Measuring Creativity in Die Manufacturing Courses for Technological and Vocational Education

Dyi-Cheng Chen*, Bo-Yan Lai, Ching-Yi Lee
Department of Industrial Education and Technology,
National Changhua University of Education, Changhua 500, Taiwan
**Corresponding Author's Email: dcchen@cc.ncue.edu.tw*

BACKGROUND
Product design and manufacturing is at the core of industrialization and commercialization. Design is defined as the process of transformingan abstract function into concrete products. Manufacturing involves the use of machines, tools, and labor to produce goods for use or sale.

PURPOSE
Creative design requires new approaches to assessment in vocational and technological education. To date, there has been little discussion on instruments used to evaluate dies produced by students in vocational and technological education.

DESIGN/METHOD
This study recruited thirty-eight college students enrolled in a Product Design and Development course. The participants were 33 male and 5 female aged between 20 and 22 years of age. The study was conducted in a mechanical facility in which a CNC milling machines and conventional milling machines were employed as the primary tools.

RESULTS
This paper presents an instrument for measuring the creativity in the design of products by expanding the Consensual Assessment Technique (CAT). The content-based scale was evaluated for content validity by 5 experts. The scale comprises 5 criteria: originality; practicability; precision; aesthetics; and exchangeability. Nine experts were invited to evaluate the dies produced by 38 college students who enrolled in a Product Design and Development course.

CONCLUSIONS
Results provide evidence to support the use of the CAT in the assessment of creativity in the design of dies. Inter-judge reliability scores achieved significance, with coefficients ranging from 0.529 to 0.71for each of the 5 dimensions rated.

KEYWORDS
Die creative product, technological and vocational education.

I. Introduction

Product design and manufacturing is at the core of industrialization and commercialization. Design is defined as the process of transforming an abstract function into concrete products. Manufacturing involves the use of machines, tools, and labor to produce goods for use or sale. Manufacturers have realized that improving production quality, accelerating production processes, and reducing costs are essential to survival in the competitive global market (2002). A wide range of products are made from dies and some products comprise thousands of components formed from dies (2010). Die making represents a critical element of the manufacturing sector.

In this rapidly changing era, creativity and technology are closely related. The instruction of creativity in technology education focuses on engaging students through the development of new products to solve technological problems, thereby becoming familiar with engineering as well as technical knowledge and skills(Peterson 2001; Johnson and Daugherty 2008; Siu 2003). Determining how to promote creativity among students is an important topic in vocational and technological education; however, evaluating creativity is problematic. Developing a measurement for judging dies is crucial.In recent years, considerable efforts have gone into developing the means by which to measure the creativity in product innovationfor specific topics. For example, Horng (2006) applied grounded theory to develop the Creative Culinary Product Criteria Matrix for analyzing the properties of innovative culinary products. Hsu et al. (2008)developed the Technical Creativity Tests of Electronic and Electric Cluster for high schools. Horng and Lin (2009)developedthe Scale for Evaluating Creative Culinary Products and adopted the Consensual Assessment Technique (CAT) to establish the credibility of the scale.

Over the past several years, there has been a great deal of product creativity and impressive empirical investigations in this field. The development of a scale to evaluate creativity in the production of diesis limited, and using such an instrument out of context can be misleading. A more authentic and fair method of assessment could help instructors to evaluate technical implementation, and comment on the value of the product to encourage students to engage in creative thinking.

II. Literature Review

A. Creative person

The creative person is regarded as an important factor in creativity, including individual characteristics, intelligence, and motivation(John Baer and Kaufman 2005; Sternberg and Lubart 1995; Davis 2004). Considerable research in this field has demonstrated that the creative person is characterized by a number of specific attributes, such as independence, dominance, introversion, openness to stimuli, wide interests, self-acceptance, intuition, flexibility, asocial attitude, lack of concern for social norms, and neuroticism tempered by ego-strength (Dellas and Gaier 1970; Martinsen 2011). Other studies have investigated the personality correlates of creativity (Gelade 2002). Feist (1998) conducted a meta-analysis using a five-factor model of personality. The sixteen personality factor (16PF) questionnaire (Cattell 1949; 1995), the Eysenck personality questionnaire (EPQ) (Eysenck 1991), and the California psychological inventory (CPI)(Gough 1996)were also used in a comparison of artists and scientists to explore the relationship between personality and creativity. Gough’s findings indicate that creative individuals are more open to new experiences, less conventional and less conscientious, more self-confident, self-accepting, driven, ambitious, dominant, hostile, and impulsive. Simonton (2000) claimed that the significant characteristics of a creative person include the ability to cultivate ideas, a high level of independence, an unconventional attitude, a higher likelihood to take risks, a wide range of interests, and an openness to new experiences. Furnham et al. (2008) found that extraversion had a significant correlation with self-rated creativity and divergent thinking (r = .35, .26 respectively).

As for the intelligence of creative individuals, Guilford (1975, 1985) used factor analysis to develop the structure-of-intellect (SI) model of 120 abilities, which was later expanded to150abilities. He stated that intelligence is often associated with creativity, which includes fluency, flexibility, originality, and elaboration. However, earlier investigations revealed that the relationship between creativity and intelligence (Getzels and Jackson 1962; McCloy and Meier 1931; Sternberg 1985)is only modestly correlated (r =.22, .26, .69 respectively). Amabile's (1983a, 1996) componential model of creativity proposed that domain-relevant skills, creativity- relevant skills, and task motivation were required for creativity. Domain-relevant skills include knowledge, technical skills, and specialized abilities; creativity-relevant skills are personal skills, for example, tolerance for ambiguity, self-discipline, and a willingness to take risks; task motivation is generally accepted as a key factor in creative individuals, particularly for intrinsic motivation. Gagne and Deci (2005) argued that intrinsic motivation is more effective than extrinsic motivation in predicting persistence in interesting tasks, because intrinsic motivation is driven by an interest or enjoyment in the task itself.

B. Creative process

The creative process comprises several phases. It is the actual experience of being creative (Kaufman et al. 2008b). The important aspect is the idea of flow, or optimal experience, which refers to a person being intensely engaged in an activity, fully immersed in a feeling of energized focus, full involvement, and success in the process of the activity (Csikszentmihalyi 1996). Wallas (1926)described four stages of creation: preparation, incubation, illumination, and verification. Preparation: the combination of old and new knowledge to gain information in a specific field of study. Incubation: many great ideas occur to us when we are away from the problem but continue thinking about potential solutions unconsciously. Illumination: a mysterious flash of insight. Verification: the problem is solved using the novel idea. Feldman and Page (1989) noted that the most widely-accepted model of the new product-planning process included seven phases: (1) exploration,(2) screening of ideas,(3) business analysis,(4) concept testing, (5) development, (6)testing to determine marketability, and (7) commercialization. Another model of the creative process is found in the generation model of creative cognition (Finke et al. 1992). This model includes two stages: generation and exploration. In the generation stage, raw ideas that are vague or unfocused are constructed, but require further processing to become viable. The exploration stage refers to evaluating the vague ideas from various perspective sun til arriving at the best one. Goldenberg and Mazursky (2002) and McMahon and Lane (2002) adopted the view that the exploration stage includes many techniques. Amabile (1996) describes five steps in the creative process: (1) problem or task identification, (2) preparation,(3) response generation, (4) response validation and communication, and (5) outcome.

C. Creative press (environment)

The creative press (environment) includes the social and the physical aspects of the environment within which an individual operates. The creative environment is often designed to encourage creativity, taking into account the individual, the field in which they work, the interaction between individuals in the given creative environment, and the climate. A creative climate encourages creative thinking and innovation. Amabile and Gryskiewicz (1989)claimed that perceptions of one's work environment (KEYS)influence the generation and development of creative ideas. Characteristics of such a climate include the following: (l) organizational encouragement,(2) supervisory encouragement, (3) work group supports,(4) freedom, (5) sufficient resources, (6)challenging work, (7) creativity, and (8) productivity. Previous studies have indicated that when people experience positive interaction and lower stress levels as well as feel valued, they are more likely to engage in creative behaviour, generate creative ideas, and solve problems creatively (Isaksen and Ekvall 2010; Fredrickson 2001; Cohen-Meitar et al. 2009).

III. Results

Each die had to be consistent with CAT methodology. The instrument was designed according to the tenets of the precision machinery manufacturing course, combined with (CSDS) (Cropley et al. 2011; Cropley and Cropley 2005) and car product creativity (Rubera et al. 2010), to assess creativity in the production of dies (see Table1). The experts assigned scores from 1 to 5 points according to each of these criteria, indicating the degree to which the product was considered creative, relative to the dies produced by other students.

Table 1: Measuring creativity in the production of dies

criteria	definition	score
originality	Created or invented product considered new or different from anything that anyone has thought of before, and thus can be distinguished from reproductions	5 points: Compared toother students' products, the repeatability of overall design concept is less than 1% 4 point: Compared toother students' products, the repeatability of overall design concept is less than 1~1.99% 3 points: Compared toother students' products, the repeatability of overall design concept is less than 2~2.99% 2 points: Compared toother students' products, the repeatability of overall design concept is less than 3 ~ 3.99 1 points: Compared toother students' products, the repeatability of overall design concept is above 4%
practicability	The function of the product is considered in terms of practicality, functioning without complex secondary parts.	This was scored on a 5-point Likert type scale ranging from 5 for a product that is easily applicable in real life to 1-for a product that is inapplicable in real life.
precision	The product was designed with mechanical structure, and accuracy in accordance with geometric tolerances	5 points: According to basic shaft and hole system tolerance; 70% of the parts and component between H11-h11toH7-h6. 4 points: According to basic shaft and hole system tolerance, 70% of the parts and component between H7-g6 3 points: According to basic shaft and hole system tolerance, 70% of the parts and component between H8-e8toH7-f7 2 points: According to basic shaft and hole system tolerance, 70% of the parts and component between H8-e8toH7-e7 1 points: According to basic shaft and hole system tolerance, of the 70% parts and component between H11-d11toH7-d7
aesthetics	Product appearance has a specialvisual appeal.	Points were awarded on a 5-point Likert type scale ranging from 5 for the product is artistic to 1 for the product is inartistic
exchangeability	Different parts and mechanism can be	5 points: 70% of the parts can be exchanged for ISO parts.

	substituted for lost ones, enabling the same performance after the exchange.	4 points: 50% of the parts can be exchanged for ISO parts. 3 points: 30% of the parts can be exchanged for ISO parts. 2 points: 10% of the parts can be exchanged for ISO parts. 1 points: 5% of the parts can be exchanged for ISO parts.

Nine expert raters in the field of die making were invited to participate as judges in this study. Each of the judges had consider able experience in precision machining or machine-driven industries. The expert sinitially assessed the creativity of all of the dies using a 5-point scale in randomly assigned order to prevent order effects. Second, expert rater sassessed the dies individually and without any instructions from the researcher. The experts did not meet or talk about their ratings with one another until after all the ratings had been submitted.

As shown in Table 2, medium and significant reliability was found among the nine judges for each of the dimensions. Significan treliability coefficients ranged from .529 to .71.

Table 2: Results for the Kendall's coefficient of concordance

Die criteria	Kendall W
originality	.529*
practicability	.710*
precision	.695*
aesthetics	.689*
exchangeability	.548*

**p*<.05

In order to understand the different ways of teaching courses on precision mould manufacturing cognitive differences that due to the limited sample size and insufficient statistical data. This study used Kruskal-Wallis test differences for results can know the freedom is 1, the χ^2 value is .934. It can be seen that there is no striking effect of creative instruction on cognition in mould manufacturing courses. The results show in Table 3.

Table 3: Different teaching methods for precision mould manufacturing course of cognitive KRUSKAL-WALLIS test

Group	Number	Mean	χ^2
Creative teaching group	19	17.76	.934 n.s.
General teaching group	19	21.24	

n.s.: Not significant

IV. Conclusion

Results provide evidence to support the use of the CAT in the assessment of creativity in the design of dies. Inter-judge reliability scores achieved significance, with coefficients ranging from 0.529 to 0.71for each of the 5 dimensions rated. Hopefully these findings will encourage college instructors to include instruction in creativity, giving them confidence to proceed with the assessment and development of creativity in die production. Two groups students in precision machinery manufacturing course no significant differences in cognitive abilities

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