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The impact of creative tendency, academic performance, and self-concept on creative science problem-finding

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Abstract: This study was designed to address the impacts of science performance, science self-concept, and creative tendency on the creative science problem-finding (CSPF) ability of a sample of Chinese middle-school students. Structural equation modeling was used to indicate that CSPF could be directly predicted by creative tendency and academic performance, and indirectly predicted by science self-concept. The findings strongly support the idea that curiosity, imagination, and domain-specific knowledge are important for CSPF, and science self-concept could be mediated by knowledge that affects CSPF.

Keywords: creative problem-finding; creative tendency; middle-school student; science performance; science self-concept
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Creativity as the expression of flexibility, diversity, and imaginative ways of thought is a central objective in educating the young (Koren, Klavir, & Gorodetsky, 2005). Creativity could well contribute to students' attitudes towards and success in science learning, which is becoming increasingly important both in Western industrialized countries and in the Chinese context. Moreover, empirical research suggests that *problem finding* is an important and distinct component in the creative process (Chand & Runco, 1993; Runco & Okuda, 1988). Problem finding/generation has been recognized as one of the abilities that is valued as essential to science and society (Getzels & Csikszentmihalyi, 1976). Creative problem finding/generation is the ability to generate new problems to solve or issues to explore. It entails the ability to imagine, look for discrepancies and apparent contradictions, and entertain new hypotheses about old problems, or to generate entirely novel questions or problems to be solved (Carson & Runco, 1999; Runco, 1994).

The problem-finding ability allows adolescents to think of a problem and then to provide solutions. In one important study (Runco & Okuda, 1988), the unique variance of the discovered problems was reliably and significantly related to creative performance. Also, one study has found that problem-finding scores were significantly correlated with problem-solving scores, and correlated more highly with criteria of creativity (i.e., originality, fluency, and flexibility) than problem-solving scores (Wakefield, 1985). Nakamura and Csikszentmihalyi (2003) reported an 18-year longitudinal study which suggested that the problem-finding skills of artists were effective in predicting the quality of their future work (see Runco, 2004). Although Gürses, Açıkyıldız, Doğar, and Sözbilir (2007) suggested that a problem-finding learning approach in a physical chemistry laboratory course can promote critical thinking and problem-solving skills, generally there is a lack of research that investigates problem finding among adolescents in the science domain.

Psychologists and educators frequently ask questions about the content generality of cognitive abilities (Perkins & Salomon, 1989; Sternberg, 2006), and creativity is not an exception (Plucker, 2004). While perhaps the most popular viewpoint is that creativity has both domain-general and domain-specific components (Lubart & Sternberg, 1995; Sternberg, 2005), Sternberg and Lubart (1995) have suggested that the achievement of creativity must be dependent, at least in part, on other elements, such as knowledge, personality, and motivation (Amabile, 1996; Sternberg & Lubart, 1995). For example, the efficient exploration of a problem depends on knowledge and experience (Ward, Smith, & Finke, 1999), and a conceptually well-organized knowledge base makes an important contribution to problem-solving or creative thinking (Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991). Many researchers report low correlation coefficients for creativity measured across different domains (Runco, 1987, 1989; Sternberg, 2006), suggesting a greater role for domain-specific creativity compared with domain-general creativity. It is evident that domain-specific or discipline-based knowledge and skills are major components of creativity (Amabile, 1996; Gardner, 1993; Sternberg & Lubart, 1995). Nickerson (1999) also stressed the importance of domain-specific knowledge as a determinant of creativity and held the view that it is generally underestimated, even though investigators have given it considerable emphasis.

Thus, scientific creativity, which must depend on scientific knowledge and skills, is distinctly different from other creativity because it is concerned with creative science experiments, creative science problem-finding and -solving, and creative science activity (Hu & Adey, 2002). Obviously, science knowledge is quite domain-specific and plays a critical role in scientific creativity. While most researchers have focused on studying the creativity of famous scientists or college students to show the importance of domain-specific or discipline-based knowledge and skills to creativity (Gardner, 1993; Simonton, 1984), this study will investigate the role of academic science performance in creative science problem-finding for ordinary middle-school students.

Age-related differences in creativity have been stressed in previous research (Hu & Adey, 2002), but school grade may be more informative for investigating scientific creativity, because school grade levels indicate which science lessons a student has taken. Hu, Adey, Shen, and Lin (2004) compared British and Chinese students on creative science problem-finding and found that the creative problem-finding ability increased steadily with age. They also found that age 11–13 years was the fastest period of development for British adolescents and that age 14–16 years was the fastest period of development for Chinese adolescents. But their focus was comparison; they did not further explore why the fastest development happened in those periods. In China, the elementary science curriculum is mainly focused on the cultivation of interest in science and the degree of specialization is comparatively low. On entry to the intermediate school the science curriculum begins to differentiate and becomes increasingly specialized. Students begin to study biology in seventh grade, physics from eighth grade, and chemistry from ninth grade. Grades 8–10 in China correspond to ages 14–16 years, and learning in this period is more and more related to science knowledge. The question is whether science-related academic performance contributes to the scientific creativity of adolescents at that stage or not. One purpose of this study, therefore, is to examine the role that academic performance plays in the development of creative problem-finding ability in students in Grades 8–10.

Self-concept and achievement motivation are important factors in children's school achievement (Liu, Guo, & Wang, 1991; Solmon, 2003). Cokley and Patel (2007) proposed that "academic self-concept is an important psychological construct because it has been found to be both a cause and an effect of academic achievement" (p. 89). Academic self-concept is defined as the student's view of their own academic or intellectual abilities, including their feelings and attitudes, particularly when comparing themselves to other students (Cokley, 2000; Lopez, Lent, Brown, & Gore, 1997). It will influence what they do and how they try to do it, particularly in challenging situations. Given that science knowledge could facilitate scientific creativity, another purpose of this study is to investigate how academic self-concept affects creative science problem-finding, that is, whether or not there is an effect and, if yes, whether the effect is direct or indirect.

Although the chief sciences are chemistry, physics, and biology, it has been suggested that mathematics is the "critical filter" that influences students' science interests and courses taken in science (Fouad & Smith, 1996; Lapan, Hinkelman, Adams, & Turner, 1999; O'Brien, Martinez–Pons, & Kopala, 1999). Mathematics appears to provide a useful (usually even essential) tool for mastering knowledge of science subjects. For Chinese middle-school students, math is mostly regarded as an important part of the sciences and in the present study mathematics is included in the category of science.

Some researchers have pointed out that knowledge about a field can not only facilitate creativity, but also result in a closed and entrenched perspective, leading to a person's not moving beyond the way in which he or she has seen problems in the past (Sternberg & Lubart, 1995). However other components can help a person to conquer this limitation, such as a creative tendency or personality. A creative tendency or personality, which refers to a positive psychological tendency toward creative activity (Shen, Wang, & Shi, 2005), is regarded as a necessary component of creativity (Amabile, 1996; Sternberg & Lubart, 1995). In more recent years, researchers put more emphasis on the affective process and personality aspects (Claxton, Pannells, & Rhoads, 2005). Feist (1999) proposed that creative personality dispositions do regularly and predictably relate to creative achievement. From a review of the literature on personality and creativity, he concluded that personality has an influence on creative achievement in art and science. Feist and Barron (2003) examined personality, intellect, potential, and creative achievement in a 44-year longitudinal study, and showed that personality variables explained up to 20% of creativity variance over and above intellectual potential. The third purpose of this study is to address the extent to which a general creative tendency influences creative science problem-finding.

As is well known, problem-finding is a particularly important component in the creative process because it occurs first, and because the quality of a problem may in part determine the quality of the solutions (Runco & Okuda, 1988), particularly for creative science problem-finding. There has been a dearth of research investigating creative science problem-finding, but it is valued as essential to science and society as a specific domain. Many researchers have examined the relation of problem-finding and divergent thinking/creative process, but fewer have examined the relation of problem-finding to the cognitive and noncognitive components (i.e., knowledge vs. creative personality, self-concept). Based on a literature review, we propose the following hypotheses:

Hypothesis 1: Science-related academic performance has a positive relation with creative science problem-finding in eighth to 10th grade students.

Hypothesis 2: General creative tendency and academic self-concept have direct relations with creative science problem-finding.

Hypothesis 3: General creative tendency and academic self-concept indirectly facilitate creative science problem-finding through science-related academic performance.

Materials and methods

Participants

The participants for the study were 161 eighth to 10th grade secondary school students (76 male, 85 female) from Shanxi Province in China (see Table 1). As an indication of the representativeness of the school, the middle school is ranked 40th out of 88 schools in that city. Their ages ranged from 14 to 17 years, with a mean of 15.71 years ($SD = 1.15$).

Materials

CSPF

The item used in this study was chosen from the scientific creativity test for secondary-school students designed by Hu and Adey (2002). The item used for problem finding was: "If you can take a spaceship to travel into outer space and go to a planet, what scientific questions do you want to research? Please list as many as you can."

The subjects' responses were scored in terms of fluency, flexibility, and originality. The *fluency* score is simply the number of questions generated. *Flexibility* is scored as the number of categories across which a subject's questions are distributed. The categories are predetermined, before any individual's response is scored, by pooling all responses together and categorizing them based on the nature of all of the questions. The more a student's responses are distributed across categories, the higher the student's flexibility score. The *originality* score is based on the frequency as a percentage for a given response in the total sample. A student will gain a score of two points if the response frequency percentage is smaller than 5%, one point if the response frequency is between 5% and 10%, and 0 points if the frequency is above 10%. The CSPF was trialed with 30 students and their scripts were given to three judges with a set of scoring rules to check for interrater reliability. The interscorer reliability reached .897.

Table 1
Mean scores and standard deviations for creative science problem-finding

		Fluency		Flexibility		Originality	
Grade	Sex	*M*	*SD*	*M*	*SD*	*M*	*SD*
8	Female	17.29	1.32	3.07	0.17	15.16	1.47
	Male	19.54	1.39	3.39	0.18	17.89	1.55
9	Female	18.28	1.47	3.17	0.17	15.69	1.52
	Male	15.96	1.39	2.96	0.18	13.79	1.55
10	Female	18.41	1.36	3.24	0.19	17.20	1.64
	Male	17.40	1.64	3.10	0.21	17.20	1.83

Williams' Creativity Assessment Packet (Test of Divergent Feeling)

This is a 50-item scale designed to measure the affective-feeling behavioral components of creativity, including four factors: curiosity, imagination, challenge-taking, and risk-taking (Williams, 1994 [1980]). Respondents are required to rate the degree to which each item is true for them on a 3-point Likert-type scale format. All items range from 1 (totally disagree) to 3 (totally agree), except 8 items with inverse direction. Higher scores reflect a higher creative potential. The test's split-half reliability is .82–.86; the Cronbach's alpha internal reliability is .81–.85.

Science self-concept

The academic science self-concept variable refers to students' perceptions of their science ability when comparing themselves to other students (Cokley, 2000; Lopez et al., 1997). Two items were designed to measure the perceptions students have about their academic abilities in math and physics, for example, "When compared with your classmates, which description for physics or math fits you?" It uses a 5-point Likert-type scale ranging from 1 (I am the worst in class) to 5 (I am the best in class). Higher scores reflect a more positive academic self-concept.

Academic performance

Academic performances in end-of-term examinations in math and physics were collected as measures of science achievement. Eighth grade students do not attend chemistry classes and ninth grade students do not attend biology classes, but all eighth to 10th grade students have math and physics classes. The raw scores were standardized into z scores to analyze scores taken from students of different grades.

Results

Descriptive statistics for the CSPF

The mean scores and standard deviations of the CSPF by grade and sex for the overall sample are shown in Table 1. As described above, the student's responses to the CSPF were rated for their fluency, flexibility, and originality.

It can be seen that there was an upward trend in all three factors for girls across grades, and that in Grades 9–10, girls' scores in fluency and flexibility were superior to those of boys. However, when a MANOVA was used to assess the main and interaction effects of sex (2) and grade (3) on fluency, flexibility, and originality, none of the differences reached statistical significance, even at the $p = .05$ level.

The relation of creative tendency, science performance, science self-concept and CSPF

In order to explore the relations between creative science problem-finding, creative tendency, science performance, and science self-concept, a series of correlations was carried out. Fluency, flexibility, and originality were indicators of CSPF. Curiosity, imagination, challenge, and risk taking were indicators of creative tendency, self-concept in math and physics were indicators of science self-concept, and end-of-term scores for math and physics were indicators of academic science performance.

As can be seen from Table 2,

- The three factors of CSPF were strongly related with one another ($r = .9$ or greater).
- The four factors of creative personality were moderately well related ($r = .43$ or greater).
- The CSPF factors and the creative personality factors were weakly related to one another, although their correlations

Table 2
Correlations between creative tendency, science performance, science self-concept, and creative science problem-finding

		1	2	3	4	5	6	7	8	9	10
Creative science problem-finding	1 Fluency										
	2 Flexibility	.947**									
	3 Originality	.957**	.899**								
Creative tendency	4 Risk-taking	.193*	.177*	.196*							
	5 Curiosity	.158*	.168*	.152	.497**						
	6 Imagination	.173*	.168*	.200*	.431**	.452**					
	7 Challenge-taking	.229**	.243**	.256**	.502**	.472**	.412**				
Academic performance	8 Math performance	.152	.134	.099	–.059	.090	.037	.141			
	9 Physics performance	.279**	.252**	.231**	.021	.062	.097	.171*	.780**		
Science self-concept	10 Math self-concept	.116	.086	.081	.085	.017	.068	.186*	.382**	.459**	
	11 Physics self-concept	.018	.021	–.009	.008	–.012	–.012	.037	.333**	.360**	361**

*$p < .05$. **$p < .01$.

did reach statistical significance. The highest r-value in this group was .26, between challenge-taking and originality.

- Math performance was not related to any of the other factors except, unsurprisingly, physics performance.
- Physics performance was weakly (but significantly) related to the CSPF factors, but not to a creative personality.
- The self-concept scores were related to their corresponding subject matter scores (r values of approximately 0.4).

Testing the measurement model and the structural model

According to the recommendation of Anderson and Gerbing (1988), the measurement model that shows the relations between the latent variables and their indicators was first tested for an acceptable fit to the data through a confirmatory factor analysis. Then the structural model that shows the potential causal dependencies between the endogenous and exogenous variables was tested after an acceptable measurement model was developed. The measurement model was estimated using the maximum likelihood method in Lisrel (Version 8.54).

In the current study, the measurement model was based on a four-factor measurement model consisting of four latent variables, namely CSPF, creative tendency, academic science performance and science self-concept. The results showed that the four-factor measurement model fit the data relatively well: $\chi^2/df = 0.89$, NFI = .96, CFI = 1.00, GFI = .96, RMSEA = .001. All of the loadings of the observed variables on the corresponding latent variables were greater than .5 and statistically significant ($p < .001$, see Table 3). Therefore, all of the latent variables appear to have been adequately measured by their respective indicators. Table 4 shows the correlations among the latent variables for the measurement model.

On the basis of these correlations, the structural model showed the relations between creative tendency, science performance, science self-concept, and CSPF. Creative tendency, science self-concept, and academic science performance are exogenous variables. Originality, flexibility, and fluency have high correlations with each other, so CSPF was treated as their latent variable, the endogenous variable in the model.

The model preserves an ideal goodness of fit index: $\chi^2/df = 2.08$, NFI = .97, CFI = 1.00, TLI = 1.00, RMSEA = .01. As can be seen from Figure 1, creative tendency and science performance positively predicted CSPF directly ($\beta = .24$, $p < .01$ and $\beta = .35$, $p < .01$, respectively) while science self-concept did not predict CSPF directly ($\beta = .13$, $p > .05$), and was only indirectly mediated by science performance. Science self-concept predicted science performance significantly ($\beta = .69$, $p < .01$). That is to say, CSPF was significantly predicted by three paths, which were "creative tendency → CSPF," "science performance → CSPF." and "self-concept → science performance → CSPF." As for the determined coefficient, the model showed that creative tendency, science self-concept, and science performance together accounted for 24.5% of the variance in CSPF.

Table 3
Factor loadings for the measurement model

	β	*SE*	*z*
Creative science problem-finding			
Fluency	1.00***	0.41	17.98
Flexibility	.95***	0.48	16.28
Originality	.94***	0.06	15.97
Creative tendency			
Curiosity	.69***	0.02	8.76
Imagination	.62***	0.03	7.60
Challenge	.69***	0.02	8.75
Risk taking	.71***	0.02	9.05
Academic performance			
Performance of math	.79***	0.08	10.50
Performance of physics	.89***	0.07	13.59
Science self-concept			
Self-concept in math	.68***	0.11	6.79
Self-concept in physics	.53***	0.08	5.77

***$p < .001$.

Table 4
Correlations among latent variables for measurement model

Latent variable	CSPF	CT	AP	SSC
CSPF	–	.27***	.28***	.13
CT		–	.13	.14
AP			–	.69***
SSC				–

Note. AP = academic performance; CSPF = creative science problem-finding; CT = creative tendency; SSC = science self-concept.
***$p < .001$.

Discussion

Although the girls' scores in fluency, flexibility, and originality were slightly higher than those of the boys, except in eighth grade, there was no significant sex difference, which replicates the results found in some earlier studies (Hu & Adey, 2002; Shukla & Sharma, 1986). This absence of a sex difference supports the idea of equality between the sexes in

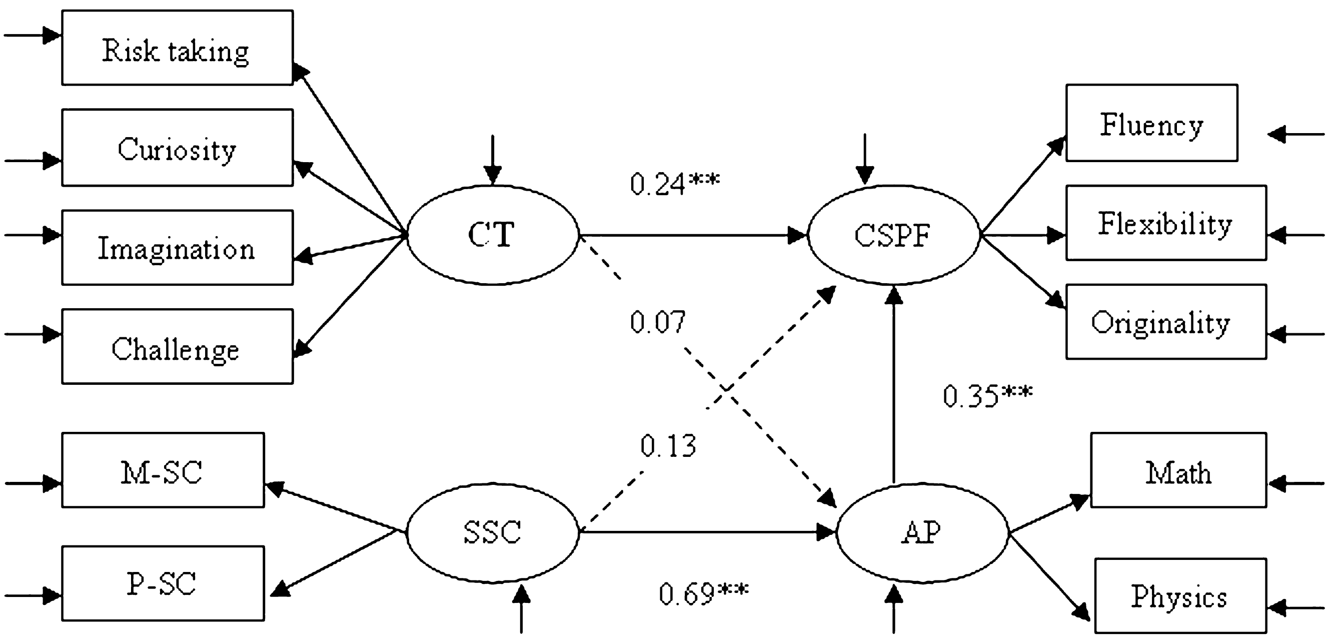

Figure 1. Structural model of creative science problem-finding. AP = academic performance; CSPF = creative science problem-finding; CT = creative tendency; M-SC = math self-concept; P-SC = physics self-concept; SSC = science self-concept. $^{**}p < .01$.

education and is consistent with the modern Chinese practice of parents and educators expecting excellence in their children, boys or girls. As to grade, the present result revealed that there was an upward trend in fluency, flexibility, and originality during the period from eighth to 10th grade, except for a slight drop for boys in ninth grade, but the differences did not reach statistical significance.

Structural equation modeling was used to explore further the role that academic science performance played in CSPF. Academic science performance was found to have a significantly positive and direct effect on CSPF. The present study only considered students' performance in math and physics, with the result confirming that science-related knowledge can not only facilitate the "big C" of scientists, as other researchers have suggested, but can also predict the "small c" of ordinary students. Creative science problem-finding can happen once an individual has learnt some of the relevant rules or knowledge. As an individual masters more science knowledge, they are able to find more questions in a given situation. As Sternberg (2006) said, one needs to know enough about a field to move forward, either with respect to the field in general or to one's own understanding of it. Thus, creative problem-finding as one component of creativity is firmly grounded in knowledge.

This study also explored whether academic self-concept has a direct relation to scientific creativity. Against expectations, academic self-concept did not appear to have any direct relation to CSPF, although it indirectly affected CSPF through a significantly positive effect on academic science performance, which can facilitate CSPF. This may be explained by the items that academic self-concept contained. In the current study, only the self-concepts for math and physics corresponding to academic performance were selected to measure the academic self-concept. Consequently, compared with academic performance, the variance of CSPF explained by self-concept was small. Notably, 69% of the variance in academic performance was explained by academic self-concept. This result suggests that academic self-concept is a noncognitive factor that perhaps should receive more attention in education. An effort to improve and cultivate academic self-concept could make a great contribution to the development of science achievement and scientific creativity.

Nevertheless one must have knowledge of a field if one hopes to produce something novel within it. It is also widely assumed that too much experience can leave one in a rut, so that one cannot go beyond stereotyped responses (Sternberg, 2006; Weisberg, 1999). It might be expected that, to a certain extent, a creative personality or tendency can help a person to conquer this kind of limitation. In the present study, the insignificant relation between creative tendency and academic performance showed that a creative tendency is not a prerequisite for academic performance. Creative personality as a component of creativity mainly influenced the creative activities. Curiosity, imagination, challenge-taking, and risk-taking were shown to have a close relation with the three aspects of CSPF, and the model showed that creative tendency can predict the CSPF of students. Accordingly, curiosity and imagination were the two better indicators for predicting creative tendency in the current sample. Curiosity was conceptualized as a positive emotional–motivational system associated with the recognition, pursuit, and self-regulation of novelty and challenge (Kashdan, Rose, & Fincham, 2004). Some aspects of curiosity are a willingness to explore and tolerance for uncertainty in a situation. It was predicted that there would be overall performance differences between high- and low-curious subjects, with high-curious subjects, who generally prefer a higher degree of unfamiliarity and uncertainty, predicted to perform better (Arnone, Grabowski, & Rynd, 1994). Imagination is often successfully invited by putting together hitherto isolated items and by finding unsuspected connections (Mills, 1959). Many researchers have suggested that active imagination is a personality characteristic shared by creative artists and scientists (Amabile, 1996; Feist, 1999). To sum up, it is evident that one who has higher curiosity and imagination can find more creative science problems.

There are several limitations to the current study. To begin with, the sample was only from Shanxi, limiting both the power and generalizability. Second, our analyses were based only on academic performance, with no consideration of extracurricular science activities. Future research might need to investigate all the kinds of science-related activities in which the students participate in order to understand better the effects of science-related knowledge and engagement on CSPF. The current study highlighted that academic performance is a useful factor for predicting students' CSPF. However, a reasonable argument can be made that the effects are likely to be bidirectional, with academic performance fostering students' CSPF and this in turn facilitating the understanding and mastery of science knowledge. Longitudinal and intervention studies are needed to adequately examine the direction of the effects. A better understanding of the dynamic correlations between the academic performance and the CSPF of normal students will be useful in improving teaching methods and learning performance. Third, as mentioned above, for Chinese middle-school students math is mostly regarded as an important part of the sciences and, in the present study, mathematics was included in the category of science, so the generalizability of our findings is limited to similar settings. Fourth, there may be several additional factors (e.g., motivation) that were not included in this study. Fifth, Wolfradt and Pretz (2001) suggested that there is a need to clarify the nature of the creative personality across domains of expertise, so in future work the personality characteristics unique to those with higher abilities in CSPF should also be considered to get a more comprehensive understanding of students' CSPF.

Even with these limitations, this study may have made several contributions. First, this study expands our knowledge of CSPF and related factors in middle-school students. Second, the results showed that science-related knowledge can predict the "small c" of ordinary students, that is, domain-specific knowledge contributed greatly to domain creativity, and that the role of academic self-concept in CSPF is mainly shown through academic science performance. Third, we found that creative tendency (i.e., curiosity, imagination, challenge-taking, and risk-taking) as a component of creativity can facilitate the CSPF of students. To conclude, the results suggested that noncognitive factors should receive more attention in education.

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References

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

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423. doi:10.1037/0033-2909.103.3.411

Arnone, M. P., Grabowski, B. L., & Rynd, C. P. (1994). Curiosity as a personality variable influencing learning in a learner controlled lesson with and without advisement. *Educational Technology Research and Development*, *42*(1), 5–20. doi:10.1007/BF02298167

Carson, D. K., & Runco, M. A. (1999). Creative problem solving and problem finding in young adults: Interconnections with stress, hassles, and coping abilities. *The Journal of Creative Behavior*, *33*(3), 167–190. doi:10.1002/j.2162-6057.1999.tb01195.x

Chand, I., & Runco, M. A. (1993). Problem finding skills as components in the creative process. *Personality and Individual Differences*, *14*(1), 155–162. doi:10.1016/0191-8869(93)90185-6

Claxton, A. F., Pannells, T. C., & Rhoads, P. A. (2005). Developmental trends in the creativity of school-age children. *Creativity Research Journal*, *17*(4), 327–335. doi:10.1207/s15326934crj1704_4

Cokley, K. (2000). An investigation of academic self-concept and its relationship to academic achievement in African American college students. *Journal of Black Psychology*, *26*(2), 148–164. doi:10.1177/0095798400026002002

Cokley, K., & Patel, N. (2007). A psychometric investigation of the academic self-concept of Asian American college students. *Educational and Psychological Measurement*, *67*(1), 88–99. doi:10.1177/0013164406288175

Feist, G. J. (1999). The influence of personality on artistic and scientific creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 273–296). Cambridge, UK: Cambridge University Press.

Feist, G. J., & Barron, F. X. (2003). Predicting creativity from early to late adulthood: Intellect, potential, and personality. *Journal of Research in Personality*, *37*(2), 62–88. doi:10.1016/S0092-6566(02)00536-6

Fouad, N. A., & Smith, P. L. (1996). A test of a social cognitive model for middle school students: Math and science. *Journal of Counseling Psychology*, *43*(3), 338–346. doi:10.1037/0022-0167.43.3.338

Gardner, H. (1993). *Multiple intelligences*. New York, NY: Basic Books.

Getzels, J. W., & Csikszentmihalyi, M. (1976). *The creative vision: A longitudinal study of problem finding in art*. New York, NY: John Wiley and Sons.

Gürses, A., Açıkyıldız, M., Doğar, C., & Sözbilir, M. (2007). An investigation into the effectiveness of problem-based learning in a physical chemistry laboratory course. *Research in Science and Technological Education*, *25*(1), 99–113. doi:10.1080/02635140601053641

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, *24*(4), 389–403. doi:10.1080/09500690110098912

Hu, W., Adey, P., Shen, J., & Lin, C. (2005). The comparisons of the development of creativity between English and Chinese adolescents. *Acta Psychologica Sinica*, *36*(6), 718–731.

Kashdan, T. B., Rose, P., & Fincham, F. D. (2004). Curiosity and exploration: Facilitating positive subjective experiences and personal growth opportunities. *Journal of Personality Assessment*, *82*(3), 291–305. doi:10.1207/s15327752jpa8203_05

Koren, Y., Klavir, R., & Gorodetsky, M. (2005). Students' multimodal re-presentations of scientific knowledge and creativity. *The Journal of Creative Behavior*, *39*(3), 193–215. doi:10.1002/j.2162-6057.2005.tb01258.x

Lapan, R. T., Hinkelman, J. M., Adams, A., & Turner, S. (1999). Understanding rural adolescents' interests, values, and efficacy expectations. *Journal of Career Development*, *26*(2), 107–124. doi:10.1023/A:1018669417022

Liu, X. 刘晓明, Guo, Z. 郭占基, & Wang, L. 王丽荣. (1991). 成就动机，自我概念与学生学业成绩的关系研究 [Study on the relations among achievement motivation, self-concept and school achievement of students]. *Psychological Science* [心理科学], *2*, 18–21.

Lopez, F. G., Lent, R. W., Brown, S. D., & Gore, P. A. (1997). Role of social-cognitive expectations in high school students' mathematics-related interest and performance. *Journal of Counseling Psychology*, *44*(1), 44–52. doi:10.1037/0022-0167.44.1.44

Lubart, T. I., & Sternberg, R. J. (1995). An investment approach to creativity: Theory and data. In S. M. Smith, T. B. Ward, & R. A. Finke (Eds), *The creative cognition approach* (pp. 269–302). Cambridge, MA: MIT Press.

Mills, C. W. (1959). *The sociological imagination*. New York, NY: Oxford University Press.

Mumford, M. D., Mobley, M. I., Uhlman, C. E., Reiter-Palmon, R., & Doares, L. M. (1991). Process analytic models of creative capacities. *Creativity Research Journal*, *4*(2), 91–122. doi:10.1080/10400419109534380

Nakamura, J., & Csikszentmihalyi, M. (2003). Creativity in later life. In R. K. Sawyer & V. John-Steiner (Eds.), *Creativity and development* (pp. 186–216). New York, NY: Oxford University Press. doi:10.1093/acprof:oso/9780195149005.001.0001

Nickerson, R. S. (1999). Enhancing creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 392–430). Cambridge, UK: Cambridge University Press.

O'Brien, V., Martinez-Pons, M., & Kopala, M. (1999). Mathematics self-efficacy, ethnic identity, gender and career interests related to mathematics and science. *Journal of Educational Research*, *92*(4), 231–235. doi:10.1080/00220679909597600

Perkins, D. N., & Salomon, G. (1989). Are cognitive skills context-bound? *Educational Researcher*, *18*(1), 16–25. doi:10.3102/0013189X018001016

Plucker, J. A. (2004). Generalization of creativity across domains: Examination of the method effect hypothesis. *The Journal of Creative Behavior*, *38*(1), 1–12. doi:10.1002/j.2162-6057.2004.tb01228.x

Runco, M. A. (1987). The generality of creative performance in gifted and nongifted children. *Gifted Child Quarterly*, *31*(3), 121–125. doi:10.1177/001698628703100306

Runco, M. A. (1989). The creativity of children's art. *Child Study Journal*, *19*, 177–189.

Runco, M. A. (1994). *Problem finding, problem solving, and creativity*. Norwood, NJ: Ablex.

Runco, M. A. (2004). Creativity. *Annual Review of Psychology*, *55*, 657–687.

Runco, M. A., & Okuda, S. M. (1988). Problem discovery, divergent thinking, and the creative process. *Journal of Youth and Adolescence*, *17*(3), 211–220.

Shen, J., Wang, X., & Shi, B. (2005). A study on the structure and development of adolescents' creative tendencies. *Psychological Development and Education*, *21*(4), 28–33.

Shukla, J., & Sharma, V. (1986). Sex differences in scientific creativity. *Indian Psychological Review*, *30*(3), 32–35.

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

Solmon, M. A. (2003). Student issues in physical education classes: Attitudes, cognition and motivation. In S. J. Silverman & C. D. Ennis (Eds.), *Student learning in physical education: Applying research to enhance instruction* (2nd ed., pp. 147–164). Champaign, IL: Human Kinetics.

Sternberg, R. J. (2005). Creativity or creativities? *International Journal of Human-Computer Studies*, *63*(4-5), 370–382. doi:10.1016/j.ijhcs.2005.04.003

Sternberg, R. J. (2006). The nature of creativity. *Creativity Research Journal*, *18*(1), 87–98. doi:10.1207/s15326934crj1801_10

Sternberg, R. J., & Lubart, T. I. (1995). An investment perspective on creative insight. In R. J. Sternberg & J. E. Davidson (Eds.), *The nature of insight* (pp. 535–558). Cambridge, MA: MIT Press.

Wakefield, J. F. (1985). Towards creativity: Problem finding in a divergent-thinking exercise. *Child Study Journal*, *15*, 265–270.

Ward, T. B., Smith, S. M., & Finke, R. A. (1999). Creative cognition. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 189–212). Cambridge, UK: Cambridge University Press.

Weisberg, R. W. (1999). Creativity and knowledge: A challenge to theories. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 226–250). Cambridge, UK: Cambridge University Press.

Williams, F. E. (1994). *威廉斯创造力测验* [Creativity Assessment Packet: (CAP)] (HT Lin 林幸台 & MJ Wang 王木榮, Trans.). Taipei, Taiwan: Psychological Publishing. (English original published in 1980 by D.O.K. Publishers, East Aurora, NY)

Wolfradt, U., & Pretz, J. E. (2001). Individual differences in creativity: Personality, story writing, and hobbies. *European Journal of Personality*, *15*(4), 297–310. doi:10.1002/per.409