

Exploratory Examination of Relationships between Learning Styles and Creative Thinking in Math Students

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Abstract

It is believed that identifying any strong relationships between learning styles and creative thinking within the context of the math classroom will help improve instruction by providing course delivery strategies tailored to different learning preferences and promotion of creative thinking. Thus, the purpose of the current study is to identify which (if any) of the cognitive learning dimensions would be related to creative thinking in math students. The major findings of this study indicate that creative thinking, assessed by RAT, and learning preferences, evaluated by ILS, are not highly correlated. Over all, students in this study show a balanced learning preference across four dimensions. In summary, this study directs a possible path for future researchers to investigate this phenomenon.

Keyword: Learning style, creative thinking, math tutoring, math classroom.

Introduction

Students learn in different ways, so it is expected that teaching methods should also vary. As a result, Felder and Silverman (1988) state that “how much a given student learns in a class is governed in part by that student’s native ability and prior preparation but also by the compatibility of his or her learning style and the instructor’s teaching style” (p. 674). Most importantly, instructors should recognize the variety of students’ learning preferences and adapt their teaching strategies to fit this variance in order to create an optimal learning situation for most students in classes (Felder & Silverman, 1988). As Felder and Spurlin (2005) pointed out, it is possible that when learning styles and teaching styles are seriously mismatched, students’ academic performance might not attain the expected outcomes because of violating their learning modes.

Several theories and empirical studies have offered various perspectives that illuminate creativity development (Baer & Garrett, 2010; Davis, 2004; Hennessey, 2010; Piirto, 2010). The major findings of those studies arrive to two conclusions about creativity: (a) everyone has creativity and (b) creativity can be taught and developed. Therefore, teachers can be an imperative resource in facilitating students' learning experience and unleash their potential in the classrooms. As a result, one of key responsibilities of teachers is to plant the creativity seed in students' minds (Baldwin, 2010; Nickerson, 1999).

In mathematics classrooms creative problem solving serves as an important vehicle to promote creative thinking (Loewen, 1995; Pelczar & Gamboa Rodríguez, 2011; Sak & Maker, 2006). Chia-Yi and Seokhee (2011) investigated the effects of creative problem solving ability in math on 409 Taiwanese fifth and sixth grades students. It was concluded that divergent thinking and domain specific knowledge could predict the math problem-solving ability. However, Nickerson (1999) has recognized that "how to enhance creativity is not well understood, but there are possibilities that merit exploration" (p. 392). For example, Mednick and Andrews (1967) investigated a relationship between creativity and IQ, by using the Remote Associates Test (RAT; Medicak, 1962) to measure creative thinking, and the Scholastic Aptitude Test (SAT) of verbal and mathematical ability (SAT-V & SAT-M) as the indicators of IQ. The results from scores of high school students and college freshman showed a moderate correlation between intelligence and creative thinking.

The aim of this study is exploratory in nature. It is believed that identifying any strong relationships between learning styles and creative thinking within the context of the math classroom will help improve instruction by providing course delivery strategies tailored to different learning preferences and promotion of creative thinking. As a consequence, the purpose of the current study is to identify which (if any) of the cognitive learning dimensions on the Index of Learning Styles (ILS; Felder & Soloman, 1997) would be related to creative thinking (RAT; Medicak, 1962) in math students.

The Models of Learning Styles

As an educator, it is important to recognize different learning styles and preferences of students. Felder (1996) wrote:

If professors teach exclusively in a manner that favors their students' less preferred learning style modes, the students' discomfort level may be great enough to interfere with their learning. On the other hand, if professors teach exclusively in their students' preferred modes, the students may not develop the mental dexterity they need to reach their potential for achievement in school and as professionals. (p. 18)

As a result, he suggested that education should highlight both preferred and less preferred leaning styles, thereby fitting different needs of students and developing their potential.

According to the literature of learning styles, several scholars have proposed and developed learning models to explain the learning needs of students, including the Myers-Briggs Type Indicator (MBTI; Lawrence, 1994), Kolb's Learning Style model (Kolb, 1984), Herrmann Brain Dominance Instrument (HBDI; Herrmann, 1990), and Felder-Silverman Leaning Model (Felder & Silverman, 1988). The MBTI framework identifies four ranges of classifications: (a) extraverts or introverts, (b) sensors or intuitors, (c) thinkers or feelers, and (d) judgers or perceivers. Kolb's model classifies students as having a preference with four types, including (a) concrete experience and reflective observation, (b) abstract

conceptualization and reflective observation, (c) abstract conceptualization and active experimentation, and (d) concrete experience and active experimentation. The model of HBDI identifies four modes based on the function of the brain, including (a) left brain, cerebral: logical and critical; (b) left brain, limbic: sequential and organized; (c) right brain, limbic: emotional and interpersonal; and (d) right brain, cerebral: visual and holistic. Felder-Silverman Learning Model classifies different learning modes. It includes (a) sensing learners or intuitive learners, (b) visual learners or verbal learners, (c) inductive learners or deductive learners, (d) active learners or reflective learners, and (e) sequential learners or global learners.

The development of these models plays dual roles. As Felder and Silverman (1988) observed, “a learning-style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information” (p. 674). On the other hand, it also implies that the development of “teaching-style model, which classifies instructional methods according to how well they address the proposed learning style components” (p. 674). Therefore, “most of the learning and teaching style components parallel one another” (Felder & Silverman, 1988, p. 674).

A number of educators have applied the previously mentioned four models in educational settings. Based on investigations, it is believed that educators could design better curriculum for improved teaching and learning (Du Torr, De Boer, Bothma, & Scheepers, 2012; Felder, Felder, & Dietz, 2002; Felder & Henriques, 1995; Palermo, Walker, Brown, & Zogi, 2009). Felder and Spurlin (2005) argued that the most important implication of learning styles is grounded in designing effective teaching strategies and instruction. As a consequence, they stated,

The optimal teaching style is a balanced one in which all students are sometimes taught in a manner that matches their learning style preferences, so they are not too uncomfortable to learn effectively, and sometimes in the opposite manner, so they are forced to stretch and grow in directions they might be inclined to avoid if given the option. (p. 105)

According to the Felder-Silverman model, Felder and Silverman (1988) encourage teachers to use several techniques to address all learning styles: (a) motivate learning; (b) provide a balance of concrete information and abstract concepts; (c) balance material that emphasizes practical problem-solving methods with material that emphasizes fundamental understanding; (d) provide explicit illustrations of intuitive patterns and sensing patterns; (e) provide concrete examples of the phenomena the theory describes and then develop the theory or formulate the mode; (f) do not fill every minute of class time instead providing intervals for students to think; (g) assign some drill exercises to provide practice in the basic methods being taught but do not overdo them; (h) give students the option of cooperating on homework assignments to the greatest possible extent; (i) applaud creative solutions, even incorrect ones; and (j) talk to students about learning styles, both in advising and in classes (p. 680).

In addition., Felder (1996) provided some suggestions for teachers to maximize the effects of learning: (a) teach theoretical material by first presenting phenomena and problems that relate to the theory; (b) balance conceptual information with concrete information; (c) make extensive use of sketches, plots, schematics, diagrams, and physical demonstration in addition to oral and written explanations and derivations in lecture and readings; (d)

occasionally give some experimental observations before presenting the general principle; (e) provide class time for students to think about the material being presented and for active student participation; (f) encourage or mandate cooperation on homework; and (g) demonstrate the logical flow of individual course topics, but also point out connections between the current material and other relevant material in the same areas (pp. 22-23). Finally, Felder (1996) suggested each model has its face value and concluded that “a learning style model is useful if balancing instruction on each of the model dimensions meets the learning needs of essentially all students in a class” (p. 23).

Creative Thinking

In psychology literature, divergent thinking is closely married to creativity (Guilford, 1957; Torrance, 1988; Williams, 2004). Indeed, divergent thinking is viewed as one major element of the cognitive process in creativity (Guilford, 1970; Runco, 2004). Divergent thinking is dependent on fluidity of thinking and free association, which is independent of intelligence (Fasko, 2006; Sternberg & Lubart, 1995).

Mednick (1962) extends the research of divergent thinking proposed by Guilford (1956, 1959) and presents the associative theory of creative thinking. The associative theory of creative thinking is not meant for any specific field but for delineating the general process of creative thought. Mednick (1962) defines creative thinking as “the forming of associative elements into new combinations which either meet specified requirements or are in some way useful. The more mutually remote the elements of new combinations, the more creative the process or solution” (p. 221). Additionally, Mednick indicates three approaches to bring associative elements together: serendipity, similarity, and mediation. Serendipity refers to the environmental appearance of stimuli evoking associative elements. The second mode of creative solution is by observing similarities and homogeneity in the structure. The last method is through the mediation of common elements and using symbols to evoke remote ideas (pp. 221-222).

Mednick (1962) believes that highly creative people will have a flat hierarchy of association in which responses to creative solutions are slow and steady but produce more ideas. On the other hand, less creative people tend to have a steep hierarchy of association with responding at a higher rate but generating fewer responses. Mednick (1962) notes the former is like a “multi-producer” and the latter a “one-shot producer” (p. 223). Following this line, Michalko (2001) also recognizes the importance of associative ability on creativity and wrote:

A major characteristic of creative geniuses is the tendency to extend their associative horizon widely and unusually. The rest of us tend to constrain our associative horizons, in the spirit of linear and explanatory thinking, and to minimize imaginative connections, which are seen as carelessness and lack of discipline. Yet associations and imaginative connections are essential elements of creativity; they distinguish ideas that are truly original and innovative from those that are logical but inconsequential. (p. 56)

According to the literature, the RAT serves as an important creativity test and was used to examine the relationship between cognitive style (Noppe & Gallagher, 1977), cognitive flexibility and adaptive regression (Murray & Russ, 1981), intelligence (Mendelsohn, 1976; Schlicht Jr. et al., 1968), duration experience (Frauenfelder, 1980), illusory feedback

(McFarlin & Blascovich, 1984), unconscious thought (Chen-Bo, Dijksterhuis, & Galinsky, 2008), and creative problem solving (Storm, Angello, & Bjork, 2011). These studies indirectly support the validity of the RAT in the examination of creativity.

Method

The research design was a correlation design, using a convenient sampling with four college-level math classes. The Index of Learning Styles (ILS; Felder & Soloman, 1997) and the Remote Associates Test (RAT; Mednick & Mednick, 1967) were administered. The relationship of learning styles and creative thinking was examined in the context of math classrooms.

Subjects

A total of 88 subjects (51 females, 37 males) were drawn from a population of undergraduate students within a southwest private university. Four undergraduate math classes were recruited for this study (two algebra, one precalculus, and one calculus). The mean age of students was 19.74 ($SD = 2.48$, 1 missing) and the majority were freshman (49 students, 2 missing). The demographic breakdown (4 missing) was as follows: 10 Asian, 4 African Americans, 23 Caucasians, 45 Hispanics, and 2 mixed backgrounds.

Instruments

The Index of Learning Styles (ILS). This inventory was developed by Felder and Soloman and used for identifying different learning styles (Richard M. Felder and Barbara A. Soloman, *Index of Learning Styles*, <http://www.ncsu.edu/felder-public/ILSpage.html>, accessed March 3, 2013). This instrument measures learning style on four bi-polar dimensions related to the preference for the type of information perceived (sensory to intuitive), the modality by which that sensory information is most effectively perceived (visual to verbal), the manner in which it is processed (active to reflective), the manner in which a learner progresses toward understanding (sequential to global) (Felder & Silverman, 1988). More specifically, there are four pairs of four dimensions; (a) sensing (concrete thinker) vs. intuitive (abstract thinker) (S-N dimension), (b) visual (prefer visual presentations) vs. verbal (prefer written and spoken explanations) (Vs-Vb dimension), (c) active (prefer working in groups) vs. reflective (prefer working alone) (A-R dimension), and (d) sequential (linear thinking process) vs. global (holistic thinking process) (Sq-G dimension) (Felder & Spurlin, 2005, p. 103).

ILS is a 44-question instrument designed to evaluate learning preference based on four dimensions of Felder-Silverman framework. Each learning style has associated with it 11 items with two options (a or b), representing one or the other category of the dimension (e.g., sensing or intuitive). The purpose of this dichotomous structure is to force participants to make a decision between the two options, thereby avoiding ambiguity and increasing the chance to detect preferences.

With regard to validity and reliability of ILS, Felder and Spurlin (2005) examined several studies using ILS and reported adequate information for supporting the validity and reliability of this construct. Litzinger, Lee, Wise, and Felder (2007) reexamined the reliability, factor structure, and construct validity of ILS through using random samples of 1000 students from three colleges. They arrived the conclusion that the ILS “generates data with acceptable levels of internal consistency reliability, and that evidence for its construct validity from both factor analysis and student feedback is strong” (p. 316). Moreover, several advantages of using this instrument as an evaluation tool of individual learning preferences are: (a) free web-based questionnaire, (b) its automatic reporting feature, and (c) the accompanying descriptive

information provided by the authors. Internal consistency reliability was checked. Cronbach's coefficient alpha revealed that S-N, Vs-Vb, A-R, and Sq-G were 0.65, 0.56, 0.47, and 0.10 respectively. However it is important to not that this conclusion of internal reliability is not consistent with other studies (Litzinger, Lee, Wise, & Felder, 2007).

Remote Associates Test (RAT). This test was initially developed by Mednick (1962) and associates (Mednick & Mednick, 1967) and has been extended by other scholars. The original RAT consists of 30 items. Kihlstrom, Shames, and Dorfman (1996) revised the original version and extended to 68 items, which is free on the Internet (<http://socrates.berkeley.edu/~kihlstrm/RATest.htm>). For the purpose of this study, subjects will be tested 20 items (10 easy items and 10 difficult items) from Kihlstrom et al. (1996) revision.

In this test, subjects are presented with a series of words and are asked to come up with a single word that links the words. Mednick and Mednick (1967) report the reliability of the RAT for two student groups are over .90. The validity of the RAT to evaluate creative thinking is also supported by researchers (Murray & Russ, 1981). The premise of the RAT is grounded in that in order to come up with a word that fits the stimulus words, people need to use their associational thinking to link this relationship. This cognitive function is highly related to creative thinking.

Procedure

Subjects were administered the two instruments in a class session. The purpose of the research was briefly explained, and students were asked to review and sign the informed consent form for participating in the study. The two instruments were distributed to subjects. They had ten minutes to complete the ILS and another fifteen minutes to finish the RAT.

The data from the ILS was entered into the Statistic Package for Social Sciences (SPSS), and scored according to Felder and Soloman's guidelines. Each of the subject's scores on each of the four bi-polar LSI scales range on an equivalent scale from +11 to -11. Using the active-reflective dimension as an example for statistical analyses, subjects' scores 5-7 or 9-11 on the ILS represent a moderate or strong preference of reflective learning, and for those who are balance in their style, scores of 1 or 3. Similarly, scores -5 to -7 or -9 to -11 on the ILS represent a moderate or strong preference of active learning, and -1 or -3 means the balance learning style. For scoring the RAT test, one point for correct answers and zero point for incorrect.

Results

Prior to analysis, several missing values in scores of A-R, S-N, Vs-Vb, and Sq-G dimension and age were identified. Inserting a group mean for the missing value was used. Table 1 shows the characteristics of learning styles in students. It is clear that the majority of students had balanced learning preferences within four dimensions. It is also true in two gender groups. However, in the Sq-G dimension, there was a significant difference between two genders in the category of moderate preference, $\chi^2(1) = 4.73, p = .03$.

Table 1

Frequency of Four Learning Dimensions on Genders (n = 88)

Learning style	Male (n)	Female (n)	Total
A-R dimension			
Balanced	20	30	50
Moderate	16	18	34

Strong	1	3	4
S-N dimension			
Balanced	16	24	40
Moderate	19	18	37
Strong	2	9	11
Vs-Vb dimension			
Balanced	12	19	31
Moderate	9	20	29
Strong	16	12	28
Sq-G dimension			
Balanced	28	27	37
Moderate	9	24	33
Strong	0	0	0

A Pearson correlation coefficient was calculated for the relationship between participants' age, creativity, and learning style dimensions. As Table 2 shows, there were no significant relationship among creativity and other variables. Interestingly, a negative weak correlation between creativity and four learning dimensions was found. A weak negative, but significant, correlation was found between age and A-R and Vs-Vb dimension, $r = -.262$, $p < .05$, $r = -.339$, $p < .01$. Another significant weak positive correlation was found between S-N and Sq-G dimension, $r = .229$, $p < .05$.

Table 2

Means, Standard Deviations, and Intercorrelations on Age, Creativity, Four Dimensions of Learning (n = 88)

Variables	M	SD	1	2	3	4	5	6
1. Age	19.73	2.46	--					
2. Creativity	4.32	2.95	.186	--				
3. A-R dimension	1.60	4.17	-.262*	-.199	--			
4. S-N dimension	2.83	4.73	-.054	-.001	.078	--		
5. Vs-Vb dimension	5.12	3.82	-.339**	-.032	.209	.029	--	
6. Sq-G dimension	1.90	3.25	-.185	-.010	.052	.229*	.060	--

* $p < .05$.

** $p < .01$.

In evaluating the gender differences of creativity and four learning dimensions, an independent-samples t test was calculated comparing the mean scores of the two groups. Table 3 displays no significant difference between two groups in terms of creativity, A-R, and Vs-Vb dimension, $t(86) = 0.71$, $p = .483$, $t(86) = -1.01$, $p = .315$, $t(86) = 0.89$, $p = .378$, respectively. However, there was a significant difference between two groups in terms of S-N and Sq-G dimension, $t(86) = -2.25$, $p = .027$, $t(86) = -2.26$, $p = .027$, respectively. The mean of the female students was higher (S-N, $M = 3.78$, $SD = 4.29$; Sq-G, $M = 2.55$, $SD = 3.16$) than the mean of male students (S-N, $M = 1.53$, $SD = 5.04$; Sq-G, $M = 1.00$, $SD = 3.20$). Moderate effects size was also found (Cohen's $d = 0.49$ for S-N; $d = 0.49$ for Sq-G).

Table 3

Gender Differences for Creativity and Four Dimensions of Learning (n = 88)

Variables	Male(n =37)		Female(n =51)		t (86)	p	Cohen's d	95%CI
	M	SD	M	SD				
Creativity	4.59	3.55	4.12	2.44	0.71	.483	0.15	[-0.88, 1.83]
A-R dimension	1.07	4.15	1.98	4.18	-1.01	.315	0.22	[-2.70, 0.88]
S-N dimension	1.53	5.04	3.78	4.29	-2.25	.027	0.49	[-4.23, 0.26]
Vs-Vb dimension	5.54	4.02	4.81	3.67	0.89	.378	0.19	[-0.91, 2.37]
Sq-G dimension	1.00	3.20	2.55	3.16	-2.26	.027	0.49	[-2.91, 0.18]

One of the questions was to ask students whether or not used math tutoring lab before. It was found, as shown in Table 4, that only A-R dimension was significantly difference, $t(86) = 2.33$, $p = .022$, $d = 0.5$. The mean of students with active learning style were higher ($M = 2.78$, $SD = 3.79$) than the mean of students with reflective learning style ($M = 0.74$, $SD = 4.25$). This effect was moderate.

Table 4

Group Differences of Using Math Tutoring Lab for Four Dimensions of Learning (n = 88)

Variables	Yes(n =37)		No(n =51)		t (86)	p	Cohen's d	95%CI
	M	SD	M	SD				
A-R dimension	2.78	3.79	0.74	4.25	2.33	.02 2	0.50	[0.30, 3.79]
S-N dimension	2.51	5.15	3.07	4.44	-0.55	.58 7	0.12	[-2.60, 1.48]
Vs-Vb dimension	5.38	3.85	4.92	3.82	0.55	.58 2	0.12	[-1.19, 2.10]
Sq-G dimension	1.76	2.96	2.00	3.47	-0.34	.73 3	0.07	[-1.64, 1.16]

A direct logistic regression analysis was performed to predict the use of math tutoring lab by five predictors: age, A-R, S-N, Vs-Vb, and Sq-G dimension. A test of full model with all predictors against a constant-only model was statistically significant, $\chi^2(5) = 11.73$, $p = .039$, indicating that the predictors, as a set, reliably distinguished between students who have used the lab and who have not been there. However, the variance in using lab accounted for is small, with Nagelkerke $R^2 = .168$. Classification was unimpressive, with 43.2% of that have used math tutoring lab and 76.5% of that have not used lab correctly predicted, for an overall success rate of 62.5%. Table 5 shows logistic regression predicting lab use. Only age and A-R dimension are statistically significant predictors in this model. However, the odds ratio of .779 for age, .847 for A-R dimension shows little change in the likelihood of using lab on the basis of a one-unit change in age and A-R dimension.

Table 5

Summary of Logistic Regression Analysis Predicting Math Tutoring Lab Use

Variable	B	SE	OR	95% CI	Wald statistic	p
Age	-.249	.111	.779	[0.63, 0.97]	5.039	.025
A-R dimension	-.166	.063	.847	[0.75, 0.96]	6.959	.008
S-N dimension	.034	.050	1.035	[0.94, 1.14]	.470	.493
Vs-Vb dimension	.054	.067	.947	[0.83, 1.08]	.664	.415
Sq-G dimension	-.003	.076	.997	[0.86, 1.16]	.002	.967

Discussion

The major findings of this study indicate that creative thinking, assessed by RAT, and learning preferences, evaluated by ILS, are not highly correlated. In fact, the results reveal that the relationship is negative and weak. It is possible that two variables are of a different construct. An individual's learning style may not be related to his/her creativity. Creativity is viewed as a complex syndrome with multivariate factors that affect individuals' creative behavior (Mumford & Gustafson, 1988; Runco, 2010). However, two things should be noticed to arrive this conclusion. First, the reliability of ILS is not consistent with other studies, especially the Sq-G dimension (Felder & Spurlin, 2005; Litzinger, Lee, Wise, & Felder, 2007). It is possible that the sample size of the current study is under 100, whereas the subjects of other studies are over 200. More research needs to be investigated this issue. Furthermore, there were several international students in the pool of subjects and their scores of RAT were zero. It indicates the nature of RAT is not a culture-free creativity test. In other words, for those students, the test of RAT does not properly reflect their authentic creativity ability, because of the language issue. For the future study, using other creativity tests (e.g., TTCT, Torrance, 1974) might avoid this issue.

Over all, students in this study show a balanced learning preference across four dimensions. However, in terms of gender differences, the results demonstrate that female students have more moderate or strong preferences in the S-N and Sq-G dimension than that of male students. More specifically, females favor sensing learning (concrete thinkers). Additionally, females tend to prefer of sequential learning (linear thinkers) more than male

students. This finding, nevertheless, cannot be confirmed because the sample size between two groups is quite different. The numbers of females are larger than males. Thus, for the future study, a balanced design could be useful. To our knowledge, there is no study available using ILS to detect gender differences. A possible avenue for future investigation could follow this direction.

It is interesting to notice that age and A-R dimension predict the use of math tutoring lab in the school. More active learners will seek this extra resource to assist learning. The results of this study further confirm this notion. In our sample, the older students the more chance to visit the lab for help. It could be that more mature students are willing to spend more time on their studies and at same time to seek possible resources to assist leanings.

In summary, owing to this investigation of that is exploratory, the generalization is tenuous. Bigger sample sizes and heterogeneous samplings might be beneficial to uncover the possible relationship between creativity and learning styles. Furthermore, using different instruments will help clarify this possible link. More research energy needs to involve this examination. Taken as a whole, this study directs a possible path for future researchers to investigate this phenomenon.

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