Relationship between Thinking Styles and Academic Achievement

Asma Mumtaz[1], Rahmat Ullah Bhatti[2] & William Bart[3]

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Abstract

Students differ in the ways that they think about problems and how they learn. Thinking style is the term used to describe the individual differences among students in how they think and learn. This study was designed to determine the relationship between thinking styles and academic achievement of secondary school students. The population in this study consisted of science students at grade 9 from male and female secondary schools of Tehsil Rawalpindi. Random sampling technique was used to select the sample. In the present study, two research instruments were used. The Convergent and Divergent Test was used to identify the thinking styles of the secondary school students and the Achievement Tests of Chemistry were used to identify the academic achievement of the students. The collected data was analyzed to calculate means, T-statistics, and Pearson product-moment correlations. Male students were mostly convergent thinkers and female students were mostly divergent thinkers. The relationship between thinking styles and academic achievement of secondary school students was positive and significant.

Keywords: Thinking styles, academic achievement, convergent thinking, divergent thinking.

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[1] Department of Secondary Teacher Education, Allama Iqbal Open University, Islamabad

[2] Department of Early Childhood Education & Elementary Teacher Education, Allama Iqbal Open University, Islamabad

[3] Department of Educational Psychology; University of Minnesota, USA

Introduction

Thinking style is the term, which was proposed by various researchers for explaining the individual differences and needs of the students (Murphy & Janeke, 2009). Thinking styles differ from person to person and influence every face of individual's life i.e., personal, interpersonal and social life of the individual. Educational personnel should know the manners in which thinking styles influence the academic achievement of the students. They should suggest possible ways of promoting effective teaching and learning process and academic achievement (Seif, 2008).

Sternberg and Zhang (2014) stated that thinking styles are the different approaches used by an individual for acquiring and processing information and problem solving. They comprise of different approaches used by an individual for acquisition and organization of knowledge, ability of problem solving and decision making, building opinions and views, and expressing one-selves to others. He added that thinking style cannot be defined as the ability of a person but the preferred way of using one's abilities.

According to Cassidy (2004), thinking styles can be defined as an attribute way of a person to perform his mental and rational activities. According to Armstrong and Cools (2009), thinking style is the comfortable way to perceive and remember information, solve problems and make decisions used by an individual. These ways show the priorities of an individual in information processing. Chang (2013) used the same concept to define thinking styles, according to him thinking style is a person's preferred way to sort out and process information.

Most commonly used terms in researches of thinking styles are convergent and divergent thinking styles which refer to specific way of receiving and recognizing information, problem solving and decision making. Convergent thinking refers to the ability of solving problems with familiar techniques, and draw expected conclusions. On the contrary, divergent thinking is the ability of creativity and solving problems with new and unexpected solutions (Kolb, 2014). Convergent thinkers are good at finding readymade solutions of a problem. Convergent thinkers are characterized by logical thinking. Divergent thinkers can find multiple ways of solving a problem. They have new ideas and can lead to various results of a single phenomenon. Divergent thinking can be referred as creative and imaginative thinking. The quality of divergent thinkers to find various possible solutions to a problem does not mean that they are not able to reach a distinctive and unique solution (Duff, 2004; Hudson, 2017).

According to Nezhad (2013), the convergent thinkers follow the logical sequences for selecting the best possible solution of the problem. As opposed to this, divergent thinkers discover new options rather choosing from the available ones. Convergent thinkers depend more on rational approach and less on imagination. They

have logical and systematic thoughts. On the other hand, the divergent thinkers depend more on creativity. They have a free and unplanned flow of thoughts. According to Danili and Reid (2006), convergence is the synonym of intelligence and divergence is the synonym of creativity.

Fatt (2000) described the characteristics of convergent and divergent thinkers in the same words as other researchers did. He stated that convergent thinking style is rational and diagnostic while the divergent thinking style is creative, dynamic and imaginative. They can solve a problem by multiple solutions. According to Williams (2003), convergent thinkers have the ability to find a distinct solution of a problem, in contrast to this; divergent thinkers have the ability to find multiple answers of an incoming problem.

According to Sofo (2008), maximum benefits can be attained from a person if the surrounding environment supports his thinking styles. The studies on thinking styles show that the knowledge about the thinking styles enables a person to match his preferred style with his surroundings. He may change his thinking styles according to the situation. In this way his efficiency and effectiveness may increase and he can perform well (Sofo, 2005, 2008). The students can show good results and the academic environment can become more fruitful when teacher understands thinking styles of the students (Seif, 2008). According to Zhang (2010), sudden improvement in the results of the students was noticed when their thinking styles were addressed and kept into view during academic activities.

According to Drysdale, Ross and Schulz (2001), good performance can be attained from the students in examinations if they are made aware of their thinking styles. It will help them in adopting study habits that match to their thinking styles. The research conducted by them on the thinking styles of 4,546 students of first year and their effects on the academic achievement of students showed that a positive relationship prevails between thinking styles and their academic performance. According to Duff (2004), convergent students were more successful in science exams. Stamovlasis, Tsitsipis and Papageorgiou (2010) and Acar and Runco (2019) found a positive relationship between divergent thinking style and academic performance in science.

According to Felder and Spurlin (2005), the teacher should know about the thinking styles of their students because every individual is different from other. It helps them to get the knowledge about the preferences of his students and resultantly the teaching process can be more productive for students. The importance of thinking style cannot be ignored because it is necessary for students especially in educational environment. Every learner has a specific thinking style, which helps him in the retention of the learned material (Chuah, Singh & Goh, 2014). According to Chaudhry (2004) in his research declared that thinking styles influenced the performance of

students in exams. Many researches revealed that the performance of the individual in educational environment is affected by his thinking styles (Fan, Zhang & Hong, 2019).

Less research is being done on the topic of convergent and divergent thinking styles and academic achievement of students in science. There are many branches of science. Chemistry, Biology, Geology, Astronomy and Physics are its major branches. All of the above mentioned branches have chemistry in their foundations. It is important to understand chemistry because every branch of science has matter and the study of the relations prevails among different forms of matter is called chemistry (Silberberg, 2003). Chemistry is also known as "central science". It ties all the branches of science with each other, which are physics, astronomy, biology and geology. In all the nations of the world, Chemistry is given important place in science education. Because of this importance of chemistry among other science subjects, relationship is found between thinking styles and academic achievement of students in chemistry.

This study has the following objectives: (1) To identify the thinking styles of students at the secondary level; (2) To find the difference between academic achievement of students having convergent and divergent thinking styles; (3) To study the relationship of convergent thinking style with academic achievement of secondary school students; and (4) To study the relationship of divergent thinking style with academic achievement of secondary school students.

Methodology

Research design

Descriptive research design was used in this study. The study was a correlation research. Quantitative method was used for collecting data from the students.

Population and Sampling

The population in this study consisted of science students at grade 9 from male and female public secondary schools of Tehsil Rawalpindi in academic year 2018-2019. The ages of the students were between 14-17 years. Random sampling technique was used to select science students from male and female public secondary schools of Tehsil Rawalpindi. The total number of students selected for the sample was 368 students of which 184 (50% of the total sample) were boys and 184 (50% of the total sample) were girls.

Instruments for Research

There were two instruments used in this research.

Convergent/Divergent Test: This test is based on a test developed and evaluated by Bahar (1999) at the Center of Science Education, University of Glasgow. Keeping in view the copyrights and moral obligations, permission to use this test was gained by email from the Center of Science Education, University of Glasgow. This test was used by various researchers such as Bahar and Hansell (2000), Alamolhodaei (2001), Danili (2004), Zamman (2006), Hindal (2007) and Bhatti (2013) in their research studies to separate Convergent and Divergent thinkers. It consisted of six sub-tests. For the ease of understanding an example was given at the start of each sub-test so that the students can get an idea about solving the test. Every test had different time limits and the total time allowed for this test was 20 minutes. For each question, the students were asked to give maximum number of answers. Every single correct answer got one mark. The highest possible score for this test was 130. Following is the explanation of this test. The first subtest assessed the ability of the respondent to write as many synonyms of a word as possible. Three words, i.e., "strong, clear and dark", were given to the respondent. Four minutes were given to attempt this test.

The second subtest assessed the ability of the respondent to produce as many sentences as possible that come to mind involving four given words. The sequence of the words was to remain constant while making sentences. The words given were "write, words, long, enough" and "friend, man, year, catch". Only meaningful sentences received marks. Four minutes were given to attempt this test. The third subtest was a nonverbal test. This test assessed the ability of the respondent to draw diagrams and pictures according to the idea given in question. The words given were "energy, happiness, technology, and silence". The time allocated to this test was five minutes. The fourth subtest assessed the ability of the respondent to think of as many things as possible which are similar in one way or the other. The word "round" was given and the respondent had to write the names of objects that are round in shape. The time allocated to this test was two minutes. The fifth subtest assessed the ability of the respondent to think of as many words as possible which start with G and end at T. the respondent was not allowed to write the names of places or persons. The time allocated to this test was two minutes. The sixth subtest assessed the ability of the respondent to formulate as many ideas as possible related to a given phrase. The respondent had to write the ideas that came to mind related to the phrase "working in laboratories" that was given in the question. The time allocated to this test was three minutes.

To separate the male and female students into convergent, divergent and normal (all-rounder) thinkers, the responses of the students were assessed and formula; which

was used by Bahar and Hansell (2000), Alamolhodaei (2001), Danili (2004), Zamman (2006), Hindal (2007) and Bhatti (2013) was applied to the results of students in convergent and divergent test.

- The Convergent $\leq$ Mean - 0.25 Std. Deviation
  The Convergent $\leq$ 42.58- 0.25 (11.56)
  The Convergent $\leq$ 42.58 - 2.89
  The Convergent $\leq$ 39.69
- Normal (all-rounder) $=$ Mean $\pm$ 0.25 Std. Deviation
  Normal (all-rounder) $=$ 42.58 $\pm$ 0.25 (11.56)
  Normal (all-rounder) $=$ 42.58 $\pm$ 2.89
  Normal (all-rounder) $=$ 39.69 - 45.47
- The Divergent $\geq$ Mean + 0.25 Std. Deviation
  The Divergent $\geq$ 42.58 + 0.25 (11.56)
  The Divergent $\geq$ 42.58 + 2.89
  The Divergent $\geq$ 45.47

The students who had scores less than or equal to 39.69 were identified as convergent. The students who had scores between 39.69 and 45.47 were identified as normal (all-rounder) and the students who had scores more than or equal to 45.47 were identified as Divergent.

Chemistry Achievement Test: Five Chemistry achievements tests were constructed from the Chemistry textbook (Punjab Textbook Board, 2018-2019) and were based on the first five chapters of the textbook. The tests were the following: (a) Test 1:Fundamentals of Chemistry; (b) Test 2: Structure of Atoms; (c) Test 3: Periodic Table and Periodicity of Properties; (d) Test 4: Structure of Molecules; and (e) Test 5: Physical states of Matter.

The tests were developed and organized according to the cognitive domain of the Revised Bloom's taxonomy (2001). There were test items that related to each of the six levels of Bloom's taxonomy. Each test had two sections: (a) multiple-choice items; and (b) short-answer items.

Validity and Reliability of Research Tools

Bahar and Hansell (2000), Alamolhodaei (2001), Danili (2004), Zamman (2006), Hindal (2007) and Bhatti (2013) have made productive use of the convergent and divergent test. The extent of convergent and divergent test is known to be valid and reliable and a test-retest reliability check here gave a correlation of 0.94. The validity of questionnaire items is difficult to establish and the finding there must be treated with

some caution. However, other studies (Reid, 2003) have shown that reliability is rarely an issue.

A panel of veteran teachers carefully examined the chemistry achievement tests to examine the content validity of the tests and minor adjustments in the test items were made to improve the content validity of the tests. Reliability was ensured after Pilot Study in two secondary schools. Reliability of chemistry achievement tests was calculated by using Cronbach's alpha coefficient, which was 0.81. That is why the achievement tests were considered acceptably reliable and were taken to schools for data collection from students.

Procedure

With the permission of District Education Officer, District Rawalpindi, and principals of the selected public secondary schools, the survey was conducted in ten selected public secondary schools, with five being schools for girls and five being schools for boys. First, the convergent and divergent tests were administered and the responses of students were recorded. Second, the chemistry tests were administered. After grading the test responses, scores of the students in all five tests were then recorded.

Results

The frequencies of students in each category of thinking styles are as follows: 142 Students with convergent thinking style, 144 Students with divergent thinking style, and 82 all-rounders. In 184 male students, the frequencies of students in each category of thinking styles and their respective percentages are as follows: 92 Students with convergent thinking style (50%), 50 Students with divergent thinking style (27.17%) and 42 All-rounders (22.82%). In 184 female students, the frequencies of students in each category of thinking styles and their respective percentages are as follows: 50 Students with convergent thinking style (27.17%), 94 Students with divergent thinking style (51.08), and 40 All-rounders (21.74%). The present study focused on the convergent and divergent thinking styles; therefore, All-rounders were not taken into consideration.

The independent sample t-test was applied to find the differences between academic achievement of students having convergent and divergent thinking styles. According to Table 1 (given below), there is a significance difference between academic achievement of students having convergent and academic achievement of students having divergent thinking style. (t= -20.542, $p < 0.05$). It also shows that the students with divergent thinking style have higher academic achievement than students having convergent thinking style.

Table 1

Comparison between academic achievement of students having convergent and divergent thinking style

Variables	N	Mean	t	*P*	α
Convergent	142	22.76			
			-20.542	0.001	0.05
Divergent	144	42.49			

According to Table 2 (given below), there is a significance difference between the academic achievement of boys having a convergent thinking style and the academic achievement of boys having a divergent thinking style (t= -14.683, $p < 0.05$). It also shows that the boys with divergent thinking style have higher academic achievement.

Table 2

Comparison between academic achievement of male students having convergent and divergent thinking style

Variables	N	Mean	t	*p*	α
Convergent	92	20.29			
			-14.683	0.006	0.05
Divergent	50	40.24			

According to Table 3 (given below), there is a significance difference between academic achievement of girls having convergent thinking style and academic achievement of girls having divergent thinking style (t= -14.240, $p < 0.05$). It also shows that the girls with divergent thinking styles have higher academic achievement.

Table 3

Comparison between academic achievement of female students having convergent and divergent thinking styles

Variables	N	Mean	t	*p*	α
Convergent	50	27.30			
			-14.240	0.412	0.05
Divergent	94	43.68			

According to Table 4 (given below), there is a significance difference between academic achievement of boys and girls having convergent thinking style (t= -5.326, p < 0.05) with the girls having higher academic achievement.

Table 4
Comparison between academic achievement of boys and girls having convergent thinking style

Variables	N	Mean	t	*p*	α
Boys	92	20.29	-5.326	0.001	0.05
Girls	50	27.30			

According to Table 5 (given below), there is significance difference between academic achievement of boys and girls having divergent thinking style (*t*= -2.925, *p* < 0.05) with the girls having higher academic achievement.

Table 5
Comparison between academic achievement of boys and girls having divergent thinking style

Variables	N	Mean	t	*p*	α
Boys	50	40.24	-2.925	0.906	0.05
Girls	94	43.68			

A Pearson product-moment correlation coefficient was calculated to determine the relationship between thinking style and academic achievement of students. According to Table 6 (given below), there is a significant relationship between the convergent thinking style of students (boys and girls) and their academic achievement, alpha = 0.01, $r = 0.282$, $N = 142$, $p = 0.001$.

Table 6
Relationship between convergent thinking style and academic achievement

Variables	N	Mean	Correlation coefficient	Level of Significance
Scores in Con/Div. test	142	31.11	0.282	0.001
Academic Achievement	142	22.76		

Note: α=0.01

According to Table 7 (given below), there is a significant relationship between the divergent thinking style of students (boys and girls) and their academic achievement, alpha = 0.01, $r = 0.454$, $N = 144$, $p = 0.001$.

Table 7
Relationship between divergent thinking style and academic achievement

Variables	N	Mean	Correlation coefficient	Level of Significance
Scores in Con/Div. test	144	54.20	0.454	0.001
Academic Achievement	144	42.49		

Note: α=0.01

According to Table 8 (given below), there is a positive correlation between convergent thinking style and academic achievement of male students, alpha = 0.05, $r = 0.189$, $N = 92$, $p = 0.072$.

Table 8
Relationship between convergent thinking style and academic achievement of male students

Variables	N	Mean	Correlation coefficient	Level of Significance
Scores in Con/Div. test	92	29.73	0.189	0.072
Academic Achievement	92	20.29		

Note: α=0.05

According to Table 9 (given below), there is a positive correlation between divergent thinking style and academic achievement of male students, alpha = 0.01, $r = 0.452$, $N = 50$, $p = 0.001$.

Table 9
Relationship between divergent thinking style and academic achievement of male students

Variables	N	Mean	Correlation coefficient	Level of Significance
Scores in Con/Div. test	50	53.70	0.452	0.001
Academic Achievement	50	40.24		

Note: α=0.01

According to Table 10 (given below), there is a positive correlation between convergent thinking style and academic achievement of female students, alpha = 0.05, *r* = 0.235, *N* = 50, *p* = 0.100.

Table 10
Relationship between convergent thinking style and academic achievement of female students

Variables	N	Mean	Correlation coefficient	Level of Significance
Scores in Con/Div. test	50	33.66	0.235	0.100
Academic Achievement	50	27.30		

Note: α=0.05

According to Table 11 (given below), there is a positive correlation between divergent thinking style and academic achievement of female students, alpha = 0.01, *r* = 0.461, *N* = 94, *p* = 0.001.

Table 11
Relationship between divergent thinking style and academic achievement of female students

Variables	N	Mean	Correlation coefficient	Level of Significance
Scores in Con/Div. test	94	54.47	0.461	0.001
Academic Achievement	94	43.68		

Note: α=0.01

Discussion and Conclusion

The majority of male students were convergent thinkers and the majority of female students were divergent thinkers. Significant difference was found between academic achievement of students having convergent and divergent thinking style. The results revealed that the students having divergent thinking style have higher academic achievement than students having convergent thinking style. Significant difference was found between academic achievement of boys having convergent thinking style and academic achievement of boys having divergent thinking style. Similarly, a significant difference was found between academic achievement of girls having convergent thinking style and academic achievement of girls having divergent thinking style. The results reveal that male and female students having divergent thinking style have higher academic achievement than students having convergent thinking style. These results are

supported by the findings of the studies conducted by Bahar and Hansell (2000), Chaudhry (2004), Danili (2004), Stamovlasis, Tsitsipis and Papageorgiou (2010), Bhatti (2013), and Acar and Runco (2019)

A significant difference was found between academic achievement of boys and girls having convergent thinking style with girls having the superior academic achievement. Similarly, a significant difference was found between academic achievement of boys and girls having divergent thinking style. In general, female students had higher academic achievement than male students.

In general, it seems that there is a positive relationship between convergent and divergent thinking style and academic achievement of students at secondary level. This conclusion is supported by numerous research studies including Alamolhodaei (2001), Drysdale, Ross and Schulz (2001), Chaudhry (2004), Danili (2004), Seif (2008), Stamovlasis, Tsitsipis and Papageorgiou (2010), Bhatti (2013), Chuah, Singh and Goh (2014), and Acar and Runco (2019) who found significant relationships between thinking styles and academic achievement.

However, our current educational system does not accommodate divergent thinkers; all the teaching methods and assessment techniques which are used, support converger thinkers. Being ignored, students having divergent thinking style do not like to participate actively in the academic activities. Because of this situation we are losing individuals having creative and imaginative abilities. This situation should no longer be prevailed. In order to cope with it, we have to redesign our teaching learning environment in our educational institutions to make it favourable for all types of thinkers. Otherwise we cannot provide leaders in the field of science and technology and our dream of scientific development will not be fulfilled.

Implications and Directions for Future Research

Keeping in view the results, conclusions and discussions of the study, following were the implications and directions for future research:

- Since the focus is on child-centered pedagogy, teachers can modify their instructional method and keep into consideration different individual needs of the students when they have the understanding of thinking styles of students. By adjusting the teaching method according to the thinking styles of students, teachers can facilitate them to grasp the concept in a better way.
- For the curriculum designers this study is fruitful in such a way that while suggesting curriculum for different subjects they can inculcate the activities and instructional material, which is favorable to both type of thinkers.

- Future researchers can take this study as a base for their further studies in the field of thinking styles. They can take a step forward by exploring the relationship of thinking styles with other elements of teaching and learning process, as less work is done on the relationship of thinking styles with instructional methods and curriculum and their effect on academic performance of students.

References

Acar, S., & Runco, M. A. (2019). Divergent thinking: New methods, recent research, and extended theory. *Psychology of Aesthetics, Creativity, and the Arts*, *13*(2), 153. https://doi.org/10.1037/aca0000231

Alamolhodaei, H. (2001). Convergent/Divergent cognitive styles and mathematical problem solving. *Journal of Science and Mathematics Education in Southeast Asia*, *24*(2), 102-117. Retrieved from https://www.yumpu.com/en/document/download/48560627/a7c43-36607-fdae4-f237c-16c73-845a8-3e369-626e8

Armstrong, S., & Cools, S. (2009). *Cognitive Styles and Their Relevance for Business and Management.* New York: Springer.

Bahar, M. (1999). *Investigation of Biology student's cognitive structure through word association tests, mind maps and structural communication grids* (Doctoral dissertation). University of Glasgow. https://doi.org/10.1080/00219266.1999.9655653

Bahar, M., & Hansell, M. H. (2000). The Relationship between some psychological factors and their effect on the performance of grid questions and Word Association Tests. *Educational Psychology,* *20*(3), 349-364. https://doi.org/10.1080/713663739

Bhatti, R. (2013). *The Impact of Cognitive Learning Styles on Academic Achievement of Students at Secondary Level.* (Unpublished doctoral dissertation). NUML, Pakistan. Retrieved from http://www.journal.netsed.net/index.php/sedi/article/view/57

Cassidy, S. (2004). Learning styles: An overview of theories, models, and measures. *Educational psychology*, *24*(4), 419-444. https://doi.org/10.1080/0144341042000228834

Chang, T. Y. (2013). Illuminating creativity with cultural engagement: Colour inspiration in cooperative learning through reflective action. *International Journal of Education through Art*, *9*(3), 369-385. DOI:10.1386/eta.9.3.369_1

Chaudhry, M. I. (2004). *The relationship between students learning style preferences and their academic achievement.* (Unpublished M. Phil thesis). Quaid-e-Azam University, Islamabad, Pakistan.

Chuah, J. S., Singh, M. K. M., & Goh, S. Y. (2014). International Students' English as a Foreign Language (EFL) Learning Styles: Socratic and Confucianistic. *Academic Research International*, *5*(5), 262. Retrieved from http://www.savap.org.pk/journals/ARInt./Vol.5(5)/2014(5.5-28).pdf

Danili, E. (2004). *A Study of Assessment Formats and Cognitive Styles Related to School Chemistry.* (Unpublished doctoral dissertation). University of Glasgow. Retrieved from https://theses.gla.ac.uk/5501/7/2004daniliphd.pdf

Danili, E., & Reid, N. (2006). *Cognitive Factors That Can Potentially Affect Pupils' Test Performance. Chemistry Education Research and Practice,* 7(2), 64-83. Retrieved from https://pubs.rsc.org/en/content/articlelanding/2006/rp/b5rp90016f

Drysdale, M. T., Ross, J. L., & Schulz, R. A. (2001). Cognitive learning styles and academic performance in two post-secondary computer application courses. *Journal of Research on Computing in Education*, *33*(4), 400- 412. https://doi.org/10.1207/S15327671ESPR0603_7

Duff, A. (2004). The role of cognitive learning styles in accounting education: developing learning competencies. *Journal of Accounting Education*, *22*(1), 29-52. DOI: 10.1016/j.jaccedu.2003.09.004

Fan, J., Zhang, L. F., & Hong, Y. (2019). The malleability of thinking styles over one year. *Educational Psychology*, 1-16. https://doi.org/10.1080/01443410.2019.1684449

Fatt, J. P. (2000). Understanding the Learning Styles of Students: Implications for educators. *The International Journal of Sociology and Social Policy*, 20, 31-45. Retrieved from https://doi.org/10.1108/01443330010789269

Felder, R. M., & Spurlin, J. E. (2005). Application, reliability and validity of the index of learning styles. *International Journal of Engineering Education*, 21(1), 103-112. Retrieved from https://www.engr.ncsu.edu/wp-

content/uploads/drive/1ZbL_vMB7JmHGABSgr-xCCP2z-xiS_bBp/2005-ILS_Validation(IJEE).pdf

Hindal, H.S. (2007). *Cognitive characteristics of students in middle schools in State of Kuwait, with emphasis on high achievement.* (Doctoral dissertation). University of Glasgow. Retrieved from https://eleanor.lib.gla.ac.uk/record=b2578426

Hudson, L. (2017). *Contrary imaginations: A psychological study of the English schoolboy*. Routledge. DOIhttps://doi.org/10.4324/9781315112114

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development.* FT press. Retrieved from http://www.learningfromexperience.com/images/uploads/process-of-experiential-learning.pdf

Murphy, A., & Janeke, H. (2009). The relationship between thinking styles and emotional intelligence: an exploratory study. *South African Journal of Psychology,* 39(3), 357-375. https://doi.org/10.1177/008124630903900310

Nezhad, H. P. (2013). The impact of task type and divergent thinking on reading proficiency. *International Journal of English Language and Literature Studies*, 2(2), 124-137. Retrieved from https://archive.aessweb.com/index.php/5019/article/view/692/1142

Reid, N. (2003). *Getting started in pedagogical research in the physical sciences*. LTSN Physical Sciences Centre. ISBN 13:9781903815076

Seif, A. A. (2008). Theory of Personality. Tehran: Roshd Publication.

Silberberg, M. S. (2003). *Chemistry, the Molecular Nature of Matter and Change*. New York, NY: The McGraw-Hill Company, lnc. Retrieved from https://www.studmed.ru/silberberg-ms-chemistry-the-molecular-nature-of-matter-and-change_ebd2abfe90f.html

Sofo, F. (2005). Thinking styles of modern Chinese leaders: Independence and exploration in a historically conditional China. *Australian Journal of Adult Learning,* 45(1), 304-330. Retrieved from https://files.eric.ed.gov/fulltext/EJ797617.pdf

Sofo, F. (2008). Differences of degree or differences in kind? A comparative analysis of thinking styles. *The International Journal of Interdisciplinary Social Sciences,* 3(1), 293-301. DOI: https://doi.org/10.18848/1833-1882/CGP/v03i01/52375

Stamovlasis, D., Tsitsipis, G., & Papageorgiou, G. (2010). The effect of logical thinking and two cognitive styles on understanding the structure of matter: an analysis with the random walk method. *Chemistry Education Research and Practice*, *11*(3), 173-181. DOI: 10.1039/C005466F

Sternberg, R. J., & Zhang, L. F. (Eds.). (2014). *Perspectives on thinking, learning, and cognitive styles*. Routledge. ISBN 9780805834314

Williams, Y. (2003). Convergent thinking: definition, examples & quiz. *Education Portal*, *13*(3).

Zamman, T. U. (2006). The Sciences, Subject-Choice, Performance and Extent of Divergence. *Science, Technology and Development*, 25(3), 5-6.

Zhang, L. F. (2010). Do thinking styles contribute to meet cognition beyond self-rated abilities? *Educational Psychology,* 30(4), 481-494. https://doi.org/10.1080/01443411003659986