0.340	0.490	0.270	0.540	1.000	0.000
C11	0.690	0.570	0.630	0.490	0.530	0.660	0.510	0.730	0.460	0.000	1.000

Table 8 The weighted 11*11 matrix of creativity evaluation criteria $\boldsymbol{W_w}$

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	0.590	0.000	0.000	0.113	0.169	0.113	0.270	0.150	0.160	0.022	0.089
C2	0.000	0.590	0.000	0.244	0.200	0.181	0.350	0.360	0.410	0.218	0.229
C3	0.000	0.000	0.590	0.269	0.256	0.332	0.380	0.490	0.430	0.318	0.240
C4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.005
C5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.134	0.124
C6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.114
C7	0.168	0.135	0.176	0.052	0.058	0.056	0.000	0.000	0.000	0.057	0.065
C8	0.209	0.189	0.217	0.078	0.077	0.060	0.000	0.000	0.000	0.091	0.099
C9	0.033	0.086	0.016	0.027	0.022	0.041	0.000	0.000	0.000	0.050	0.034
C10	0.000	0.000	0.000	0.111	0.102	0.074	0.000	0.000	0.000	0.000	0.000
C11	0.000	0.000	0.000	0.107	0.115	0.144	0.000	0.000	0.000	0.000	0.000

final results are summarized in Table 9 along with the rankings of each creativity evaluation criteria. Based on Table 9, the most critical creativity criterion is "Personal Characteristic (C3), $w = 0.3125$," followed by "Self Motivation (C2), $w = 0.2656$," "Parents' way of Fostering Children (C8), $w = 0.1456$," "Knowledge Learning (C1), $w = 0.1403$," "Family Living Style (C7), $w = 0.1132$," and "Children's Recognition of Learning Model (C9), $w = 0.0320$."

5 Discussions and implications

Under circumstances where improving innovation is among the main ways for an education system to create competitive advantages, where creativity is the foundation of innovation, where organizations that really understand human creativity and are committed to nurturing it and living with the consequences of doing so are the ones most likely to succeed, and where students are a major constituency already deemed the backbone of the country's

Table 9 The limiting 11*11 supermatrix for creativity evaluation criteria W_{final} and ranking

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	Ranking
C1	0.1403	0.1403	0.1403	0.1403	0.1403	0.1403	0.1403	0.1403	0.1403	0.1403	0.1403	4
C2	0.2656	0.2656	0.2656	0.2656	0.2656	0.2656	0.2656	0.2656	0.2656	0.2656	0.2656	2
C3	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	1
C4	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	7
C5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	7
C6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	7
C7	0.1132	0.1132	0.1132	0.1132	0.1132	0.1132	0.1132	0.1132	0.1132	0.1132	0.1132	5
C8	0.1456	0.1456	0.1456	0.1456	0.1456	0.1456	0.1456	0.1456	0.1456	0.1456	0.1456	3
C9	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	6
C10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	7
C11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	7

* Weight <0.0001

development, this study attempts to explore critical creativity criteria that could significantly improve students' creativity. Although similar studies can be found today, these studies seem to ignore the different effects of creativity evaluation dimensions, leading to results that are irrational and not completely suitable for practical applications. In this study, while taking the interrelationships among dimensions into account, an integrated MCDM model containing DEMATEL and ANP is adopted to achieve the aim.

In accordance with the result, obviously, students' Personality Traits (D1) and Family Influence (D3) are two main dimensions believed to have a significant effect on determining whether a student is creative or could become creative. Then, all of the evaluation criteria [Personal Characteristic (C3), Self Motivation (C2), Parents' way for Fostering Children (C8), Knowledge Learning (C1), Family Living Style (C7), and Children's Recognition of Learning Model (C9)] along these two dimensions are further extracted so as to precisely indicate how best to improve these two creativity evaluation dimensions in order to more successfully enhance students' creativity.

As modesty and silence are two cultural values in Asia, including Taiwan, a majority of students, regardless of their educational system, always intend to remain speechless or passive in class, especially within higher education systems. Such a personality trait is far from that associated with creativity, the particular goal of higher education, the basis of fostering high-tech talent, the key driver of national quality, and the country's competitiveness (Fairweather 2000; Meek 2000; Chen and Chen 2010).

To improve upon today's students' negative personality traits, changing a student's personal characteristics especially from their surrounding situations takes top priority. In accordance with previous studies, it is believed that putting students in a permanent framework of ambiguity and amidst a confusion of conflicting ideologies, rather than placing them in the context of bureaucratic rules, academic conventions, and the demands of external agencies (Clegg 2008), are encouraged ways of making students more creative. More precisely, teachers are therefore encouraged to hold non-periodical team or personal class projects or critical issue debates to make students not only involve themselves in ambiguous situations but also become practiced in brainstorming and thus to further stimulate students' creativity (Katz 1978; Wu et al. 2010).

Additionally, self-motivation is also crucial for improving students' creativity. Currently, both studies and businesses highly emphasize the importance of providing motivation and pay less attention to increasing self-motivation. Based on the investigation of past experiences in teaching in higher education, students with high self-motivation are more likely to perform well with classwork than those with low self-motivation. This is also supported by research (Cox 2008). Thus, teachers are advised to amend the classical teaching style, lecturing (Chen and Chen 2009a,b,c,d), to incorporate a more activity-oriented approach. That is, they are advised to make students like to engage in what they are learning and not just make students learn. Otherwise, helping students overcome their limitations and reach their goals is also a good approach. Teachers are encouraged to either raise their grade evaluation standards or to make goals difficult to achieve within activity-oriented classes so that students cannot just involve themselves in learning but must also strive to acquire high scores as well. Such a process could therefore unconsciously train students to enhance their creativity (Clegg 2008).

It has been discovered that students who perform well with this kind of learning could thus be more likely to develop creativity (Getzel and Jackson 1962; Torrance 1963). In this regard, continuous knowledge learning is also a critical part in enhancing students' creativity. Teachers are therefore suggested to diversify or extend what they teach; that is, they are suggested to stop simply focusing on textbooks. Specifically, providing the latest social news, the latest related knowledge, and case studies is encouraged, particularly case studies, as they involve debate opportunities, during which students can conduct brainstorming. Unfortunately, in Taiwan, awareness of the importance of case studies is still on the rise and continues to have room to improve (Chen and Chen 2009a,b,c,d). Therefore, case study is highly recommended as a knowledge-related method of significantly improving students' creativity.

Despite the university life, family influence is also a critical factor that could greatly impact a student's creative development (Hitchfield 1973; Siegelman 1973), due to the effect of the family's being long-term oriented and hesitant to change. In most Taiwanese families, parents are highly protective of their children. However, such an approach has been shown to decrease a child's creativity (Siegelman 1973).Therefore, parents are encouraged to give their children more privacy and self-determination so as to let their children independently develop and solidify their own creativity.

It has been confirmed that a student who does not have a warm family has more creativity than a student who has a warm family (Hitchfield 1973). Since it is irrational to advocate having a difficult family setting, parents are advised to give their children more chances to present their thoughts and opinions, including challenges if these challenges are constructive and positive. On the contrary, demanding that a student highly obey a family's golden role is not recommended, as such a style will decrease a student's creativity.

Moreover, social learning/mimicry can influence a student's creativity. Traditionally, in Taiwan, neighbors or relatives are used to comparing their children to those of others. Furthermore, within each family, parents are sometimes used to comparing their children with one another. Since this is shown to have an impact on students' development of creativity, parents are therefore suggested to discreetly choose their children. An example of this is encouraging children to follow or make a benchmark of a university classmate who has shown great academic performance. Doing so presents a promising opportunity to improve childrens' creativity.

Though there are still a number of creativity criteria that must be achieved to comprehensively improve students' creativity within the context of higher education, based on the concept of the 80/20 principle and a group committee of senior higher education experts' opinions, the study claimed that the top six creativity evaluation criteria could provide significant performance while improving students' creativity. Hence, the higher education system

and parents are both encouraged to pursue the top six creativity criteria along with provided suggestions. When this is accomplished, it is then recommended to pursue other creativity criteria to further improve or enhance the creativity of university students.

6 Conclusion

It is known that organizations in each industry today face great domestic and international competition. As improving creativity to further enhance innovation has been deemed a critical driver of competitive advantages on an international scale, the responsibility of the higher education system has thus increased drastically, especially in Taiwan, where it is the foundation of fostering high-tech talent and the key driver of national quality as well as the country's competitiveness. However, the Taiwanese higher education system is rapidly losing its competitive advantages against systems of other countries and is falling short of the country's goal of becoming a kingdom of innovation. Under the propositions that improving innovation is among the main ways for a nation to develop competitive advantages, that creativity is the foundation of innovation, that organizations that truly understand human creativity and are committed to nurturing it and living with the consequences of doing so are the ones most likely to succeed, and that students are a major constituency already considered the backbone of a nation's development, the study aims to explore critical creativity criteria that could significantly improve students' creativity. Although similar studies can be found, most of these studies do not take the interrelatedness of the dimensions into account, making the results irrational and not completely suitable for practical applications. This study conquers this technical problem at the computational stage. According to the study's results, six critical creativity criteria are confirmed to help maintain and even enhance today's college students' creativity.

References

Allison, D.: Creativity, students' academic writing, and EAP: exploring comments on writing in an English language degree programme. J. Engl. Acad. Purp. **3**, 191–209 (2004)

Amabile, T.M.: The Social Psychology of Creativity. Springer, New York (1983)

Amabile, T.M: A model of creativity and innovation in organizations. In: Staw, B.M., Cummings, L.L. (eds.) Research in Organizational Behavior, pp. 123–167. JAI, Greenwich (1988)

Amabile, T.M.: Creativity in Context: Update to the Social Psychology of Creativity. Westview Press, Boulder (1996)

Baer, J.: The case for domain specificity of creativity. Creat. Res. J. **11**, 173–178 (1998)

Barron, F.: The disposition toward originality. J. Abnorm. Soc. Psychol. **51**, 478–485 (1955)

Batey, M.D.: A psychometric investigation of everyday creativity. Unpublished doctoral thesis, University of London (2007)

Baughman, W.A., Mumford, M.D.: Process-analytic models of creative capacities: operations influencing the combination and reorganization process. Creat. Res. J. **8**, 37–62 (1995)

Bharadwaj, S., Menon, A.: Making innovation happen in organizations: individual creativity mechanisms, organizational creativity mechanisms or both? J. Prod. Innov. Manag. **17**, 424–434 (2000)

Brophy, D.R.: Understanding, measuring, and enhancing individual creative problem solving efforts. Creat. Res. J. **11**, 123–150 (1998)

Chen, I.S., Chen, J.K.: Improvement in national innovation: student creativity and innovative universities. Manuscript submitted for publication (2009a)

Chen, I.S., Chen, J.K.: To be a creative student: a study on secondary education system. Manuscript submitted for publication (2009b)

Chen, J.K., Chen, I.S.: A network hierarchical feedback system for Taiwanese universities based on the integration of total quality management and innovation. Manuscript submitted to a journal (2009c)

Chen, J.K., Chen, I.S.: TQM measurement model for biotechnology industry in Taiwan. Expert Syst. Appl. **36**(5), 8789–8798 (2009d)
Chen, J.K., Chen, I.S.: A pro-performance appraisal system for the university. Expert Syst. Appl. **37**, 2108–2116 (2010)
Clegg, P.: Creativity and critical thinking in the globalised university. Innov. Educ. Teach. Int. **45**(3), 219–226 (2008)
CNA: Taiwan Breaking News. http://gov.cna.com.tw/ReadNews/FeatureNews_Read.aspx?TopicNo=86&ID=200901170227 (2009a). Retrieved 8 Aug 2009
CNA: Taiwan Breaking News. http://gov.cna.com.tw/ReadNews/FeatureNews_Read.aspx?TopicNo=86&ID=200901170030&pageNum=1 (2009b). Retrieved 8 Aug 2009
Cox, S.: How to unleash your creativity. Balanced Existence. http://www.pickthebrain.com/blog/unleash-your-creativity/ (2008). Retrieved 1 Dec 2009
Cropley, A.J.: Definitions of creativity. In: Encyclopedia of Creativity, pp. 511–524. Academic Press, San Diego (1999)
Davidson, J.E.: The suddenness of insight. In: Sternberg, R.J., Davidson, J.E. (eds.) The Nature of Insight, pp. 125–155. MIT, Cambridge (1995)
Dewett, T., Gruys, M.L.: Advancing the case for creativity through graduate business education. Think. Skills Creat. **2**, 85–95 (2007)
DiPietro, W.R., Anoruo, E.: Creativity, innovation, and export performance. J. Policy Model. **28**, 133–139 (2006)
Dodds, R.A., Smith, S.M., Ward, T.B.: The use of environmental clues during incubation. Creat. Res. J. **14**, 287–304 (2002)
Driver, M.: Fostering creativity in business education: developing creative classroom environments to provide students with critical workplace competencies. J. Educ. Bus. **77**(1), 28–33 (2001)
Erickson, K.A., Charness, W.: Expert performance: its structure and acquisition. Am. Psychol. **49**, 725–747 (1994)
Eysenck, H.J.: Creativity and personality: suggestions for a theory. Psychol. Inq. **4**, 147–178 (1993)
Eysenck, H.J.: Genius: The Natural History of Creativity. Cambridge University Press, Cambridge (1995)
Fagerberg, J.: The need for innovation-based growth in Europe. Challenge **42**(5), 63–78 (1999)
Fairweather, J.S.: Diversification or homogenization: how markets and governments combine to shape American higher education. High. Educ. Policy **13**, 79–98 (2000)
Flowers, L.S., Hayes, J.R.: A cognitive process theory of writing. Coll. Compos. Commun. **32**, 365–387 (1981)
Furnham, A., Batey, M., Anand, K., Manfield, J.: Personality, hypomania, intelligence and creativity. Pers. Individ. Differ. **44**, 1060–1069 (2008)
Gardiner, H.: Creating Minds. Basic Books, New York (1993)
Gelade, G.: Creative style, personality and artistic endeavour. Genet. Soc. Gen. Psychol. Monogr. **128**, 213–234 (2002)
George, J.M., Zhou, J.: When openness to experience and conscientiousness are related to creative behavior: an interactional approach. J. Appl. Psychol. **86**, 513–524 (2001)
Getzel, J.W., Jackson, P.W.: Creativity and Intelligence: Exploration with Gifted Children. Wiley, New York (1962)
Ghiselin, B: Ultimate criteria for two levels of creativity. In: Taylor, C.W., Barron, F. (eds.) Scientific Creativity: Its Recognition and Development, pp. 30–43. Wiley, New York (1963)
Gilad, B.: Entrepreneurship: the issue of creativity in the market place. J. Creat. Behav. **18**, 151–161 (1984)
Gilbert, F.W., Prenshaw, P.J., Ivy, T.T.: A preliminary assessment of the effectiveness of creativity training in marketing. J. Market. Educ. **18**, 46–56 (1996)
Guilford, J.P.: Creativity. Am. Psychol. **5**, 444–454 (1950)
Guilford, J.P.: Way Beyond the IQ. Creative Education Foundation, Buffalo (1977)
Hervani, A., Helms, M.M.: Increasing creativity in economics: the service learning project. J. Educ. Bus. **79**(5), 267–274 (2004)
Hitchfield, E.M.: In Search of Promise. William Clowes and Sons, London (1973)
Huang, J.J., Tzeng, G.H., Ong, C.S.: Multidimensional data in multidimensional scaling using the analytic network process. Pattern Recogn. Lett. **26**, 755–767 (2005)
James, K.: Goal conflict and originality of thinking. Creat. Res. J. **8**, 270–285 (1995)
Kasoff, J.: Creativity and breadth of attention. Creat. Res. J. **10**, 303–316 (1997)
Katz, A.H.: Creativity and the right cerebral hemisphere: towards a physiological based theory of creativity. J. Creat. Behav. **12**, 253–264 (1978)
Kaufman, J.C., Lee, J., Baer, J., Lee, S.: Captions, consistency, creativity, and the consensual assessment technique: new evidence of reliability. Think. Skills Creat. **2**, 96–106 (2007)

Kulkarni, D., Simon, H.: The process of scientific discovery: the strategy of experimentation. Cogn. Sci. **12**, 129–175 (1990)
Leonard, D.: Wellsprings of Knowledge. Harvard Business School Press, Boston (1998)
Lin, C.J., Wu, W.W.: A causal analytical method for group decision-making under fuzzy environment. Expert Syst. Appl. **34**(1), 205–213 (2008)
Liou, J.H., Tzeng, G.H., Chang, H.C.: Airline safety measurement using a hybrid model. J. Air Transp. Manag. **13**(4), 243–249 (2007)
Lubart, T.I., Guignard, J.H: The generality specificity of creativity: a multivariate approach. In: Sternberg, R.J., Grigorenko, E., Singer, J.L. Creativity: From Potential to Realization, APA, Washington (2004)
Magee, G.B.: Rethinking invention: cognition and the economics of technological creativity. J. Econ. Behav. Organ. **57**, 29–48 (2005)
Martindale, C: Personality, situation, and creativity. In: Glover, J.A., Ronning, R.R., Reynolds, C.R. (eds.) Handbook of Creativity, pp. 211–232. Plenum Press, New York (1989)
McCloskey, D.N: 1066 and a wave of gadgets: the achievements of British growth. In: Gouk, P. (ed.) Wellsprings of Achievement: Cultural and Economic Dynamics in Early Modern England and Japan, pp. 114–132. Variorum, Aldershot (1995)
Meek, V.L.: Diversity and marketisation of higher education: incompatible concepts. High. Educ. Policy **13**, 23–39 (2000)
Ministry of Education: The White Paper of Creative Education. Ministry of Education, Taipei (2002)
Mody, A., Yilmaz, K.: Imported machinery for export competitiveness. World Bank Econ. Rev. **16**(1), 23–48 (2002)
Mokyr, J.: The Gifts of Athena: Historical Origins of the Knowledge Economy. Princeton University Press, Princeton (2002)
Momoh, J.A., Zhu, J.: Optimal generation scheduling based on AHP/ANP. IEEE Trans. Syst. Man Cybernet. B **33**(3), 531–535 (2003)
Moss, S.A.: The impact of environmental clues in problem solving and incubation: the moderating effect of ability. Creat. Res. J. **14**, 207–211 (2002)
Mumford, M.D., Gustafson, S.B.: Creativity syndrome: integration, application, and innovation. Psychol. Bull. **103**, 27–43 (1988)
Mumford, M.D.: Managing creative people: strategies and tactics for innovation. Hum. Resour. Manag. Rev. **3**(3), 313–351 (2000)
Mumford, M.D.: Where have we been, where are we going? Taking stock in creativity research. Creat. Res. J. **15**, 107–120 (2003)
Mumford, M.D., Reiter-Palmon, R., Redmond, M.R.: Problem construction and cognition: applying problem representations in ill-defined domains. In: Runco, M.A. (ed.) Problem Finding, Problem Solving, and Creativity, pp. 3–39. Ablex, Norwood (1994)
Oldham, G.R., Cummings, A.: Employee creativity: personal and contextual factors at work. Acad. Manag. J. **39**, 607–634 (1996)
Owens, W.A.: Cognitive, non-cognitive, and environmental correlates of mechanical ingenuity. J. Appl. Psychol. **53**, 199–208 (1969)
Qin, Y., Simon, H.A.: Laboratory replication of scientific discovery processes. Cogn. Sci. **14**, 281–312 (1990)
Redmond, M.R., Mumford, M.D., Teach, R.J.: Putting creativity to work: leader influences on subordinate creativity. Organ. Behav. Hum. Decis. Process. **55**, 120–151 (1993)
Ripple, R.G.: Teaching creativity. In: Encyclopedia of Creativity, pp. 629–638. Academic Press, San Diego (1999)
Runco, M.A., Chand, I.: Problem finding, evaluation thinking, and creativity. In: Runco, M.A. (ed.) Problem Finding, Problem Solving, and Creativity, pp. 40–76. Ablex, Norwood (1994)
Saaty, J.T.: The Analytic Hierarchy Process. McGraw-Hill, Columbus (1980)
Sanchez, M.P., Elena, S.: Intellectual capital in universities improving transparency and internal management. J. Intellect. Cap. **7**(4), 529–539 (2006)
Scott, R.K.: Creative employees: a challenge to managers. J. Creat. Behav. **29**, 64–71 (1995)
Shalley, C.E.: Effects of productivity goals, creativity goals, and personal discretion on individual creativity. J. Appl. Psychol. **76**, 179–185 (1991)
Shin, S.J., Zhou, J.: Transformational leadership, conservation, and creativity: evidence from Korea. Acad. Manag. J. **45**(6), 703–714 (2003)
Siegelman, M.: Parent behavior correlates of personality traits related to creativity in sons and daughters. J. Consult. Clin. Psychol. **40**, 43–47 (1973)
Simonton, D.K.: Age and outstanding achievement: what do we know after a century of research? Psychol. Bull. **104**, 251–267 (1988)

Sternberg, R.J.: The Nature of Creativity: Contemporary Psychological Perspectives. Cambridge University Press, Cambridge (1988)
Sternberg, R.J.: The Nature of Cognition. MIT, Cambridge (1999)
Sternberg, R.J.: Wisdom, Intelligence, and Creativity Synthesized. Cambridge University Press, Cambridge (2003)
Sternberg, R.J.: Creativity or creativities?. Int. J. Human-Computer Stud. **63**, 370–382 (2005)
Sternberg, R.J., Davidson, J.E.: Cognitive development of the gifted and talented. In: Horowitz, F.D., O'brien, M. (eds.) The Gifted and Talented: A Developmental Perspective, American Psychological Association, Washington (1985)
Tardif, T.Z., Sternberg, R.J. : What do we know about creativity?. In: Sternberg, R.J. (ed.) The Nature of Creativity: Contemporary Psychological Perspectives, pp. 429–440. Cambridge University Press, Cambridge (1988)
Taylor, C.W.: Various approaches to and definitions of creativity. In: The Nature of Creativity: Contemporary Psychological Perspectives. Cambridge University Press, Cambridge (1988)
Tierney, P., Farmer, S.M., Graen, G.B.: An examination of leadership and employee creativity: the relevance of traits and relationships. Pers. Psychol. **52**, 591–620 (1999)
Torrance, E.P.: Creativity: What Research Says to the Teacher. Association of Classroom Teachers of the National Education Association, Washington (1963)
Tzeng, G.H., Chiang, C.H., Li, C.W.: Evaluating intertwined effects in e-learning programs: a novel hybrid MCDM model based on factor analysis and DEMATEL. Expert Syst. Appl. **32**(4), 1028–1044 (2007)
Walberg, H.J: Creativity and talent as learning. In: Sternberg, R.J. (ed.) The Nature of Creativity, pp. 340–361. Cambridge University Press, Cambridge (1988)
Weifens, P., Addison, J., Audretsch, D., Gries, T., Grupp, H.: Globalization, Economic Growth and Innovation Dynamics. Springer, Berlin (2000)
Weiner, R.P.: Creativity and Beyond: Cultures, Values, and Change. State University of New York Press, Albany (2000)
Weisburg, R.W.: Creativity: Genius and Other Myths. Freeman, New York (1986)
Whiting, B.G.: Creativity and entrepreneurship: how do they relate?. J. Creat. Behav. **22**, 178–183 (1988)
Williamson, B.: Lifeworlds and Learning: Essays in the Theory, Philosophy and Practice of Lifelong Learning. National Institute of Adult and Continuing Education, Leicester (1998)
Williamson, B.: Creativity, the corporate curriculum and the future: a case study. Futures **33**, 541–555 (2001)
Wolfradt, U., Pretz, J.: Individual differences in creativity: personality, story writing, and hobbies. Eur. J. Pers. **15**, 297–310 (2001)
Woodman, R.W., Schoenfeldt, L.F. : Individual differences in creativity: an interactionist perspective. In: Glover, J.A., Ronning, R.R., Reynolds, C.R. (eds.) Handbook of Creativity: Perspectives on Individual Differences, pp. 3–32. Plenum Press, New York (1989)
Woodman, R.W., Sawyer, J.E., Griffin, R.W.: Toward a theory of organizational creativity. Acad. Manag. Rev. **18**, 293–321 (1993)
Wu, H.Y., Chen, H.C., Huang, R.J., Chen, I.S.: A study on the critical evaluation factors of creativity for college students. Manuscript submitted to a journal (2009)
Wu, H.Y., Chen, J.K., Chen, I.S.: Innovation capital indicator assessment of Taiwanese universities: a hybrid fuzzy model application. Expert Syst. Appl. **37**(2), 1635–1642 (2010)
Wynder, M.: Facilitating creativity in management accounting: a computerized simulation. Account. Educ. **13**, 150–231 (2004)
Yang, Y.P., Shieh, H.M., Leu, J.D., Tzeng, G.H.: A novel hybrid MCDM model combined with DEMATEL and ANP with applications. Int. J. Oper. Res. **5**(3), 160–168 (2008)
Yu, R., Tseng, G.H.: A soft computing method for multi-criteria decision making with dependence and feedback. Appl. Math. Comput. **180**(1), 63–75 (2006)
Zhou, J.: Feedback balance, feedback style, task autonomy, and achievement origination: interactive effects on creative performance. J. Appl. Psychol. **83**, 261–276 (1998)
Zhou, J.: When the presence of creative coworkers is related to creativity: role of supervisor close monitoring, developmental feedback, and creative personality. J. Appl. Psychol. **88**, 413–422 (2003)
Zhou, J., George, J.M.: When job dissatisfaction leads to creativity: encouraging the expression of voice. Acad. Manag. J. **44**, 682–696 (2001)
Zhou, J., George, J.M.: Awakening employee creativity: the role of leader emotional intelligence. Leadersh. Q. **14**, 545–568 (2003)
Zuckerman, H., Cole, J.R.: Research strategies in science: a preliminary inquiry. Creat. Res. J. **7**, 391–406 (1994)