Creativity Research Journal
2004, Vol. 16, No. 1, 11–25

Copyright 2004 by
Lawrence Erlbaum Associates, Inc.

The Interactive Influences of Three Ecological Systems on R & D Employees' Technological Creativity

Yu-Chu Yeh
Institute of Teacher Education & Center for Creativity and Innovation Studies, National Chengchi University

ABSTRACT: This study proposes the Ecological Systems Model of Creativity Development, which emphasizes the dynamic relationships among 4 ecological systems, each individually representing personal characteristics, the family and school experiences, organizational environment, and the social milieu. The findings here confirm the patterns of influence of the first 3 ecological systems—namely the microsystem, the mesosystem, and the exosystem—along with that of creative ability on information technology R & D staff across software and hardware companies. The findings fully support the proposed model and strongly suggest that the 3 ecological systems tested dynamically and interactively influence R & D employees' degree of technological creativity, although the patterns of influence vary somewhat across types of companies.

Innovation, which refers to the successful implementation of "creative ideas" within an organization (Amabile, 1988; Kanter, 1988), is fundamental for information technology companies to be able to maintain their superiority in the greatly competitive market. To successfully innovate, information technology companies have to, first of all, identify the interactive patterns among the various factors that influence their employees' creativity, especially in the case of those who work in research and development (R & D). Because creativity may vary across domains, a revised or a new conceptual model specifically pertaining to the field of "technology" is required for studying the technological creativity of R & D staff.

Traditionally, creativity is defined from the perspective of one of the "4Ps," or, to be more precise, from the viewpoint of person (Feldhusen, 1995; Mellou, 1996; Oldham & Cummings, 1996), process (Koestler, 1969; Torrance, 1988), place/press (Amabile, 1988; Amabile, Conti, Lazenby, & Herron, 1996, Oldham & Cummings, 1996), and product (Amabile, 1996; Sternberg & Lubert, 1996). Recently, researchers have begun to interpret creativity from a more holistic, dynamic, and multidimensional perspective, with the result that many proposed theories and models now abound (Amabile, 1996; Csikszentmihalyi, 1990; Gruber & Davis, 1988; Lubart & Getz, 1997; Runco, 1996; Runco, Nemiro, & Walberg, 1998; Sternberg & Lubert, 1996). Although there is a general consensus that multiple components must converge in order for creativity to take place in a specific domain, no previous study has ever tried to conceptually formulate a model and to empirically validate it in the domain of "technology," not to mention devise and test one that precisely focuses on R & D's technological creativity. Accordingly, in this study, I propose the *Ecological Systems Model of Creativity Development*, as well as empirically validate it among information technology companies with a specific focus on R & D staff. This model emphasizes the dynamic relationships among four ecological systems—the microsystem, the mesosystem, the exosystem, and the macrosystem—in conjunction with the development of creativity. The ways in which the microsytem, the mesosystem, and the exosystem influence R & D employees' creativity in information technology companies are of particular interest here. The macrosystem is not included because it refers to the

This research was supported in part by the National Science Council, Taiwan under Grant NSC89–2519–S–110–001.

Correspondence and requests for reprints should be sent to Yu-Chu Yeh, Institute of Teacher Education, National Chengchi University, 64, Chih-nan Rd., Sec. 2, Wenshan, Taipei 116, Taiwan. E-mail: ycyeh@nccu.edu.tw

social milieu, which is broad and hard to measure quantitatively.

The Ecological Systems Model of Creativity Development

The Ecological Systems Model of Creativity Development has evolved from four resources: (a) previous interviews and pilot studies in information technology companies (Yeh, 1999, 2000); (b) Bronfenbrenner's (1989) ideas concerning ecological systems theory; (c) information-processing theories (Pressley & McCormick, 1995); and (d) the central ideas of well-known confluence models of creativity, such as Amabile's (1996) *Componential Model of Creativity*, Gruber's *Evolving System Model of Creativity* (Gruber & Davis, 1988; Gruber & Wallace, 1999), Csikszentmihalyi's (1990) *Three-pronged Systems Model of Creativity*, Gardner's (1993) *Interactive Perspective of Creativity*, and Sternberg & Lubert's (1996) *Investment Theory of Creativity.* To explain creativity from a perspective different from that used in the well-known confluence models, I use the central ideas of Bronfenbrenner's ecological systems theory, which is that four systems—the microsystem, the mesosystem, the exosystem, and the macrosystem—all influence an individual's development. Two concepts are central to the Ecological Systems Model of Creativity Development. First, as individuals grow up, the ecological systems that influence their development with respect to creativity evolve from the single to the multiple, from the simple to the complex, and from the independent to the interactive until, eventually, all four ecological systems merge once the individuals reach maturity. As for the second concept, any one of the four ecological systems can have a direct influence on an individual's creativity at one given time and can also have an indirect influence at another time, and vice versa. Simply put, these four ecological systems are evolving, interacting, and, most certainly, inter-related.

Moreover, the Ecological Systems Model regards creativity as a process in which one generates a contextually and culturally "original" and "valuable" product within a certain domain. Combining this with the information-processing theory, I have redefined Wallas' (1926) creative process to include four elements: (a) preparation: collecting related information and organizing it into schematic patterns; (b) incubation: analyzing and synthesizing information in the schema; (c) insight: finding connections between information in the schema and forming a creative product; and (d) verification: applying the product and evaluating its originality and value.

Though the Ecological Systems Model of Creativity Development may also be viewed as consisting of the same four ecological systems of Bronfenbrenner's (1989) theory, the contents of each system are actually different. In the Ecological Systems Model of Creativity Development, the microsystem specifies inherent and learned personal characteristics; mainly knowledge, dispositions, and skills and strategies. These personal characteristics are the most fundamental to the generation of a creative product, and they directly affect all stages of the creative process. The mesosystem, meanwhile, consists of family and school experiences. These two subsystems interact with each other and greatly influence the creative potential of a person throughout his or her childhood, and even into his or her teens. However, as the creative person grows up, these influences may become more indirect and perhaps less influential. The exosystem comprises organizational factors that relate to an individual's work, including the people, events, and things within an organization. This system interacts with the creative person and influences the creative process both directly and indirectly. Finally, the macrosystem refers to a social milieu, including the values, laws and customs within a culture. This system has a substantial impact on the evaluation of a creative product. From a mature adult's perspective, the four layers of the system interact with one another, but only the microsystem and macrosystem directly influence the current creative process (see Figure 1).

In brief, the Ecological Systems Model regards a creative product or outcome as being the result of the interactions of individuality and the environment. Individuality includes knowledge, dispositions, skills, and strategies; whereas the environment includes the family, school, an organization, and the social milieu. Because this study focuses on exploring the relationships among the microsystem, the mesosystem, the exosystem, and technological creativity, some related literature, especially that pertaining to the area of information technology, is further discussed.

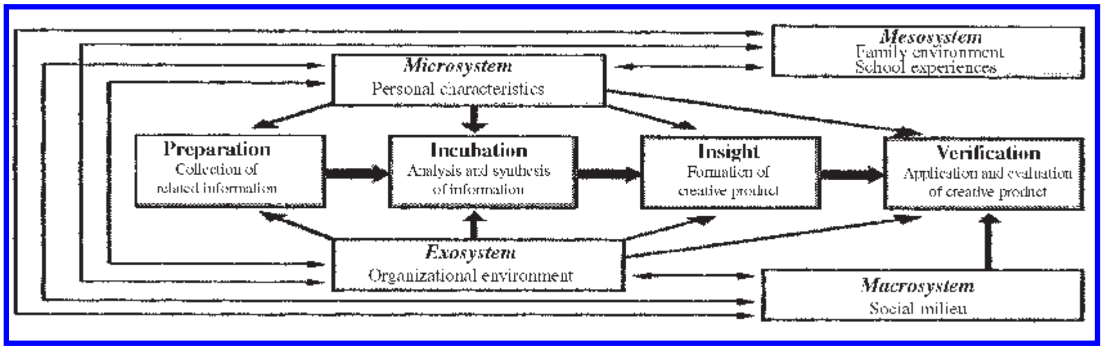

Figure 1. *Ecological Systems Model of Creativity Development.*

Personal Characteristics and Technological Creativity

That personal characteristics inherently have a great influence on creativity is widely accepted among researchers (e.g. Amabile, 1988; Amabile et al., 1996; Oldham & Cummings, 1996; Siau, 1995). Such characteristics can be grouped into knowledge and dispositions (attitudes, tendencies, and motivation), as well as skills and strategies. Based on explicit theory, Runco et al. (1998) claimed that a sound base of knowledge was the most important for the development of creativity among older respondents, and they suggested that the ability to build new structures and to be alert to gaps in knowledge are important to knowledge-building. Creative thinkers must first master the knowledge of a particular domain, and if creation is to occur, they must go on to broaden or reformulate that knowledge; in other words, and also in accordance with Feldhusen (1995), creative production, for the most part, depends on a large and thorough knowledge base within a given domain.

As for dispositions, great emphasis is put on both the componential (Amabile, 1996) and investment models (Sternberg & Lubart, 1996). Torrance (1988) also determined that creative individuals have the following main traits: courage, independence of thought and judgment, honesty, perseverance, curiosity, and a willingness to take risks. Along somewhat similar lines, Simonton (2000) has found that creative people are independent, nonconformist, unconventional (not to mention bohemian), and that they are likely to have wide interests, greater openness to new experiences, more conspicuous behavioral and cognitive flexibility, and greater risk-taking boldness.

The capacity for creativity can be at both the cognitive (Guilford, 1967) and metacognitive levels (Feldhusen, 1995). Donnelly (1994) defined creativity as the ability to see and transform materials and objects into new and original forms; Feldhusen (1995) regarded creative thinking as a metacognitive process in which such metacognitive abilities as planning, monitoring, and evaluating cognitive operations are required. To be sure, fluency, flexibility, originality, and elaboration are the most commonly measured abilities in creativity tests (Torrance, 1966).

Based on a review of the literature (e.g. Amabile, 1988; 1996; Donnelly, 1994; Feldhusen, 1995; Mellou, 1996; Oldham & Cummings, 1996; Runco, 1996; Runco et al., 1998; Simonton, 2000; Sternberg, 1995, 2000; Sternberg & Lubart, 1996; Torrance, 1988), interviews with highly creative people in information technology (Yeh, 1999), and an empirical study in information technology companies (Yeh, 2000), I have identified nine categories of elements that stem from the personal characteristics that are crucial to technological creativity. These are:

1. Tryout: The person likes to try new things, is good at problem-solving, enjoys challenging work, likes to disassemble or fix things, keeps thinking of creative ideas, and is curious about things.
2. Joy in work: The person enjoys doing creative work, stays enthusiastic, is devoted to work, maintains persistent efforts in doing a task, pursues progressiveness and self-growth, and thinks reflectively about work.

3. Adaptive cognition: The person is humorous and optimistic, is good at communicating and managing emotions, and learns from others' experiences.

4. Multidimensional reasoning: The person is good at thinking retrospectively, analyzing cause-effect relationships, and at thinking from varied perspectives.

5. Independence: The person does not readily go along with what others think and say; is defiant, and is able to solve problems alone.

6. Problem-solving ability: The person is good at organizing and analyzing problems as well as at planning, controlling and adjusting working progress, stays judgmental in solving problems, is expressive of opinions, is self-confident, and is sensitive in observation.

7. Interaction and prudence: The person thinks highly of interpersonal relationships, likes to share creative ideas, is prudent in decision-making, and remains suspicious of evidence.

8. Interest: The person likes to read, has broad interests, and is aesthetic.

9. Intuition and imagination: The person considers "interest" as the main reason for doing things, and is imaginative and versatile.

These nine dimensions of derivatives of the personal characteristics are important components in the microsystem.

The Family and Technological Creativity

The positive influences of the family environment on the development of creativity seem to most favor early parental loss, marginality, and the availability of mentors and role models. Research findings (Csiksentmihalyi, 1996; Simonton, 1988; Walberg, 1988) have suggested that exceptional creativity does not always emerge from the most nurturing environments. Unlike exceptionally well developed creativity, creative potential seems to require a certain exposure to a positive family environment, for this seemingly helps weaken any constraints imposed by conventional socialization and strengthens a person's level of perseverance (Simonton, 1984). Such positive influences are mostly related to parenting styles, parent-child interactions, and family atmosphere. Findings also showed that a less authoritarian parenting style brought about more independence on the part of the offspring and developed more original-thinking children (Jensen & Kingston, 1986). As for parent-child interactions, research findings (Michel & Dudek, 1991) indicated that the avoidance of over protection and intervention, combined with the reception of more love and encouragement, strongly contribute to children's creativity. Moreover, a constructive family atmosphere—such as having flexibility in the family structure, caring about family members, trusting and supporting each other, having chances to express feelings, and thinking highly of cultural and intellectual activities—serves well in the development of creative potential (Bomba & Moran, 1991; Olszewski, Kulieke, & Buescher, 1987).

Again, based on the literature review (e.g. Bomba & Moran, 1991; Csiksentmihalyi, 1996; Michel & Dudek, 1991; Olszewsk et al., 1987; Olszewski-Kubilius, 2000; Simonton, 1984, 1988, 2000; Walberg, 1988) and empirical findings (Yeh, 1999, 2000), I have determined two dimensions with respect to family factors that are important for the development of technological creativity: (a) model setting and support: parents and siblings act as models during the creative process; parents give opinions and guidance while children are in the process of problem-solving; parents encourage independence and autonomy; and (b) open atmosphere: the family atmosphere is free and open; parents support their childrens' decision-making; and good parent-child relationships exist. As mentioned earlier, the mesosystem consists of the family and school experiences; thus, these factors obviously represent the subsystem of the family unit.

School and Technological Creativity

The school may influence students' development of creativity through the activities, curriculum, evaluations, classroom climate, and, most of all, teacher behaviors. Tan (2001) has recently suggested that schools should provide varied activities, an open atmosphere, and changes to the traditional ways of evaluation. Cropley (1997) postulated the following nine behaviors on the part of teachers, which contribute to students creative thinking: encouraging students to learn independently, having a socially integrative style of teaching, motivating students to master factual knowledge, delaying judgment of students ideas, encouraging flexible thinking, urging students self-evaluation, taking students suggestions and questions seriously, offering students opportunities to work with a wide variety of materials, and cultivating students ability to cope with frustration and failure.

Besides teachers' behaviors, the global climate of a particular school and the immediate atmosphere of a classroom decisively influence creative performance (Dudek, Strobel, & Runco, 1993). Such classroom atmosphere as providing opportunities for decision making, accepting varied perspectives, and enhancing students self-confidence surely contribute to creative thinking (Fleith, 2000). In addition, the development of creative behaviors is the result of a holistic, interdisciplinary approach in which teaching/learning methods are interrelated. Through an interdisciplinary approach, children are stimulated to explore, discover, and invent knowledge independently as well as to assimilate and elaborate upon information at their own cognitive and affective levels (Safer, 1995). Teaching content, however, must be viewed within the complex set of variables that contribute to creativity. Rubenstein (2000) has found that mildly creative content for creative production and highly creative content for expanded thinking are better for the development of creativity.

The literature review (Cropley, 1997; Dudek, Strobel, & Runco, 1993; Fleith, 2000; Marjoribanks, 1992; Rubenstein, 2000; Safer, 1995; Soh, 2000; Tan, 2001) and empirical findings (Yeh, 1999, 2000) have helped me to ascertain that the following factors have positive effects on technological creativity: (a) teachers are supportive of students ideas and encourage their creative performance; (b) the school provides opportunities for creative performance, such as competitions, social clubs, and study clubs; (c) the curriculum provokes and improves creative thinking; and (d) the school environment is free and open. Such factors, of course, make up the other subsystems in the mesosystem—the school, in this study.

Organization and Technological Creativity

Referring to the exsosystem, a new trend in the studies of creativity in organizations involves exploring the impact of environmental factors on employees' creative performance (Puccio, Talbot, & Joniak, 2000). Amabile (1996) suggested that organizational factors have a positive influence on employees' creativity. These are recognition that failure in the work place can provide valuable information, mechanisms are available for considering new ideas, high-level encouragement of innovation is provided, immediate supervisor encouragement is present, coworkers display skill diversity, co-workers challenge ideas constructively, emphasis is put on intrinsic motivators, competition with outside organizations is ever-present, constructive work-focused feedback is provided, clear strategic direction is provided and procedural autonomy is allowed, cooperation is present, collaboration is encouraged, and good project management is assured.

Other researchers (Oldham & Cummings, 1996) also reported that employees exhibit higher performance and lower intentions to resign when their jobs are highly challenging, and when their supervisors are described as supportive and noncontrolling. However, a completely supportive environment is not necessarily the best. An overall encouraging and innovative environment with some element of frustration during the working process may be the ideal environment for creativity development (Sternberg & Lubart, 1996).

Based on the literature review (e.g. Amabile, 1988, 1996; Oldham & Cummings, 1996; Puccio et al., 2000; Sternberg & Lubart, 1996; Woodman, Sawyer, & Griffinn, 1993) and empirical findings (Yeh, 1999, 2000), I have discerned that four categories of organizational factors are important to technological creativity. These are described in the following.

1. Opportunities and needs. The organization holds activities to improve cooperative behavior; it provides opportunities for undertaking creative endeavors, thus enhancing performance; it satisfies staff needs; it offers sufficient techniques and materials; it tries to form partnerships among staff; it thinks highly of enthusiasm towards work; and it employs supervisors who stimulate concerns about things around.
2. Support and team work. Supervisors encourage and support creative performance; they emphasize the importance of teamwork, communication, professional knowledge, attitudes, and abilities, and reward creative performance; and they ensure that the organization adapts to meet developmental trends.
3. Group dynamics. Organizations emphasize heterogeneity, cooperation, open-mindedness, and the expression of opinions, and encourage optimal participation.

4. Supervision. Supervisors have sufficient knowledge and ability; they are good at leading; they treat employees compassionately and show respect towards employees creative ideas and/or products.

Hypotheses

Amabile et al (1996) reported that, on the one hand, meaningful interorganizational differences are often found when it comes to the dimensions of the work environment and that, on the other hand, meaningful intraorganizational differences among divisions, departments, and groups should be expected. Yeh (2000) found that employees working for software development in information technology companies tend to perceive their supervisors as respectful and their companies as highly interactive, whereas those working for hardware development are more likely to perceive their supervisors as heartfelt and their companies as highly supportive in terms of the materials they provide.

Therefore, although this study investigated the relationships among three of the four ecological systems (the microsystem, the mesosystem, and the exosystem) as well as their influence on technological creativity, it also took interorganizational and intraorganizational factors into consideration. In other words, two hypotheses were proposed in this study. First, it was hypothesized that there are interrelationships among the microsystem (personal characteristics), the mesosystem (family and school), and the exosystem (organization). Second, it was expected that the patterns of influence of the three ecological systems and the manner in which these systems influence employees' technological creativity should differ between hardware R & D and software R & D companies.

Method

Participants

The participants were either directly or indirectly recommended by managers or supervisors who were taking MBA courses in the Incubation Center of National Sun Yat-sen University in Kaoshiung, Taiwan. The directly recommended participants were R & D employees in companies of those managers or supervisors, whereas the indirectly recommended participants were R & D employees in other information technology companies that those managers or supervisors referred to. In all, 360 R & D employees, sampled from 84 information technology companies, participated in this study. The companies were categorized as either hardware development or software development. The hardware development companies were mainly manufacturers of electronics and semiconductors; the software development companies focused on the manufacturing of computers, networks, and high-tech vision-related software.

Among the 360 participants, 198 were working in hardware development companies, and 162 were in software development companies; 313 (89.7%) were males, 36 (10.3%) were females, and 11 did not state their gender in the distributed questionnaire. The mean ages for all participants, the hardware group, and the software group were, respectively, 31.06 (SD = 6.49), 32.60 (SD = 7.41) and 29.21 years (SD = 5.04). As for the length of employment in the current company, the means were 2.90 (SD = 2.22), 3.43 (SD = 2.28), and 2.27 years (SD = 1.41) for all participants, the hardware group, and the software group, respectively.

Instrumentation

This study employed four inventories and two questions. The inventories were The Inventory of Personal Factors in Technological Creativity Development (IPF-TCD), The Inventory of Family Factors in Technological Creativity Development (IFF-TCD), The Inventory of School Factors in Technological Creativity Development (ISF-TCD), and The Inventory of Organization Factors in Technological Creativity Development (IOF-TCD). The IPF-TCD, IFF-TCD, ISF-TCD, and IOF-TCD are all 6-point Likert-type questionnaires, with item response options of *totally disagree*, *disagree*, *slightly disagree*, *partly agree*, *agree*, and *totally agree* representing, in ascending order, 1 to 6 points.

The IPF-TCD scores indicated an individual's personal characteristics as they pertain to technological creativity. Composed of 41 items, the test included nine factors of personal characteristics: *tryout, joy in work, adaptive cognition, multiple-perspective reasoning, independence, interaction and prudence, problem-solving ability, interest,* and *intuition and* *imagination*. The Cronbach's α coefficients were .89, .81, .77, .81, .76, .75, 82, .75, .64, and .95, respectively, for the nine factors and for all items (Yeh, 1999). The IFF-TCD, consisting of 7 items, measured supportive family environment to technological creativity development. It was comprised of two factors: *model setting and support* and *open atmosphere*. The Cronbach's α coefficients were .80, .80, and .83 for the two factors and for all items, respectively (Yeh, 1999). The ISF-TCD scores indicated the contribution of school experience to technological creativity development. Though it had only one factor, the ISF-TCD consisted of 7 items and had a Cronbach's α coefficient of .87 (Yeh, 1999). Finally, the IOF-TCD, composed of 21 items, measured the positiveness of the organizational environment. It was comprised of four factors: *opportunities and needs*, *support and teamwork*, *group dynamics*, and *supervision*. The Cronbach's α coefficients for the four factors and for all items were .86, .88, .87, .77, and .94, respectively.

In this study, the participants' technological creativity was measured using the responses to two questions. The first was a multiple-choice question concerning public recognition, and respondents could choose more than one option: Has your creative ability as it concerns technology ever been rewarded? The options were (a) once obtained a patent, (b) once won a national competition, (c) once won a city- or county-wide competition, (d) once won an intracompany competition, (e) once was publicly recognized by supervisors and peers, (f) never won any rewards, and (g) other. The final option was regarded as a missing value. In this study, considering the cell sample size, two categories, rather than 6, were used. The options of 1 to 5 were recoded as 1 point, representing the category of once won rewards, and option 6 was recoded as 0, representing the category of never won any rewards. The second question concerned a self-evaluation of creativity: How would you describe the degree of creativity at your work? The options were *have no creativity at all, almost have no creativity, have little creativity, have some creativity, have much creativity,* and *have a very high degree of creativity.* They were recoded as 1 to 6 points, respectively.

Process

Managers or supervisors in the Incubation Center of National Sun Yat-sen University were contacted and asked to provide a list of information technology companies; the questionnaires were then mailed out with self-addressed stamped envelopes. One month later, the managers or supervisors were contacted if the mailed questionnaires had not been returned, and questionnaires were mailed to the potential participants again if they had lost them. Finally, by the end of the sixth month, only 360 out of the 1,450 copies mailed out had been received for a low response rate of only 25%.

Analyses

This study included descriptive statistics to analyze the features of the participants' backgrounds and employed *Structural Equation Modeling* (SEM) to test the latent path models concerning the structural relationships among the three ecological systems and technological creativity. In SEM, "person" includes the nine factor scores in the IPF-TCD; "family and school" comprises the scores of the IFF-TCD and the ISF-TCD; "organization" comprises the four-factor scores in the IOF-TCD; finally, "creativity" consists of the scores of the self-evaluation survey and public recognition of creativity. All the SEM analyses employed generalized least square (GLS) estimations and four indexes for goodness-of-fit: goodness-of-fit χ^2, the goodness-of-fit index (GFI), the adjusted-goodness-of-fit index (AGFI), and the root-mean-square residual (RMR). A nonsignificant χ^2 value, a high GFI or AGFI value, and a low RMR value indicated a model was a good fit (Loehlin, 1992; Ullman, 1996). All the SEM analyses were performed using the AMOS.

For the purpose of verifying the proposed Ecological Systems Model, two latent path models (the hypothesized and possible models) were compared in both the software and hardware groups. In the possible model, all three of the ecological systems were correlated, and all of them were shown to definitively have direct influences on technological creativity. The hypothesized model, which was based on the Ecological Systems Model, did not include the direct influence of the family and school system on technological creativity. Because they are more appropriate than covariance matrices when comparisons are made across different variables (Loehlin, 1992), correlation matrices were used in this study to compare differences between the models. Moreover, the normed fit index (nfi) and

Akaike's information criteria (AIC) were employed to determine whether the hypothesized model was significantly better than the possible model. A maximum value of nfi and a minimum value of AIC represented an optimum fit (Loehlin, 1992).

Results

Preliminary Analyses

Among the six types of rewarding experiences for creative performance, the different groupings all indicated that the participants agreed on the highest rating for getting recognition from supervisors and peers (21.8%, 20.2%, and 23.8% for the total sample, the hardware group, and the software group, respectively) and agreed on the second highest rating for getting patents (12.8%, 16.7%, and 8.1% for the total sample, the hardware group, and the software group, respectively). When categorized by "once won rewards" and "never won rewards," the percentages of the former groups were 49.0%, 58.6%, and 41.4% for the total sample, the hardware group, and the software group, respectively. The means and standard deviations of the hardware and software groups on the IPF-TCD, IFF-TCD, ISF-TCD, and the IOF-TCD are shown in Table 1.

There were significant gender effects on the scores of the IPF-TCD (Wilks's $\Lambda = .930$, $p = .006$, $\eta^2 = .070$) and the IFF-TCD (Wilks's $\Lambda = .971$, $p = .006$, $\eta^2 = .029$). More specifically, female R & D employees outperformed male R & D employees on two dimensions of personal traits, that is, "interest and intuition" and "imagination," $F(1, 319) = 7.28$, $p = .007$, $\eta^2 = .022$, and $F(1, 319) = 5.37$, $p = .021$, $\eta^2 = .017$. The females also scored higher on the two indexes of family environment ("model setting and support" and "open atmosphere") than did the males, $F(1, 344) = 8.97$, $p =.003$, $\eta^2 = .025$, and $F(1, 344) = 7.79$, $p = .006$, $\eta^2 = .022$. In addition, the females reported having more positive school experiences than did the males, $t(343) = –3.235$, $p = .001$. No significant gender differences in the scores on the IOF-TCD were found, Wilks's $\Lambda = .991$, $p = .597$; that is, the female and the male R & D em-

Table 1. *Means and Standard Deviations of Hardware and Software Groups on the IPF-TCD, IFF-TCD, ISF-TCD, and the IOF-TCD*

	Hardware (n = 170)		Software (n = 155)	
Test	*M*	*SD*	*M*	*SD*
IPF-TCD				
Tryout	4.56	.72	4.63	.71
Joy in work	4.85	.69	4.94	.58
Adaptive cognition	4.41	.65	4.54	.66
Multiple-perspective reasoning	4.56	.70	4.59	.71
Independence	4.26	.65	4.34	.63
Interaction and prudence	4.52	.67	4.51	.71
Problem-solving ability	4.79	.66	4.86	.65
Interest	4.44	.79	4.62	.86
Intuition and imagination	4.21	.75	4.42	.74
IFF-TCD				
Model setting and support	4.02	.86	4.03	.85
Open atmosphere	4.42	.92	4.60	.87
ISF-TCD				
ISF-TCD	3.97	.86	4.09	.93
IOF-TCD				
Opportunities and needs	3.99	.78	4.36	.76
Support and communication	4.23	.80	4.70	.71
Heterogeneity and cooperation	4.29	.79	4.71	.68
Supervision	4.03	.93	4.51	.80
Creativity				
Self-evaluation	3.97	1.07	4.23	.91
Public recognition	.55	.50	.42	.50

ployees did not perceive their organizational environment differently.

Relationships Among Person, Family, School, Organization, and Technological Creativity

Hardware Development Group

Hypothesized models. The SEM analysis (see Figure 2) yielded a significant χ^2 value, $\chi^2(115, N = 129) = 153.10$, $p = .010$; the other fit indexes were GFI = .86, AGFI = .81, and RMR = .09. Although the χ^2 value indicated that the model was not a satisfactory good-fit, the other fit indexes suggested that the model was acceptable. The standardized errors for P2 to P9 were .11 to .13, those for O2 to O4 were .09 to .12, and that for S was .45. As for interrelationships among the ecological systems, the two systems of *person* and *family and school* had the highest correlation ($\phi = .58$, $p < .001$); *organization* and *person* had the second highest correlation ($\phi = .49$, $p < .001$); another pair of systems, *family and schoo*l and *organization* had the lowest correlation ($\phi = .44$, $p < .01$). As predicted, *person* and *organization* had direct effects on creativity, $\gamma = .35$, $p < .01$ and $\gamma = .23$, $p < .05$. As for total effects on creativity, the coefficients were .46, .30, and .40 for *person*, *school and family*, and *organization*, respectively. These findings revealed that, first and foremost, personal characteristics had the most powerful effects on the hardware R & D employees' creative performances, and that most of the effects came from a direct causal relationship; second, organizational environment had certain effects on the employees' creative performance, and about half of the effects came indirectly because they first seemed to have affected per-

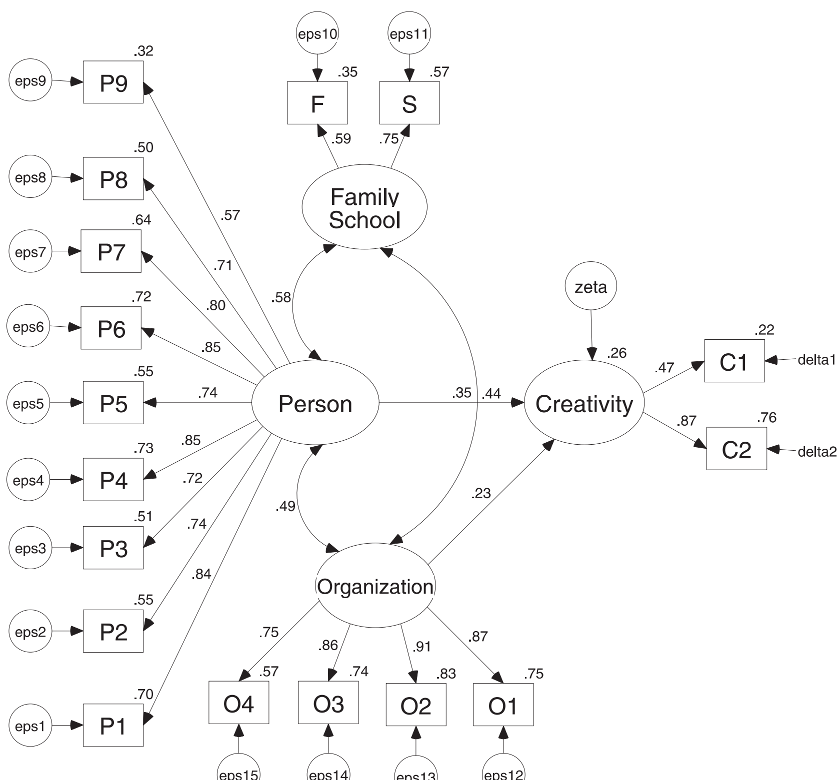

Figure 2. *Hypothesized model in the hardware development group. P1 = tryout, P2 = joy in work, P3 = adaptive cognition, P4 = multiple-perspective reasoning, P5 = independence, P6 = problem-solving ability, P7 = interaction and prudence, P8 = interest, P9 = intuition and imagination, F = family, S = school, O1 = opportunities and needs, O2 = support and team work, O3 = group dynamics, O4 = supervision, C1 = self-evaluation, and C2 = public recognition.*

sonal characteristics; finally, in a similar way, the influence of school and family experiences on employees' creativity again mainly came indirectly as personal characteristics were affected first. From the perspective of standardized loadings and uniqueness, all manifest variables had significant effects on their latent variables, Λs = .47 to .91, *p*s < .001. The most important indexes for personal characteristics were multiple-perspective reasoning, problem-solving ability, and tryout, with the Λs being .85, .85, and .84, respectively. Although the most important index for *family and school* was school experiences (Λ = .75), the most important index for organization was *support and teamwork* (Λ =.91).

Possible model. The SEM analysis yielded a significant χ^2 value, $\chi^2(114, N = 129) = 152.41$, $p = .009$); the other fit indexes were GFI = .86, AGFI = .81, and RMR = .09. Again, the fit indexes suggested that the possible model was acceptable. The standardized errors for P2 to P9 were .11 to .13; those for O2 to O4 were .09 to .12; and that for S was .41. The patterns of influence among the three ecological systems here were the same as those found in the hypothesized model. In other words, *person*, *family and school*, and *organization* were significantly correlated (*p*s < .001); the correlation coefficients (ϕs) were .58 for *person* and *family and school*, .49 for *family and school* and *organization*, and .45 for *organization* and *person*. Again, person and organization had direct effects on creativity ($\gamma = .42$, $p < .01$; and $\gamma = .27$, $p < .05$). As expected, *family and school* had no direct effects on creativity ($\gamma = -.16$, *ns*). As for the total effects on creativity, the coefficients were .46, .20, and .41 for *person*, *family and school*, and *organization*, respectively. These results support the patterns of influence proposed in the Ecological Systems Model of Creativity Development. As found in the hypothesized model, all manifest variables had significant effects on their latent variables, Λs = .47 to .86, *p*s < .001. The most important indexes for personal characteristics were tryout, multiple-perspective reasoning, problem-solving ability plus interaction and prudence, with Λs values of .84, .85, .85, and .80, respectively. In addition, the most important index for *family and school* was school experiences (Λ = .74). Finally, the most important index for organization was the factor *support and teamwork* (Λ =.91).

Software Development Group

Hypothesized model. The SEM analysis (see Figure 3) yielded a significant χ^2 value, $\chi^2(115, N = 125) = 154.75$, $p = .008$; the other fit indexes were GFI = .85, AGFI = .81, and RMR = .10. Although the χ^2 value indicated the model was not a satisfactory good fit, the other fit indexes suggested the model was acceptable. The standardized errors for P2 to P9 were .10 to .15, those for O2 to O4 were .08 to .09, and that for S was .41. As predicted, all ecological systems were closely interrelated (*p*s < .001). *Person* and *family and school*, as well as *family and school* and *organization* had the highest correlations (ϕs = .56), and comparatively, *organization* and *person* had a lower correlation (ϕ = .50). Although *person* had direct effects on creativity ($\gamma = .41$, $p < .01$), *organization* did not have any direct effects on creativity as originally expected ($\gamma = -.01$, *ns*). As for the total effects on creativity, the coefficients were 44, .25, and .22 for *person*, *family and school*, and *organization*, respectively. All manifest variables had significant effects on their latent variables, Λs = .58 to .92, *p*s < .001. The most important indexes for personal characteristics were problem-solving ability, tryout, and adaptive cognition, with Λs values of .87, .82, and .81, respectively. Although the most important index for *family and school* was school experiences (Λ = .68), the most important indexes for *organization* were the two variables of *support and teamwork* and *opportunities and needs* (Λs = .92 and .90).

Possible model. The SEM analysis yielded a significant χ^2 value, $\chi^2(114, N = 125) = 154.63$, $p = .01$); the other fit indexes were GFI = .85, AGFI = .80, and RMR = .10. Again, the fit indexes suggested that the model was acceptable. The standardized errors for P2 to P9 were .10 to .13, those for O2 to O4 were .08 to .09, and that for S was .42. The patterns of influence among the three ecological systems here were the same as those found in the hypothesized model. In other words, *person*, *family and school*, and *organization* were significantly correlated (*p*s < .001); the correlation coefficients (ϕs) were .56 for *person* and *family and school*, .56 for *family and school* and *organization*, and .50 for *organization* and *person*. Moreover, *person* had direct effects on creativity ($\gamma = .41$, $p < .01$), but *family and school* and *organization* did not have any direct effects on creativity ($\gamma = .08$, and $\gamma = -.03$, *ns*). Regarding the total effects on creativity, the coefficients were .44, .29,

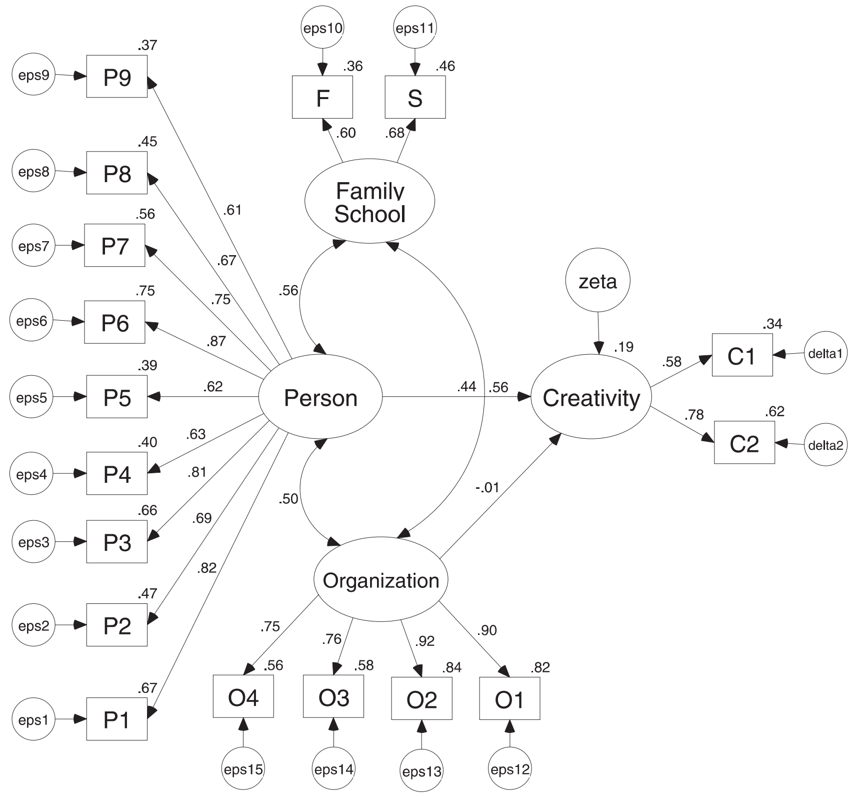

Figure 3. *Hypothesized model in the software development group. P1 = tryout, P2 = joy in work, P3 = adaptive cognition, P4 = multiple-perspective reasoning, P5 = independence, P6 = problem-solving ability, P7 = interaction and prudence, P8 = interest, P9 = intuition and imagination, F = family, S = school, O1 = opportunities and needs, O2 = support and team work, O3 = group dynamics, O4 = supervision, C1 = self-evaluation, C2 = public recognition.*

and .22 for *person*, *family and school*, and *organization*, respectively. All manifest variables had significant effects on their latent variables; that is, Λs = .58 to .92, *p*s < .001. The most important indexes for personal characteristics were problem-solving ability, tryout and adaptive cognition, and the Λs were .87, .82, and .81, respectively. In addition, the most important index for *family and school* was school experiences (Λ = .69). Finally, the most important index for organization were *support and teamwork* and *opportunities and needs* (Λs = .92 and .90).

Comparisons of the Possible and Hypothesized Models

In both the hardware group and software group, the comparisons of χ^2, NFI, and AIC indicated that the two models were not significantly different, hardware group: χ^2_{diff} = .69(1), $p > .05$, NFI_{diff} = .00; software group: χ^2_{diff} = .12(1), $p > .05$, NFI_{diff} = .00 (see Table 2). However, from the perspective of structural relationships among the latent variables (see Figures 2 and 3), the hypothesized model was better fit to the data, confirming that the Ecological Systems Model was strongly supported.

Discussion and Conclusions

Limitations

Three major limitations were inherent in this study. First, R & D employees make up only a low proportion of staff in information technology companies in Taiwan, and most of the supervisors as well as their R & D

Table 2. *Comparisons of Latent Models for the Hardware Development Group*

	Hardware Group		Software Group	
Good-Fit Index	Possible Model	Hypothesized Model	Possible Model	Hypothesized Model
c^2 (*df*)	152.41 (114)	153.10 (115)	154.63 (114)	154.75 (115)
NFI	0.86	0.86	0.85	0.85
AIC	230.41	229.1	232.63	230.75

employees lacked the motivation to participate in the study. It took half a year to obtain the self-administered questionnaires, but even then only 25% of the mailed questionnaires were returned. Second, Structural Equation Modeling is suitable for a large sample size. It is, in fact, suggested that a sample size of at least 200 be obtained to ensure the stability of the results; a small sample size may reduce any generalization and stability of the findings (Loehlin, 1992). Because of the difficulty in getting participants, the sample size in this study was close to the 200 limit but, unfortunately, not large enough. The findings in this study therefore need to be replicated. Third, due to limitations with the SEM, how the three ecological systems influence technological creativity was not analyzed by gender groups, though there were some gender differences found with respect to personal characteristics, family environment, and school experiences. Nevertheless, the results in this study provide valuable information for information technology companies as well as educators.

Interactive Relationships of Ecological Systems on Technological Creativity

This study analyzed both the possible model and the hypothesized model across R & D development groups to verify the Ecological Systems Model of Creativity Development. Though the hypothesized models were not best fit to the data (χ^2 were significant), they were acceptable (GFI = .86 and GFI = .85 for the hardware and software groups, respectively). The significance test of χ^2 was greatly influenced by sample size; it was not, however, the only criterion used to judge the goodness-of-fit of the models. Take the hypothesized model as an example; if all samples were used in the analyses, the GFI increased to .91. This means that if the sample size had been increased, the results of the model testing would likely have been more satisfactory. The results suggest, therefore, that the Ecological Systems Model holds when it is applied to the field of information technology.

In the hardware development companies, the hypothesized relationships among the microsystem, the mesosystem, the exosystem, and creativity were firmly supported. More specifically, the findings revealed that, first, personal characteristics had the most powerful effects on the hardware R & D employees' creative performances, and most of the effects came as a direct influence; second, the organizational environment had effects on the employees' creative performance, and about half of the effects came indirectly via personal characteristics; and finally, the influence of family and school experiences on the employees' creativity mainly came indirectly via personal characteristics. Such patterns of influence were replicated in the software development companies, except that in those companies, the organizational environment only had an indirect influence on the R & D employees' creative performance, and again, this was via personal characteristics. This particular difference most likely reflects the varied interaction patterns between personal characteristics and organizational environment in the two types of companies. The SEM results indicated that the indirect effect of organizational environment on creativity via personal characteristics in the software development companies was greater than that in the hardware development companies (the coefficients were .22 and .17, respectively). Further, it was found in both interviews (Yeh, 1999) and in the investigation study (Yeh, 2000) that the software development companies had, both qualitatively and quantitatively, better interactions among employees and their organizations than did the hardware development companies. Consequently, in highly interactive organizations, organizational environment may mainly influence employees' creativity by means of broadening their knowledge and cultivating their dispositions, skills, and strategies.

In brief, the findings in this study support the notion that a mature individual's creativity is built upon her or his knowledge, dispositions, and skills; and that such individualities are greatly influenced by family atmosphere (e.g., Michel & Dudek, 1991; Olszewski et al., 1987; Simonton, 2000; Walberg, 1988), school experiences (e.g., Cropley, 1997; Fleith, 2000; Rubenstein, 2000; Safer, 1995; Soh, 2000), and organizational environment (e.g., Amabile, 1996; Eunice, De Alencar, & De Fatima Bruno-Faria, 1997; Oldham & Cummings, 1996).

Person-Organization Interactions on Technological Creativity

Previous findings (Oldham & Cummings, 1996) found that employees with high creativity-relevant personal characteristics might be placed in complex, enriched jobs and be managed in a supportive, noncontrolling fashion. This study supports this proposition, as evidenced by the consistency in the scores on the IPF-TCD and the IOF-TCD. More specifically, the software R & D employees shared more personal characteristics pertaining to technological creativity, and they perceived themselves as having more organizational support during their work than did the hardware R & D employees.

Another interesting finding concerning person-organization interactions vis-á-vis technological creativity was that the hardware R & D employees had obtained more patents than had the software R & D employees. Patents are regarded as more innovative (Oldham & Cummings, 1996). According to Kirton's Adaptor–Innovator Theory (1994), people's cognitive styles, along with their way of perceiving and organizing information, influence their preferred approaches to creativity. Adaptive-oriented people tend to create by improving the current system, whereas innovative-oriented people are more likely to challenge existing paradigms. However, no matter what style individuals prefer, adaptive or innovative, as long as they perceive a fit with the environment, they must be expressing high levels of creative productivity (Puccio et al., 2000). In examining the interactions between personal characteristics and environmental concerns, this study did not take fitness into consideration. Whether the sense of fitness influences technological creativity and whether hardware R & D employees are more innovative-oriented are both worthy of further study.

Family and School Influences on the Development of Technological Creativity

Researchers in developmental psychology for creativity have focused on two aspects of longitudinal transformation—first, which childhood and adolescent experiences appear to be associated with the development of creative potential, and second, how that potential is actualized during the course of the creators adulthood and final years (Simonton, 2000). This study firmly demonstrates that family and school experiences play important roles in bringing about creative potential in technology. The SEM analyses suggest that personal characteristics represent the most crucial, direct resource for R & D employees' creative performance and that family and school experiences greatly influence technology creativity after first shaping employees' personal characteristics. Though a completely supportive family and school environment are not necessary for the development of extreme creativity, they do contribute to everyday creativity (Cropley, 1997; Fleith, 2000; Rubenstein, 2000; Soh, 2000). The experiences in early childhood carry great effects on people's development of creativity (Csikszentmihalyi, 1996). Parents, as well as teachers, are responsible for cultivating individualities prone to technological creativity, especially the abilities and dispositions of multiple-perspective reasoning, problem-solving ability, adaptive cognition, and braveness to try out.

Teachers can directly reinforce creativity through their interactions with students by building constructive classroom climates and effective evaluation measures, as well as recognizing students' creative personalities. Unfortunately, teachers are too often short of training and, more often than not, they work without having a clear definition of creative thinking (Soh, 2000). As a result, teacher-dominated classroom environments have prevailed (Fuaman, 1998; Morgan, & Forster, 1999). Therefore, more in-service as well as preservice teacher training in technological creativity is required.

Conclusions and Suggestions

In this study, I have proposed the Ecological Systems Model of Creativity Development and have explained creativity from a holistic, interactive, and developmental perspective. Four layers of ecological systems are shown to be central to the model: the microsystem, the mesosystem, the exosystem, and the macrosystem. How the microsystem, the mesosystem, and the exosystem are interrelated and how these systems influence the development of creativity are interpreted and verified here by being applied to information technology companies. Future studies might replicate the results in other fields or company settings. Besides this, this study has found that there are some common as well as unique creative-related personal characteristics and organizational factors across the two types of companies. Do people choose organizations that match their personal characteristics, or do the organizations change staff members' personal characteristics, or both? More empirical studies are required to answer this question. Finally, seldom has past research related to creativity mentioned emotional intelligence as a potential influence on creative production. This study has found that abilities related to emotional intelligence (in the factor of adaptive cognition) are important personal traits for technological creativity. How emotional intelligence impacts individuals' creating processes is a field worthy of exploration.

References

Amabile, T. M. (1988). A model of creativity and innovation in organizations. *Research in Organizational Behavior, 10*, 123–167.

Amabile, T. M. (1996). *Creativity in context*. Boulder, CO: Westview Press.

Amabile, T. M., Conti, R., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal, 39,* 1154–1184.

Bomba, A. K., & Moran, J. D. (1991). Relationship between familial style and the creative potential of preschool children. *Psychological Reports, 68*, 1323–1326.

Bronfenbrenner, U. (1989). Ecology systems theory. In R. Vasta (Ed.), *Annals of child development* (Vol. 6, pp. 187–251). Greenwich, CT: JAI Press.

Cropley, A. J. (1997). Fostering creativity in the classroom: General principles. In M. A. Runco (Ed.), *Creativity research handbook* (Vol. 1, pp. 83–114). Cresskill, NJ: Hampton Press.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.

Csikszentmihalyi, M. (1996). *Creativity*. New York: Harper Collins.

Donnelly, B. (1994). Creativity in the workplace. *The Journal of Technology Studies, 20*(2), 4–8.

Dudek, S. Z., Strobel, M. G., & Runco, M. A. (1993). Cumulative and proximal influences on the social environment and children's creative potential. *The Journal of Genetic Psychology, 154,* 487–499.

Eunice, M. L., De Alencar, S., & De Fatima Bruno-Faria, M. (1997). Characteristics of an organizational environment which stimulate and inhibit creativity. *Journal of Creative Behavior, 31,* 274–281.

Feldhusen, J. F. (1995). Creativity: A knowledge based, metacognitive skill, and personality factors. *Journal of Creative Behavior, 29,* 255–268.

Fleith, D. S. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review, 22*(3), 148–153.

Fuaman, A. (1998). Teacher and pupil characteristics in the perception of the creativity of classroom climate. *Journal of Creative Behavior, 32,* 258–277.

Gardner, H. (1993). *Creating minds*. New York: Basic Books.

Gruber, H. E., & Davis, S. N. (1988). Inching our way up Mount Olympus: The evolving-systems approach to creative thinking. In R. J. Sternberg (Eds.), *The nature of creativity* (pp. 240–273). New York: Cambridge University Press.

Gruber, H. E., & Wallace, D. B. (1999). The case study method and evolving systems approach for understanding unique creative people at work. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 93–115). New York: Cambridge University Press.

Guilford, J. P. (1967). *The nature of human intelligence*. New York: McGraw-Hill.

Jensen, L. C., & Kinston, M. (1986). *Parenting*. Orlando, FL: Holt, Rinehart and Winston.

Kanter, R. M. (1988). When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organization. In B. M. Staw & L. L. Cummings (Eds.), *Research in organizational behavior* (pp. 169–211). Greenwich, CT: JAI Press.

Kirton, M. J. (1994). *Adaptors and innovators: Styles of creativity and problem-solving* (Rev. ed.). London: Routledge.

Koestler, A. (1969). *The act of creation.* New York: Macmillan.

Loehlin, J. (1992). *Latent variable models: An introduction to factor, path, and structural analysis* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Lubart, T. I., & Getz, I. (1997). Emotion, metaphor, and the creative process. *Creativity Research Journal, 10,* 285–301.

Marjoribanks, K. (1992). Cultural, human, and social capital correlates of creativity. *Creativity Research Journal, 5,* 361–367.

Mellou, E. (1996). The two-conditions view of creativity. *Journal of Creative Behavior, 30*, 126–149.

Michel, M., & Dudek, S. Z. (1991). Mother-child relationship and creativity. *Creativity Research Journal, 4,* 281–286.

Morgan, S., & Forster, J. (1999). Creativity in the classroom. *Gifted Education International, 14*(1), 29–43.

Oldham, G. R., & Cummings, A. (1996). Employee creativity: Personal and contextual factors at work. *Academy of Management Journal, 39*, 607–634.

Olszewski, P., Kulieke, M., & Buescher, T. (1987). The influence of the family environment on the development of talent: A literature review. *Journal for the Education of Gifted, 11*(1), 6–28.

Olszewski-Kubilius, P. (2000). The transition from childhood giftedness to adult creative productiveness: Psychological characteristics and social support. *Roeper Review, 23*(2), 65–71.

Pressley, M., & McCormick, C. B. (1995). *Advanced educational psychology.* New York: Harper Collins College Publishers.

Puccio, G. J., Talbot, R. J., & Johiak, A. J. (2000). Examining creative performance in the workplace through a person-environment fit model. *Journal of Creative Behavior, 34*, 227–247.

Rubenstein, D. J.(2000). Stimulating children's creativity and curiosity: Do content and medium matter? *Journal of Creative Behavior, 31*, 1–17.

Runco, M. A. (1996). Personal creativity: Definition and developmental Issues. *New Directions for Child Development, 72*, 3–30.

Runco, M. A., Nemiro, J., & Walberg, H. J. (1998). Personal explicit theories of creativity. *Journal of Creative Behavior, 32*, 1–17.

Safer, J. (1995). The effects of play-oriented curriculum on creativity in elementary school children. *Gifted Education International, 11*(1), 4–17.

Siau, k. L. (1995). Group creativity and technology. *Journal of Creative Behavior, 29*, 201–216.

Simonton, D. K. (1984). *Genius, creativity, and leadership: Historicmetric inquiries*. Cambridge, MA: Harvard University Press.

Simonton, D. K. (1988). Creativity, leadership, and chance. In R. J. Sternberg (Ed.), *The nature of creativity* (pp. 386–427). New York: Cambridge University Press.

Simonton, D. K. (2000). Creativity: Cognition, personal, developmental, and social aspects. *American Psychologist, 55*, 151–158.

Soh, K. (2000). Indexing creativity fostering teacher behavior: A preliminary validation study. *Journal of Creative Behavior, 34*, 118–134.

Sternberg, R. J.(2000). Identifying and developing creative giftedness. *Roeper Review, 23*(2), 60–64.

Sternberg, R. J., & Lubart, T. I. (1995). *Defying the crowd: Cultivating creativity in a culture of conformity*. New York: Free Press.

Sternberg, R. J., & Lubart, T. I. (1996). Investing in creativity. *American Psychologist, 51*, 677–688.

Tan, A. G.(2001). Singaporean teachers perception of activities useful for fostering creativity. *Journal of Creative Behavior, 35*, 131–148.

Torrance, E. P. (1966). *Torrance tests of creative thinking: Normal-technical Manual.* Princeton, NJ: Personal Press.

Torrance, E. P. (1988). The nature of creativity as manifest in its testing. In R. J. Sternberg (Ed.), *The nature of creativity* (pp. 43–75). New York: Cambridge University Press.

Ullman, J. (1996). Structural equation modeling. In B. G. Tabachnick & L. S. Fidell (Eds.), *Using multivariate statistics* (3rd ed.). New York: Harper Collins Publishers.

Walberg, H. J. (1988). Creativity and talent as learning. In R. J. Sternberg (Ed.), *The nature of creativity* (pp. 340–361). New York: Cambridge University Press.

Wallas, G. (1926). *The arts of thought*. New York: Harcourt, Brace and World.

Woodman, R, W., Sawyer, J. E., & Griffinn, R. W. (1993). Toward a theory of organizational creativity. *Academy of Management Review, 18*, 293–321.

Yeh, Y.-C. (1999). *The relationships of creativity and its correlates among employees in information technology companies*. Project report of the National Science Council, Taiwan (NSC88–2519–S–110–001).

Yeh, Y.-C. (2000). *The relationships of creativity and its correlates among employees in information technology companies*. Project report of the National Science Council, Taiwan (NSC89–2519–S–110–001).