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Relationship between thinking styles and cognitive load: A contextual study of Arab special learners

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Abstract: *The current study aims to assess the relationship between thinking styles and cognitive load of regular students and of the students with learning difficulties. It also evaluates to what extent cognitive load is related with patterns of thinking according to Harrison and Bramson's theory. Random samples of 105 male and female regular students' along with 79 male female students with learning disabilities were chosen for the study. An interview form was used to identify the family situation of the samples and the Raven matrix sequence test was used to determine the intelligence level of those with learning difficulties. To diagnose the nature of samples' learning difficulties, Michael Best's scale was used and to measure five thinking patterns (synthetic, ideal, pragmatic, analytical, and realistic) researchers' self designed tool was used. To measure cognitive load, a scale prepared by ASRC was used. The results of the study indicated that those with learning difficulties think random, i.e. they do not use the five methods of thinking in an organized way for their academic achievements and in problem solving which burdens their cognitive faculty. As for regular students, their thinking was organized, and they used the five methods of thinking in a regular manner to enhance their academic achievement, which eventually reduces their cognitive load.*

Keywords*: Cognitive load; thinking patterns; Harrison and Bramson theory; special learners; learning disability*

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1. INTRODUCTION

It is important for students to acquire scientific knowledge and operations, thinking skills and problem solving skills, but the common teaching practices in the educational field pay more attention to memorization, but rarely pay attention to the mental processes of the learners which eventually is reflected in learners' differential levels of educational achievement. Cognition helps us understand human behavior through the mental processes; it is significant in learning processes as well because knowledge acquisition goes through several stages until it stabilizes in the mind (e.g. *emotions, awareness, attention and memory*). Due to the limited capacity of the brain, the information stored determines the nature of its processing. Every individual has his/her own cognitive capacity to process a mental function, and any disturbance in such processes cause cognitive load. The educators and teachers should not give excess information as the increased load of information may hinder the learning process of the ordinary students, and students with special needs in particular (Zoghbi, 2012).

Al-Maati (2005) indicated that thinking is a refined cognitive process that involves re-organization of the elements of a given situation in a noble way that requires problem solving skill. In other words, it involves many other cognitive processes such as attention, awareness, remembrance etc., and some cognitive skills such as classification, conclusion, analysis, installation, comparison, generalization and so on. There are a number of theoretical perceptions of thinking styles that differ from one another in terms of individuals' preference in their thinking. One such model is the Paivio model (1971), which envisions the existence of two types of preferences of individuals and their ways of thinking: v*erbal thinking and conceptual thinking*.

Harrison & Bramson's (1982) model proposes that the idea of thinking styles are closely related to the study of educational psychology and cognitive psychology, as the roots of research in the methods of thinking emerged in the early seventies of the last century as naming of personal concepts, but the concept of style is more related to personality (Harrison & Bramson, 2008). For those with learning difficulties, it is clear that they have difficulties in memorization, understanding, attention and awareness. They mainly suffer a lack of understanding and awareness, so those involved in developing curricula should take into account learners' low ability of retaining and understanding information. Saudi Arabia is witnessing an alarming increase in the number of cases with learning difficulties. As their percentage ranged from 5% to 10% of the total population, the cognitive load of learners with learning difficulties needs to be taken care of well, so that the decision-makers could take into account their low abilities of memorization and understanding (Aburiah 2007). The present-day students need reduced load of knowledge/information during their learning process in order to use their higher thinking skills which require a lot of information and extensive mental processes for a successful learning (Mai, 2012)

Statement of the problem

The cognitive load theory is related to facilitating the processing of information in working memory with a lot of efforts (Sweller et al, 1998). Memory, with its coding, storing, and retrieval of information, is the basis for most of thinking and learning. Discrimination and recognition processes also depend on memory, so that the individual can perform several mental processes through the information stored in the memory (Abboud & Jassem, 2011).

The cognitive load is concerned with the way in which knowledge resources are used during the process of learning and problem solving (Shehab, 2011). Thus, thinking styles are influenced by the nature of the subject (the internal cognitive load) or the way in which students demonstrate the required information and activities (the external cognitive load) (Sweller, et al., 1998). Therefore, educational materials should be designed to keep learners' cognitive load at its lowest level during the learning process (Stachel, 2011). Each learner has a preferred style of processing information, which is also known as *learning method*. Therefore, the level of cognitive load during the learning process may be affected by the learner's preferred learning method or his/her method of processing the information presented to him. The cognitive load theory is based on cognitive structure consisting of partially independent processing operations for visual / spatial verbal and auditory information that interact with long-term memory (Pass, et al., 2003). From the above it is clear that the excessive cognitive load negatively affects the styles of thinking. The level of cognitive load can be reduced by finding effective ways to present information to the learners. Learning methods can explain the differences among learners and in terms of the ways they process information. Given the paucity of studies in Arabic context, the present study explores thinking styles in the light of Harrison and Bramson's theory and its relationship to the cognitive load of ordinary students and those with learning difficulties, by answering the following two questions:

Is there a relationship among the styles of thinking (synthetic, idealistic, pragmatic, analytical and realistic)?

Is there any relationship between thinking style and cognitive load of the learners?

Objectives of the study

The study has following objectives:

a. What are the patterns and levels of cognitive load between the students with learning difficulties and regular students?

b. How Harrison and Bramson's theory accounts for this difference?

Theoretical Background

The cognitive load theory has recently become one of the crucial theories to describe cognitive processes involved in learning using multimedia or internet-based learning (Brunken, et al, 2003, p. 53). Pass et al (2003, p.1) refers to cognitive load theory as a framework for research on cognitive processes and educational design. Allen (2011, p. 11) suggests that cognitive load theory assumes that an

individual allocate part of his mental processes in order to process or learn a bundle of information. To perform a task, the amount of knowledge resources needed requires processing of memory, which eventually loads the cognitive efficiency (Huang et al, 2006, p. 141; Yao, 2006; Curie, 2008). The idea of cognitive load theory is based on the premises that working memory has a very limited capacity and learning process needs active working memory. If the working memory capacity exceeds the maximum limit, then the learning becomes ineffective. It assumes that long-term memory has unlimited capacity. Increased levels of cognitive load may result from the content of educational materials, problem solving skill in learning using traditional methods (Abu Riyash, 2007, p. 196). Therefore, there should be variation in the content to suit various learning methods (Sweller, 2008).

Adnan Yousef Al-Atoum (2004) sees that each individual has his/her own way of thinking, and the way of thinking measures individuals' linguistic and cognitive preferences and their levels of flexibility in their work and in their dealing with others; though there are different approaches to the understanding of thinking style in terms of types and nature of the methods followed by individuals in their thinking processes. For instance, the Paivio model (1971) envisions two types of individuals' preferences; verbal reasoning and conceptual way of thinking. Harrison and Bramson referred to the individual's preferred methods of dealing with different life situations, and these methods include the scale of thinking as prepared by Harrison and Bramson (Magdy Abdel Karim Habib 2008, p. 5-11). It includes the following methods: A. *Synthetic thinking* means the individual's ability to communicate new and original ideas is completely different from what others do in synthesizing various ideas. In this process, an individual looks for views that may provide better equipped solutions, and link seemingly opposing views. It requires clarity and creativity. B. *Idealistic thinking* is the individual's ability to form different points of view towards goals and to pay attention to the needs of what is beneficial for him and the society. It focuses on social values. C. *Pragmatic thinking* is the individual's ability to verify what is right and wrong in terms of personal experience and freedom to experiment and excel in finding new ways of doing things using the available resources. D. *Analytic thinking* is the individual's ability to confront problems carefully and in a systematic way, pay attention to detail and plan carefully before making a decision, and collects as much information as possible while not forming a holistic view (Anwar Omar Ibrahim, 2007, p. 18). E. *Realistic thinking* includes reliance on observation and experimentation of the real life things or events.

2. REVIEW OF RELATED LITERATURE

Cognitive Load:

Working memory (WM, hereafter) regulates the efficient use of cognitive resources (Mayer & Moreno, 2003), and there are other factors too such as

individual traits and knowledge repository, as well as fresh information related to a specific task (Wouters, Paas, & van Merriënboer, 2009). Individuals with greater WM capacity have more attentional capacity to devote to complex tasks; thus, an individual with high WM may experience less cognitive load (i.e., find the task less difficult) than an individual with low WM. The established relationships between WM and performance on complex tasks (Geary, Frensch, & Wiley, 1993; Linderholm & van den Broek, 2002; Schelble et al., 2012), and between cognitive load and complex task performance (Beilock & DeCaro, 2007; Paas et al., 2003) support this idea. Thus, individuals with fewer attentional resources (i.e., lower WM) are likely to perceive a complex task as requiring more mental effort than those who possess more attentional resources. Given the impacts of cognitive load and WM on complex tasks and the similarity of the demands of creative thinking tasks to other complex tasks (Beaty & Silvia, 2012; Benedek et al., 2012; Benedek et al., 2014; Nusbaum & Silvia, 2011; Lee & Therriault, 2013; Silvia, 2015), links among WM, cognitive load, and creative thinking are likely.

Flad (2002) conducted a study aimed at identifying the effect of increasing cognitive load in the standards of self-report and bilateral tasks of mental effort in the problem solving process. The results of the study indicated that there was a positive and statistically significant relationship between the cognitive load and the difficulty of the task. Likewise, Farnsworth (2009) conducted a study aimed at identifying differences in the Cognitive load as perceived by teachers in training manual or electronic assistive technology to teach reading and writing to the blind. The results of the study showed that there were no statistically significant differences between the groups of technological devices in quantitative measures of cognitive load or the efficiency of the Braille method in learning to read and write. While the results of the interviews indicated that there were qualitative differences in the required mental effort (cognitive load) between the groups of technological devices.

Abdul Amir Aboud and Mahdi Jassem (2011) conducted a study aimed at identifying the level of cognitive load among middle school students, and identified the differences between males and females from arts and science specializations. The results indicated a decrease in the level of cognitive load among the sample members in general, but there were no statistically significant differences in terms of gender and specializations. The results also indicated that there were no statistically significant differences in the level of cognitive load in terms of areas of study. Abu Joudeh (2004) aimed to know the effect of an educational program based on the theory of cognitive load in developing critical thinking skills. Statistical indication of the California test of critical thinking skills as a whole and of each skill reflected the effectiveness of the educational learning program based on cognitive load theory in developing critical thinking. Al-Shamsi and Hassan Study (2009) aimed at knowing the cognitive load of middle school students in Baghdad, and concluded that there were statistically significant differences in their possession of a low ability to high ability tasks.

The study also concluded that there were no statistically significant differences in terms of their gender and specializations.

Thinking Styles:

Fouqia Abdel-Fattah (2007) explored the relationship between thinking styles and moral judgments, and revealed that there were differences between the prevailing thinking methods among the academic staff, as per their styles and specializations. The results indicated that there were statistically significant differences between the averages of male and female. *Ideal* thinking style was in favor of females, and *analytical* thinking style was relatively in favor of scientific specializations. Al-Sukari and Abdul-Fattah (2006) studied emotional intelligence and its relationship to thinking styles among a sample of university students. The study revealed that there was statistically significant positive relationship between emotional intelligence and *ideal* and *analytical* thinking styles, but statistically significant negative relationship between *Pragmatic* thinking styles. There was a statistically significant relationship with the rest of the thinking styles. Zhang, Li-Fang (2001) showed the relationship between thinking styles and personality patterns.

3. RESEARCH METHODOLOGY

The research sample included a group of regular students and students with learning difficulties who were randomly selected from some primary schools in the northern border region of Rafha, Saudi Arabia. A total of 105 regular students included 60 males and 45 females. A total of 79 learners with learning difficulties included 56 males and 23 females. The study was conducted in the second semester of academic year 2019-2020. The method used in the current study was descriptive in nature. Pearson correlation coefficient was used to measure thinking styles and cognitive load of the students with learning difficulties. The same was used for the regular students as well.

Hypotheses:

The hypotheses formulated are as follow:

H01 = There is no statistically significant correlation between the scale of thinking styles and the measure of cognitive load among students with learning difficulties.

H2 = There is a statistically significant correlation between the scale of thinking styles and the measure of cognitive load among ordinary students.

Study tools:

Family Diagnostic Interview Form: The aim of the questionnaire was to identify the economic, social and cultural levels due to the important role of these levels in influencing research variables.

Raven Colored Sequential Matrices (Takaneen, Emad Ahmad Hassan, 2014): Its goal was to measure intelligence, and it was largely free of cultural influence. It mainly depended on the collective application. It could be applied individually in certain circumstances. Successive matrices consisted of 36 items distributed in three sections: (a), (a) b, and (b), and colored matrices were suitable for ages from 5.6 to 10.5 years, and were suitable for those who had disabilities. Colors were used as the background to the problems, to make the test more interesting and clear.

Psychometric properties of the test:

Stability of the test: The coefficient of persistence in the study sample ranged from male and female students to repeat the test after two weeks to the stability factor of (0.85), and *p*-value at the level of (0.01).

Validity of the test: Formative validity was used, where the correlation coefficient was estimated by months between the total grades (0.77) in the first application of the test, while the correlation coefficient was (0.81) in the second application.

A student's behavior scale (Best and Sharif, 2007) was used to assess the nature of learning difficulties of the samples. This scale is one of the survey tools for the detection and initial recognition of learning difficulties through the teacher's assessment of the verbal and non-verbal behavioral features. Verbal measure includes assimilation and language whereas non-verbal measures include general knowledge, motor coordination, personal and social behavior. This scale was valid for individual application in the age group of 5.5 - 14 years, and it consisted of 24 questions sets distributed on two scales; 13 questions sets for the verbal scale and 11 for the non-verbal measure. Under each paragraph five graded questions (1, 2, 3, 4, 5……) were given wherein each grade represented the level of teacher's assessment of the student's ability. The score ranged from 24 to 120. The score was interpreted on the basis that each regular student got a score of minimum 48 and students with learning difficulty got lesser than that.

The psychometric properties of the scale

Honesty: Michael Best (1981) codified the scale to assess the significance of honesty of the sample, whereby the validity of the scale for gender variable was * 17.32 and the status of learner variable (normal students, and students with learning difficulties) was 98. 28*. The confidence interval was found to be 0.38 – 2.25. To measure thinking styles within the framework of Harrison and Bramson's theory, the researcher adopted the following five thinking styles: *synthetic, ideal, pragmatic, analytical, realistic*. These five styles represented a reference framework and thus the researcher validated that in that case the content of the scale was able to achieve the set out goals. The researcher had the following procedures in building the scale:

The content of the questions sets was well defined. The questions sets were developed in the light of Harrison and Bramson's theory. The total number of question sets (25) was divided into five dimensions; each dimension was having five questions sets as distributed in table 1 below:

Table 1. Distribution of questions and questions sets thinking style-wise

Dimensions	Order of questions	No. of question sets
Realist	1-2-3-4-5	5
Synthesist	6-7-8-9-10	5
Pragmatist	11-12-13-14-15	5
Analyst	16-17-18-19-20	5
Idealist	21-22-23-24-25	5

Psychometric properties of the scale: To ensure statistical validity, it was applied to a sample of 25 students, and the following equation was applied to the results. (Z = 2) = Seronov - Colmogrov = to know the nature of the distribution of data (normal or not).

The significance level of 0.01 meant that the distribution was not normal. Since the distribution was not normal, laboratory tests were not applied to the data, rather non-parametric tests were applied to data (Mann-Whitney's test for calculating terminal honesty). The results are as shown in the following table 2:

***Table 2*. Results of psychometric properties of the scale test**

Gr.	N	Total score	Avg. score	Z value	Sig. level	St. sig.
Max	8	100	12.5	3.393	0.001	Sig.
Min	8	36	4.5			

The table above shows that the value of the significance level is 0.001, which is statistically significant, because it is less than 0.05. This indicates that there are differences between the maximum and minimum. This means that the tool has terminal honesty.

Internal consistency validity: To extract this type of validity, correlation coefficients were found between the five styles and the results as shown in Table 3 below:

***Table 3*. Correlation coefficients between the five thinking styles**

Correlation Factors	Syn.	Ideal.	Prag.	Analy.	Real.
Synthesist	1	**-.202	*-0.10	**-0.347	**-0.297
Idealist		1	**-0.307	**-0.191	**-0.272
Pragmatist			1	**-0.272	**-0.161
Analyst				1	*-0.11

Realist	1

It is clear from table 3 that there is a negative correlation with a function at the level of 0.01, but it is very weak among the five thinking styles. The negative correlation between one group (*structural* and *pragmatic*) and the other one (*analytical* and *realistic*) is at the level of 0.05. It is indicated that negative correlations are quite higher at the top level factors, but it decreases over the downward factors. The results confirm the validity of the scale because the styles are distinct and are independent of one another.

Stability of scale:

The stability was determined by the following two styles: Mid fragmentation, Alpha-Cronbach equation
The value of each of them is as shown in the table 4 below:

***Table 4*. Stability of scale test results**

Stability type	Spearman-Brown coefficient	Sig. level	Alpha-Cronbach	Significance level
NA	0.78	0.001	0.73	0.003

It is clear from the table that the stability coefficients have relatively high values that allow the tool to be applied safely, and with this form of honesty and reliability the tool has become valid. The cognitive load scale as prepared by the American Space Agency Research Center (ASARC), was further translated and codified by Al-Banna (2008). The researcher assessed the cognitive load and its relationship to the styles of thinking of ordinary students and of those with learning difficulties, on the task load index of the National Aeronautics Space Administration (NASA), which allows measuring the total workload by itself during the completion of the task or immediately after it. It consists of six dimensions; each of them constitutes a source of the total workload represented in defined requirements such as physical requirements, time requirements, performance, effort, and frustration. It also consists of a scale sheet assessing the degree to which the scale dimensions contribute to the overall load. The scale included a description of the five dimensions and instructing the student to place a mark (x) on the intersection of eleven gradients with the horizontal line under each question and make sure to place a mark (x) on one of the gradient lines and not between the gradient marks. The total load is calculated by dividing the total cognitive load of the six measures divided by 15 which is the number of possible statistics between each pair of measures. The study found that there is a high degree of honesty, as the correlation coefficient is 0.52 between the scale of thinking styles and the cognitive load (Al-Banna, 2007). Al-Banna (2007) verified the stability of the scale by the Alpha Cronbach method with a value of (0.77). It

is clear from the above that the scale enjoyed a good degree of honesty in many studies and therefore it was used in the current study as well.

Research procedures:

The researcher followed the following steps in carrying out the research as follows:

A questionnaire was applied to identify the economic and social status of the sample so as to ensure that these conditions did not affect the study variables. The scale of thinking styles and cognitive load was applied to 105 ordinary students in some government primary schools in the northern border region of Rafha, to determine the mental requirements of their preferred methods of thinking.

The questionnaire of methods of thinking and the cognitive load was applied to 79 students with learning difficulties from some government primary schools in the northern border region in Rafha. The procedures for diagnosing learning difficulties carried out in two stages: first, application of Raven's successive matrix test to determine the level of intelligence of the sample, which measures non-verbal intelligence, and was largely free from any cultural influence, second, using the Michael Best scale to diagnose and identify people with learning disabilities. The researcher used statistical methods to know the effect of the five thinking methods (*syntactic, idealistic, pragmatic, analytical and realist*) on the cognitive load of students with learning difficulties and of regular students as well.

4. RESULTS & DISCUSSION

The First hypothesis:

1. There is no statistically significant correlation between the scale of different styles of thinking (*synthesist, idealist, pragmatist, analyst, and realist*) and cognitive load among students with learning difficulties. Pearson correlation coefficient was used to measure the relationship between thinking styles and cognitive load of the students with learning difficulties. The results of the Pearson correlation coefficient are given in table 5 below:

***Table* 5. Pearson correlation coefficient result of students with learning difficulties**

Thinking Styles	Total degree of cognitive load	Indication
Synthesist	0.004	*----
Idealist	0.005	*-----
Pragmatist	0.006	*-----
Analyst	0.003	----*
Realist	0.008	----*

(-)there is no correlation

It is clear from table 5 that there is no correlation between the thinking styles and the cognitive load of people with learning difficulties. This means that they have random thinking, that is, they use the five thinking styles in a random, disorganized manner, and this also indicates that the sample suffers from this weakness due to, to the fact that students do not use sound mental awareness in their academic achievement, which increases their cognitive load.

The second hypothesis:

There is a statistically significant correlation between thinking styles and cognitive load among ordinary students. The results of the Pearson correlation coefficient are given in table 6 below.

***Table 6*. Pearson correlation coefficient result of regular students**

Thinking methods	Total degree of Cognitive load	Indication
Synthesist	0.238	* *
Idealist	0.235	* *
Pragmatist	0.240	* *
Analyst	0.236	* *
Realist	0.237	* *

(**)(t) is at 0.01

It is clear from table 6 that there is a correlation between thinking styles and cognitive load of regular students. This strong relationship means that thinking is organized for them, that is, they use the five methods of thinking in an organized way. This indicates that the sample has the ability to use the five thinking methods in their academic achievement and in solving their problems. This may be due to the fact that students use mental perceptions in a proper way in their academic achievement in their efforts to use their ability to organize the curriculum content and reduce their cognitive load.

Psychologists and educational researchers believe that explicit instructions are necessary for the learners to do the best what is expected of them (Klahr & Nigam, 2004; Mayer, 2004), and they have provided empirical support to their claims. Research has clearly shown that for novices (almost all), explicit instruction is more effective than partial guidance (Clark, Kirschner, & Sweller, 2012). Zhang (2002) found that students with higher cognitive development level tended to use a wide range of thinking styles than the students with lower cognitive development. The results of the present study suggest similar patterns wherein normal students follow a regular pattern in terms of thinking styles during a cognitive function, whereas the students with learning disabilities exhibit a random pattern. Thinking styles vary among the regular students exhibit a particular style of thinking (study based on Sternberg's theory of self-government) under the dimensions of functions, forms, levels, scope and learning (Thomas & John, 2019). They observed differences in preferences of

thinking styles in terms of gender, but the present study exhibited contrary results. Thomas and John's (2019) study helped the learners' self-efficiency to gain a sense of self-efficiency, and also helped the teachers to better realize students' strengths and weaknesses to take necessary steps to compensate for their limitations. Cheng (2019) also proposed similar results that qualitative conception of learning was significantly related with a wide range of thinking styles among the students with hearing impairments. Likewise, this present study found a direct relation between thinking styles and learners' cognitive load. Overloaded working memory during various learning processes cause learning impairments in normal cases as well (Kalyuga, 2015, 2016; Sweller, 2011). Therefore, it is imperative to note that the students with learning difficulties do suffer cognitive burden in their learning processes if the content and the teaching strategies are not considered well (Likourezos et al, 2019).

5. CONCLUSION & RECOMMENDATIONS

In conclusion, the researcher presents a set of recommendations which is expected to lead the development of educational work by reducing the cognitive load by using thinking styles that encourage creativity. The recommendations are:

1. Teachers should be encouraged to diversify their teaching methods to suit learners' thinking patterns.
2. Agencies and institutions concerned with students with learning difficulties should provide them with educational programs appropriate for the learners, such as the Learning Resource Room (LRC), because this would reduce the severity of the difficulty of the student, and trained and qualified staff should follow-up well to deal with the cases of learning difficulties.
3. Attention should be paid to students' preferred methods of thinking, especially those with learning difficulties, and taking this into consideration while framing educational curricula and designing educational activities that may stimulate creativity and innovation.
4. Appropriate attention should be given to school activities that encourage creativity, and improvise methods of thinking that encourage creativity.
5. Establishing educational programs and holding workshops and seminars dealing with explaining the types of thinking and their roles in educational process; these will eventually help in reducing the cognitive load of the students with learning difficulties and of regular students as well.
6. Further studies should be carried out to assess the dominant thinking styles among the special learners in the variety of learning tasks so that better arrangement of subject content and their delivery can be sequenced well.

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