

Cognitive load and its relationship with mental capacity in accordance with their levels at students of the secondary stage in terms of sweller theory

Hussain Aburayash

Education Studies Program, Arab Open University-Jordan Branch, Jordan

Article Info

Article history:

Received May 29, 2019

Revised Jun 20, 2019

Accepted Jul 26, 2019

Keywords:

Cognitive load
Mental capacity

ABSTRACT

The study aimed to identify the cognitive load and its relationship with mental capacity in accordance with their levels at the students of the secondary stage in the terms of Sweller theory. The study sample consisted of (300) male and female eleventh and twelfth grade students from the leadership schools in Amman. The researcher used the cognitive load scale and the mental capacity scale. The results showed a high level of cognitive load in male and female, a high cognitive load on students of scientific specialization rather than literary specialization, and that the mental capacity of the study sample in general is moderate, and that the mental capacity of students of scientific specialization is high compared to the mental capacity of students of literary specialization. In addition, that the association between higher mental capacity and cognitive load was higher in males than in females, and that the relationship between the mean mental capacity of both sexes with the cognitive load was statistically significant.

*Copyright © 2019 Institute of Advanced Engineering and Science.
All rights reserved.*

Corresponding Author:

Hussain Aburayash,
Education Studies Program,
Arab Open University-Jordan Branch,
Arab Open University AOU, Muhammad Ash Shibani 4, Amman, Jordan.
Email: h_aburayash@aou.edu.jo

1. INTRODUCTION

Nowadays people live busy, social lives, and meeting the challenges of our complex environments puts strain on our cognitive systems. However, cognitive resources are limited. It is unclear how cognitive load affects social decision making. Previous findings on the effects of cognitive load on other-regarding preferences have been ambiguous, allowing no coherent opinion whether cognitive load increases or does not affect prosocial consideration [1].

The source upon which most of thinking and learning processes are built is the memory, and what it includes of processes of coding, storing and information retrieval, and except for the memory, the process of learning would be impossible, for the memory performs processes of recognition and distinction, and so the individual can perform many mentality operations and solve problems through what has of information in the memory. Action of the short memory had been clarified through a group of cognitive models Atkinson and (Baddeley model; Atkinson & Shiffrin model; Broadbent model; Tulving model; Craik and Lockhart model).

Theory of cognitive load views that learning happens by two types of memory, they are: Working memory and long-term memory. The working memory is the active constituent that performs processing required information, the information required to be processed imposes a high level of difficulty for the memory to absorb at a time, for the mental capacity as one determinant of the process of thinking and learning performs this process, and it is one of the most important psychological factors for the memorizing process. The working memory is physiologically the greatest responsible for the cognitive thinking and the exciting that play a significant role in the life activities, and the student is in need of decreasing the cognitive load imposed

on his memory during learning for the sake of effective learning performed on skills of higher thinking and in need of abundant and correlated information forming a basis of its learning and building cognitive schemes [2].

Features with which this century is characterized characterize with swift change and complication of patterns of life. It had imposed a cognitive load on the human mind challenges the brain with what exerts it with the huge quantity of cognitive units, and this requires teaching the individual strategies of decreasing these cognitive units without losing any of them [3]. This indicates to the role of the mental capacity as one of the processes of thinking and learning determinants, for they do processing the information and retrying them besides performing the cognitive processes and activities that are done in memory. Also, interest in theories of cognitive learning led to increasing interest with the how of the learner's doing absorbing himself as a learner that is, his ability to plan and follow up, evaluate and recognize the cognitive operations [4].

What an exertion for the mental capacity or load it over its operational energy represents a common factor between the factors that lead to difficulties, students confront during study, but its efficiency decreases at burdening it with a great amount of information that surpass its operational energy, or the technique upon which students depend in processing the studying information and the degree of attention and concentration, the matter upon which lowness of teaching performance level for individuals depend, for attention is the first moment of perception, and man at natural conditions is very selective in the amount and type of information that he pays attention to it [5].

The rise of the cognitive load rate happening affects receiving and processing exciters and information or preparing them and producing the final responses, appropriate to the stand, so we find that from causes of insufficiency of learning is lowness of the learner's ability to understand and process information, the matter that makes them disinvest their minds at reading and memorizing, and the problem is in the matter that leads to weakness of ability of good performance at many students is in lowness of the level of their mental skills in organizing and processing information[6].

The scientific material imposes a cognitive load on the memory, the thing that hinders the alien cognitive load that hinders learning [7]. The theory of cognitive load also supposes that the cognitive structure at the man consists of numerous areas variant for storing, including existence of specified capacity for the acting memory, and a great amount of ability of storing in the long-term memory [8].

Results of studies done in Australia on students of mathematics indicate to the rise of the cognitive load level, when the scientific material was shown to them in a method leads to distribution of students' attention between the written content and the planned for. Studies deduced that university students have a high level of cognitive load, especially the scientific faculties, and the university students' mental capacity is medium at a general form at males and females, but the scientific faculties, their mental capacity is larger than the faculties of humanities, and there is a correlated relationship between the cognitive load and the mental capacity. Studies also indicated, in the domain of mental capacity and the acting memory, to significance of studies of the cognitive operations in general and study of cognitive capacity of the working memory in particular, for what it has of a role in the cognitive processing. Also indicated to existence of correlated relationship directed between the capacity of the acting memory, solving problems, studying obtainment, existence of correlated relationship between the mental capacity and the cognitive pattern (verbal, imaginative) perception haste and thinking in solving problems. Studies also proved that scientific departments possess a high mental capacity and able to build cognitive schemes and mental maps [9-12].

Some studies indicate that to existence of positive relationship between the mental capacity and the self-concept and decision –making and that there is a positive correlated relationship between the capacity of working memory, problems solving and studying obtainment [13, 14]. And no differences exist in the variable of sex and the variable of specialization being both are a cognitive phenomenon influence by complications and details either they were scientific or humanitarian [15].

Uncovering the phases of failure and be aware of them then confront them and recognize the significant parts from the cognitive mental ability (mental capacity) of students to whom the educational associations in our Arab communities did not pay attention, and to their significance and may be absent from minds of tutors. And from the information of the researcher on researcher and studies he deduced the failure of many students in processing and organizing information does not lead to decrease their intelligence or non-inclination to studying, but refers to non-learning operations that include planning, control, evaluation, storing information and control their self-ability and invest what they are asked of works at an effective form, and how to retrieve them during the need of them and employ what they have of possibilities to organize their learning.

The researcher was excused to enquire if there was a relationship between the cognitive load and the mental capacity at students, for studies in the Arab environment can be limited due to the researcher's

knowledge in spite of studies about the cognitive load and its relationship with various variables and studies about the mental capacity and its relationship with other variables.

- a. Why do students confront difficulty in their learning a large group of cognitions and new experiences non-stored at the long-term memory?
- b. Suffering of some students for operations of understanding, retrieving information and decrease of attention and perception, and this will reflect with its negative effects on their performance and behavior.

The contemporary student is in need of decreasing the cognitive load imposed on his memory during learning for the sake of effective learning performed on using high thinking skills and developing them, and he is in need of abundant information and correlated to be a basis for his learning, that is, to be the basis in building cognitive schemes in his long-term memory, so the human memory is the most significant characteristic and generality for the psychological mental system at the human, enables him to receiving the external influence and obtaining information that enables him from processing, understanding and reserving them [16].

Sweller had tested the educational effects of the memory model called the theory of cognitive load, for this theory is performed on concepts of processing information in the memory and developing the schemes and machinery of procedural cognition. And said that submitting a simple content includes few of the cognitive elements interaction makes the student able to absorb the text, and recommended to go far from including high levels of interaction, because that leads to uneffective learning, because of the increase of cognitive load about the memory and going away, as far as possible about the cognitive increase [17].

Questions of study:

- a. What is the cognitive load at students of both Grades; Eleventh and Twelfth due to variables of (sex, specialization of study)?
- b. What is the level of mental capacity at students of both grades, Eleventh and Twelfth due to variables of (sex and the specialization of study)?
- c. What is the statistical significance of the correlated relationship between level of cognitive load and the mental capacity due to the three levels (high, medium, low)?

Terminologies of study:

Cognitive Load: it is defined procedurally with total degree that the male and female student obtain at response to measurement instrument items built by the researcher. And from the theoretical part, the researcher had adopted John Sweller definition of the cognitive load as “total of mental activities that preoccupy the acting memory through a certain time [18].

Mental capacity: it is procedurally defined with the total degree that is obtained by the male and female students through his answer to a group of the cognitive activities represented in drawings, forms, and puzzles that require attention, perception, and Concentrate images, numbers and mental schemes and capacity of storage. Nevertheless, the theoretical definition of the mental capacity, the stored amount represents energy in increasing the effectiveness of unit's informatics and increase of ability on doing the mental schemes and graphic drawings. Dealing with them, processing them, analyzing them and haste of performing the task solving the problem [19].

Significance of study:

- a. It tackles two significant variables.
- b. No studies exist. Tackle the relationship of cognitive load with mental capacity in the Arab environment due to the researcher's knowledge.
- c. The mental capacity is the basis of building the human mind and has the direct influence on acquiring learning, knowledge and the individual's development and his thinking.
- d. The study tackled the secondary stage (both grades: the eleventh and twelfth) with both branches; scientific and literary.

Limitations of study:

The present study is specified on students of Secondary Stage in the Jordanian Capital- Amman, the studying years 2018/2019 and the scales that used it.

2. RESEARCH METHOD

Individuals of study consisted of male and female students of the secondary stage (both grades the Eleventh and the Twelfth), in both specializations the scientific and the literary. And consisted of 300 male

Cognitive load and its relationship with mental capacity in accordance with their ... (Hussain Aburayash)

and female students from schools of International Leaders Schools, Independent Schools, and International School in Jordan in the studying year 2018/2019. And tools of study consisted of two tools the researcher did build them both: Scale of cognitive load and Scale of Mental capacity, in the following a clarification of both scales.

2.1. Cognitive load scale

After knowledge of previous studies, literatures, that tackled the cognitive load, like [6, 7, 20]. Study, and studies that used Nasa Telex Scale and Pass Scale that measures the cognitive load accompanying experimental tasks, then an appropriate scale had been built for students of the secondary stage and in accordance with (John Sweller) theory, that depends on the group of mental activities that occupy the acting memory capacity through a certain time, and is measured by the number of units or the cognitive schemes that should be paid attention to (Cooper, 1998). For this scale had been built on the form of a group of questions, puzzles and the choice from the numerous. Total of items became (20), and after applying on an informational sample, the time spent had been specified for each item. It is two and a half minutes, one grade had been given to the correct answer and zero to non-answering or the mistaken answer, and so the highest grade be on the scale is (20) degrees and the lowest grade is zero. The superficial validity evidences were extracted and the validity of building on a sample amounted (80) male and female students from both grades; Eleventh and Twelfth. Also the variability of scale had been counted by repetition, and reliability coefficient amounted (0.80) and by the method of internal consistency (Cronbach Alpha) (0.83). This is a good indicator.

2.2. Mental capacity scale

After knowing the previous studies, literatures, and scales of them [21] scale, that consists of geometrical and mathematics forms, and [22] scale, that consists of organizing sentences and completing drawings and colors and [23] scale, that consists of lengths, geometrical forms, pictures and domains of capacity storing and domain of mental abilities, scale of mental capacity in accordance with Baddeley and Heitch's acting memory had been built, that includes ability to know facts, ideas, ability to solve problems and do tasks.. of them visual, optical and audible by exploration and puzzles – solving and using numbers to build digital system, find the relationship, find difference among similarities, completing the decrease among similarities, completing the decreasing numbers, linking lines to complete the geometric form, find the lost number and the concealed phases by the picture, and discovering the different form and find the relationship between circles and ribbed shapes. The number of scale items amounted to (40) items, the answer about them is done in accordance with the following:

The examined obtains the degree (2) if the answer was correct, and obtains the degree (1) if the answer was correct, but in it a simple decrease, and the degree (zero) if the answer was incorrect. By that the highest degree of the scale is (80), but dividing levels of mental capacity will be (51-80) a high capacity, and (21-50) is medium, and (0-20) capacity is low, due to the supposed setting.

Validity of mental capacity scale: to be asserted of validity of the scale, the researcher used two types of the validity, they are:

- a. Superficial validity: the items of scale on a group of experts and arbitrators in the domain of educational psychology, analogy and evaluation to know the appropriateness of scale items of the study sample and objectives achievement, and agreement was one at the rate of 96%.
- b. Structure validity: extracting the distinguishing strength for the mental capacity items, where applying the scale on the distinguishing sample was done, the number amounted to (170) male and female students from both branches, the scientific and literary. The answers were ascendingly and discerningly organized at a rate of 27%, the number of the highest group was (45) male and female students and the lowest group (45) male and female students. Results showed that the tabulation value at the significance level was (0.05).

2.3. Procedures of the study

- a. Inquiring the theoretical framework of cognitive load theory and mental capacity levels as well as previous studies.
- b. Prepare the study scale and verify its validity and reliability.
- c. Application of the study tools to a sample at schools in Jordan.
- d. Dissemination of students, responses to Excel software, the use of statistical packages of SPSS, arithmetical average and standard deviations was computed, and the classification of students to levels of mental capacity and the use of two variance analysis (ANOVA).
- e. Reaching the study results, discuss and write recommendation.

3. RESULTS AND ANALYSIS

3.1. Level of the cognitive load at the Secondary School students due to variables of sex and studying specialization

The arithmetic mean and standard deviation had been extracted, and the t-test of one sample was used as shown in Table 1.

Table1. Results of t-test for one sample to recognize the level of cognitive load at the sample of study

N	M	SD	T value	Level of sig
300	11.99	4.733	8.105	0.001

In general, the result indicates to a high level of the cognitive load at students of the secondary stage. T-test of one sample was used to recognize level of cognitive load at the sample of study due to sex and specialization as shown in Table 2.

Table 2. Results of t-test for one sample to recognize level of cognitive load at the sample of study due to sex and specialization.

Variables	N	M	SD	T value		Leve of sig
				Tissue	Calculated	
Male	150	11.72	4.933	3.290	5.931	0.001
Female	150	11.29	4.581	3.291	6.899	0.001
Scientific	150	13.545	4.147	14.875	3.290	0.001
Literary	150	8.980	4.208	0.805	1.890	0.005

This indicates that there is a cognitive load at both sexes, and that there is a high level of cognitive load at students of scientific specialization more than those of the literary specialization.

The researcher explains these results, that students of the general secondary certificate in Jordan confront psychological and numerous cognitive pressures of them family and social pressures, to obtain high grades to enter the university education that confronts a great competition especially at public universities, where the self-look of the student, and household and relatives' look and the community in general make-bear the student pressures lead to losing balance at him, and appearance of problems like sharp anxiety as a result of high expectations of it, and these pressures be more evident in the memory, the thing that makes the acting memory activity confused.

Also classical methods of teaching, and non-attracting the student's attention and not giving him the opportunity during the track of lessons to symbolize the information and processing it and storing it in the acting memory with increasing pressure at non-existence of a separative of enough time among classes so as to the memory starts a good processing, the thing that forms a cognitive load, especially that the students is in a case of confusion from the pressing conditions on him in the general secondary certificate. Results of the first question came agreed with [9-12].

The previous results explain that students with the high mental capacity possess a good active acting memory, and able to concentrate and pay attention and call for direct information. This is considered an indicator to mental rationality that is distinguished with their ability to symbolize information, processing them and storing them in long-term memory.

3.2. Level of mental capacity at students of the Secondary Stage due to variables of sex and the studying specialization (scientific, literacy)

The arithmetic mean of the sample of study in general was compared with the depended standard in the present study in accordance with levels of capacity (0-20) low capacity, (21-50) medium capacity, and (51-80) high capacity as shown in Table 3.

Table 3. Results define the level of mental capacity at the sample of study in general.

N	M	SD	Mental Capacity Level
300	45.127	22.990	Medium

Results indicate that mental capacity at the sample of study in general is medium.

And at recognizing the level of mental capacity due to sex and field of specialization, arithmetic mean and the standard deviation had been done as shown in Table 4.

Table 4. Results of recognizing the level of mental capacity at the sample of study due to sex

Variables	N	M	SD	Mental Capacity Level
Male	150	45.055	23.998	Medium
Female	150	45.079	22.785	High
Scientific	150	51.370	21.707	Medium
Literary	150	38.759	22.859	Medium

Results indicate that the mental capacity to both sexes is medium; meanwhile the mental capacity for students of the scientific specialization is high if compared with the mental capacity of students of the literary specialization. And this results came agreed with [17-19].

3.3. Statistical significance for the correlated relationship between level of cognitive load and the mental capacity in accordance with levels of (high, medium, low).

Pearson correlation coefficient had been counted and using t-test to indicate to correlation coefficient as shown in Table 5.

Table 5. Results of the statistical significance of the calculated correlation between mental capacity and cognitive load by sex.

Variables	Relation		Variable2	Coloration value	Level of sig
	Variable1			Calculated	
Male	High capacity	Cognitive load		0.402	0.001
	Medium capacity			0.252	0.05
	Low capacity			0.289	0.05
Female	High capacity	Cognitive load		0.370	0.01
	Medium capacity			0.520	0.001
	Low capacity			0.277	0.01
Scientific	High capacity	Cognitive load		0.061	0.05
	Medium capacity			0.462	0.001
	Low capacity			0.286	0.05
Literary	High capacity	Cognitive load		0.148	0.05
	Medium capacity			0.327	0.01
	Low capacity			0.368	0.01

Results defined the statistical significance of the value of counted correlation between the mental capacity and the cognitive load as noticed from results that result of correlation at males and between the high mental capacity and the cognitive load statistically significant, and that the value of correlation between the high mental capacity at females with the cognitive load significant too. In addition, the relationship between the medium mental capacity at both sexes together with the cognitive load statistically significant. And it is noticed that the correlated relationship between the low mental capacity at males significant but significant at females.

The results clear that the value of correlation between the high mental capacity for the scientific specialization with the insignificant cognitive load, and the medium mental capacity for the scientific specialization with the cognitive load significant. In addition, the medium mental capacity at the literary specialization with the cognitive load is statistically significant, while insignificant at the scientific specialization.

This result is explained that the students with the high mental capacity possess an acting memory active and good and they are able to pay attention, concentrate and call for information directly, and this is considered an indicator to mental rationality characterized with their ability to symbolize information, processing them and storing them at the long-term memory. This is to what studies indicated that the mental capacity influences the behavior variables in the human performance and age difference.

That is, the cognitive system grows and develop with life and haste of information equipment, and changes with time and experience, and this influences the process of inserting information and retrieving them, and the cognitive schemes of the student that they have machineries of memorizing, organizing and attention to the net of information that it is active and effective, and this result agrees with [10] study from part of scientific specialization, for the interest of both males and females, with the high mental capacity, also

the scientific specialization possesses high mental capacity. This indicates to their ability to receive information and connect them with athletic scientific educational, engineering, and medical concepts in the different studying stages.

4. CONCLUSION

Students of the Secondary Schools possess cognitive capacity resulting from the problems that lead to increasing dispersion of their attention for the external exciting beside psychological pressures and differences do not exist between both sexes, while there is a high level of the cognitive capacity at students of the scientific specialization compared with the literary specialization. Students of the Secondary School enjoy a good level of cognitive capacity and do not exist between both sexes, while there is a high level of the mental capacity at the scientific specialization more than the literary specialization.

Existence of correlated relationship between the cognitive load and the mental capacity in accordance with the three levels (the high capacity, the medium, and the low) and between both sexes and the scientific and literary specialization.

Making available an educational environment far away from psychological pressures, assists on psychological stability, the thing that leads to lightening the cognitive load and increasing the mental capacity.

Designing the educational curriculums and connecting them with the requirements of age stage, the thing that assists on lightening the cognitive load, the matter that increases the level of the process of paying attention and concentration activity. Building training programs to lightening the cognitive load through educational strategies to increase effectiveness of learning and ability of grasping and paying attention.

REFERENCES

- [1] Tina Strombach, Zsofia Margittai, Barbara Gorczyca and Tobias Kalenscher, "Effects of cognitive load on social discounting," *Open Access JOURNAL*, vol. 11, no. 10, 2016. [Online]. Available: <https://www.ncbi.nlm.nih.gov>.
- [2] Pass, F., and Sweller, J., "An evolutionary upgrade of cognitive load theory: using the human motor system and collaboration to support the learning of complex cognitive tasks," *Educational Psychology Review*, vol. 24, pp. 27-45, 2012.
- [3] Paul's, F., Peterman, F., and Leach, A. C., "Gender differences in episodic memory and visual working memory including the effects of age," *Memory*, vol. 21, no. 7, pp. 857-874, 2013.
- [4] Van Merriënboer, J. G. and Sweller, J., "Cognitive load theory and complex learning: recent developments and future directions," *Educational Psychology Review*, vol. 17, no. 2, pp. 147-177, 2005.
- [5] Lee, "Cognitive load theory and aging effect of worked examples on learning efficiency, *Learning and Instruction*," vol. 98, pp. 902-913, 2000.
- [6] Cray, P., "*Psychology*," 4th ed., U.S.A: Words Worth Publisher, 2002.
- [7] Cooper, Tindall, Ford's, and Sweller, J., "Learning," *Journal of Experimental psychology*, vol. 7, pp. 68 - 82, 1998.
- [8] Muafee, Swanson, "Levels of mental capacity of middle school students in the Makkah area and their impact in solving engineering problems and towards them," *The Second Scientific Conference of the Egyptian Society for Mathematics Education. Ain Shams University, Cairo*, pp. 373-415, 2002.
- [9] Wolfgang and Christian, K, "A.Reconsideration of cognitive load theory," *Educational psychology Review*, vol. 28, pp. 55-75, 2007.
- [10] AL Salman, Tamara," *The mental capacity and contemplative thinking and its relation to the academic achievement of postgraduate students*," PhD Desertation. Baghdad University, 2014.
- [11] Alsahmsi, Abed AL Ameer, Mahdi. Jasem, "*The cognitive load of middle school students*," Baghdad University-Education Colledge-Ibin Rushed, 2010.
- [12] Paul. A. Kirchner, "Cognitive load theory: implications of cognitive load theory on the design of learning Cognitive load theory: implications of cognitive load theory on the design of learning," *Learning and Instruction*, vol 12, no. 1, pp. 1-10, Feb 2002.
- [13] Bannert, M. B., "Managing cognitive load: Recent trends in cognitive load theory," *Learning and Instruction*, vol. 12, pp. 139-146, 2002.
- [14] Sweller, J., "Instructional design consequences of an analogy between evaluation by natural selection and human cognitive architecture," *Instructional Science*, vol. 32, pp. 9-31, 2004.
- [15] Aburayash, Hussain, "*Cognitive Learning*," Dar Almaseera-Amman, 2007.
- [16] Alhawari. Jamal., "*Self-organized learning at high and low mental capacity of university students*," Education college. Alazhr University, Cairo-Egypt, 2005.
- [17] Ayres, Paul, "Impact of reducing intrinsic cognitive load on learning in mathematical domain," *Applied cognitive psychology*, vol. 29, pp. 287-298, 2006.
- [18] Alotoom, Adnan, "*Cognitive psychology. Theory and Application*," Dar Almaseera-Amman, 2004.
- [19] Allukta. Raeda, "*The working memory capacity, the cognitive pattern (the visual-visual) and the speed of perception and its relation to the processes used to solve the problems of Jordanian students*," Master Unpublished Master Thesis - Amman Arab University-Jordan, 2007.

-
- [20] Embreston, S., "The role of working memory capacity and general control processes in problems tasks," *intelligence*, vol. 20, no. 2, 1995.
- [21] Matter, Nejat Muhammad, "*The cognitive load according to the cognitive model of sensory preferences*," Unpublished Master Thesis, University of Babel, 2011.
- [22] Paas, Fred, Renkl, Alexander and Sweller, John, "Cognitive load theory and instructional Design; Recent development," *Educational psychology*, vol. 38, no. 1, pp. 14, Lawrence Erlbaum Associates, Lee, 2003.
- [23] Swanson, H.L, and Margaret, "The Relationship between working memory and mathematical solving in children at risk and not at risk for serious mathematical," 2004.