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Cognitive Load and Its Major Pedagogical Implications, Focus on Education in Jordan

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Abstract

Through my teaching experience in Jordan, I noticed the amount of work students had to do. I noticed the tremendous amount information they received from their teachers on a daily basis. I also noticed that students forgot most of the information they learned in class right after their exams. I was wondering if that's the right way of teaching. Then, after my study at SIT, I learned that this is a cognitive overload that can impair the learning process.

Cognitive load refers to the information processing abilities in the human memory system which has limitations. When these limitations are exceeded, students suffer from cognitive overload. This is what made me come to the conclusion that students in Jordan are cognitively overloaded.

In this thesis, I will explore the Cognitive Load Theory (CLT) and make a connection between the CLT and the education system in Jordan. I will also talk about the reforms that have been carried out, taking into consideration new theories of learning including the Cognitive Load Theory.

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Chapter 1

Introduction

Overview of education in Jordan

The Hashemite Kingdom of Jordan has a unique and well-improved educational system that was established in the era of the late king Hussein (1953 – 1999). This unique education system has put Jordan at the top of the ranking in the Arab World in the field of education (http://www.newsweek.com/2010/08/15/interactive-infographic-of-the-worlds-best-countries.html, 2010).

In addition, Jordan has the highest number of researchers in the Arab World. According to World Bank Development Indicators for 2007 / 2008 (http://hdr.undp.org/en/media/HDR_20072008_EN_Complete.pdf, 2007/2008), there are about 2,000 researchers per million people. This percentage of researchers in Jordan is higher than that in some European countries such as Italy and Greece and very close to the United Kingdom and Ireland.

There are two main factors that contributed to this great success in the field of education in Jordan. The first factor is that the Jordanian government ensures that "Education is for all people." The government also subsidizes education in Jordan so that poor people don't have to worry about the education of their children in public schools. They pay a token fee, which is around JD6 = $8.5 per year. This amount includes the annual tuition and books.

The second factor is the dedication of the people of Jordan to school their children. They are aware of the importance of education in this life. This awareness came upon the carefulness of the government to spread education and decrease the illiteracy rate. All this contributed to an increase in student enrollment ratio from 71% in 1994 to 98% in 2006. This increased the literacy rate in Jordan from 33% in 1960 to 85.4% in 1996, (http://www.kinghussein.gov.jo/resources3.html, 2010).

Nowadays, the educational system in Jordan is facing a serious problem, which is the imbalance between universities and community colleges, in which students study for two academic years to get an associate bachelor's degree. High school graduates prefer to get a four-year university degree which, to them, means a decent job in the labor market.

In the labor market in Jordan, there is a great demand for university degree holders. But community college degree holders can hardly find jobs. This made high school graduates prefer university degrees that can qualify them for jobs. But the problem here is that universities in Jordan cannot accept the huge numbers of high school graduates.

However, the ministry of higher education has been trying to solve this problem. One of the plans that the ministry is applying now is to raise the tuition fees of the public universities to turn students' attention to community colleges. The ministry hopes, by adopting this strategy, to make a balance between universities and community colleges.

Reforms in the Education Sector

In the public schools in Jordan, the teaching approach was the traditional way of teaching (teacher-centered approach) in which the student is the novice and the teacher is the expert. The teacher talks most of the time and the student is either a listener or s/he copies from the board. This traditional way of teaching overwhelmed students and overloaded their minds since the teacher-centered approach makes students passive learners and information-recipients. The students' cognitive abilities were neglected.

However, His Majesty King Abdullah II and Her Majesty Queen Rania have given rigorous care to the education sector in Jordan ever since they came to power in 1999. Their directions go toward using more effective approaches of teaching. They also adopted the principle of "Quality education for all."

Following the directions of His and Her Majesties, the Ministry of Education started to hold training courses for teachers to train them in using new methods of teaching that take into consideration the students' age, personality and cognitive abilities.

These reforms in the education sector that started in 2001 didn't only include teachers. It also included curriculum, educational materials, students, managers and standards to ensure a high quality education.

The goal of these reforms is to create an education system that is based on excellence. This goal complies with the King's vision to invest in the education sector to build a knowledge-based economy.

My Observations, Connections and Enquiries

This overview of the educational system in Jordan is provided in order for the reader to be acquainted with certain facts which will be needed to understand the rest of this thesis, particularly the rest of the introduction, in which I will talk about my experience in the field of education in Jordan.

Through my experience in the educational system in Jordan as a student and as an English language teacher, I noticed the huge number of assignments students had to do. I noticed how much they worked and how little they slept. Students had to study for long hours to get high marks in their exams, particularly high school students.

The high school stage has been considered as a critical period for all high school students. They study for long hours under a great pressure from the society around them. If a student fails in the high school, this is an indicator that s/he will live in misery. So, students do their best to successfully finish this period which is considered as a changing point in their lives.

This is the case in the public schools, but it is even worse in private schools whose owners are smart businessmen/women. They are smart in the way they attract their customers. They think that the more assignments they give students, the happier the parents will be. As a result, they will keep their customers and even increase them. Unfortunately, parents are deceived. They think that the school that gives their children a lot of assignments is an excellent and successful school. At the end of the day, students leave school with a ton of homework to do for the next day. They are overwhelmed and

their parents keep them under pressure in order to cope with the burden that the school is putting on their shoulders.

I felt that there was something wrong with that. I asked myself many questions. Why were students overloaded? Why did they hate school? What was the purpose of all this tremendous amount of studying? I couldn't find answers to these questions until I was introduced to the concept of Cognitive Overload at SIT Graduate Institute, which inspired me and enlightened my mind. At that time, I realized that students are taught more than they can learn. As John Sweller (1988) stated, we are being taught the wrong way, as teaching methods do not consider the way in which we think and learn.

However, many questions started to echo in my head after my analyzing the problem. How could this be the right analysis if Jordan is ranked on top of the Arab World in the field of education? Does my analysis lack something? Is the Cognitive Load Theory not always correct? Are there any factors that I didn't take into consideration in my analysis of the problem? How can cognitive load be measured? All these questions led me to deeply explore the Cognitive Load Theory to find answers to my questions.

The Value of The Cognitive Load Theory

The value of the Cognitive Load Theory is twofold. It is important in cognition and instructional design. According to Harry O'Neil (2010), "The Cognitive Load Theory bridges cognition and instruction and is one of the few prescriptive instructional theories" (review of the book Cognitive Load Theory, http://www.amazon.com/Cognitive-Load-

Theory-Jan-Plass/dp/0521677580). This theory explained the challenges that some learners face in their learning. It also shed light on the individual differences among learners in their cognition abilities (Philip H. Winne, 2010), commented on this issue by saying:

> *Cognitive Load Theory and the empirical research it has spawned over two decades provide a powerful tool for understanding why learners surmount or succumb to challenges in learning, solving problems and transferring skill (review of the book Cognitive Load Theory*, (http://www.amazon.com/Cognitive-Load-Theory-Jan-Plass/dp/0521677580*).*

The Cognitive Load Theory has also become one of the most important theories in the field of instructional design. According to Richey & Nelson (1996), instructional design is the science of finding specifications to facilitate learning. The Cognitive Load Theory (Sweller, 1998) states that designing instructional materials should take into consideration the learners' cognitive processing abilities. This means that instructional designers, whose role is to analyze, solve performance problems and implement solutions that make learners more productive and knowledgeable, should build instructional materials based on the learners' cognitive processing abilities.

I believe that this matter is very important since the capacity of the human working memory is very limited and cannot process a huge amount of information at the same time. This is a fact that teachers and instructional designers should take into consideration. Otherwise, learners will be overwhelmed and the learning outcomes will not comply with the teaching objectives. Consequently, the learning process will fail.

There are three types of cognitive load that are related to the human working memory; the intrinsic cognitive load, the extraneous cognitive load and the germane cognitive load. All these types that will be thoroughly discussed in chapter 4 should be considered by teachers and instructional designers.

> *When people are faced with new material, the cognitive load imposed by that material will consist of the intrinsic cognitive load due to element interactivity and extraneous cognitive load determined by the instructional design used. If that total cognitive load is excessive, learning and problem solving will be inhibited* (Sweller, 1994, p. 7)

These three cognitive types are based on the human cognitive architecture which is the basis of the Cognitive Load Theory. The human cognitive architecture is a scientific explanation of how humans process new information. It gives an explanation of the human cognitive structures and functions. It states that there are two types of human memory: long-term memory and working memory. Each of them has specific features and functions that educators should know in order to make the learning process more successful. However, this thesis will provide further information about the human cognitive architecture in chapter 3.

Chapter 2

Defining cognitive load theory

The cognitive load theory (CLT) is a psychological theory that originated from the field of cognitive science. It was developed to explain the effects of the design of learning materials on what happens in the human brain when learning takes place. (Jan L Plass, Roxana Moreno & Roland Brunken, 2010, p. 9).

The CLT has been the focus of instructional designers, educators and psychologists because it can be applied to various learning environments. This is because the CLT makes a connection between the design of learning materials and the characteristics of the human information processing system that is made up of working memory and long-term memory. It suggests that learning happens best when instructional materials comply with the human cognitive architecture (Sweller, 1998), and that learning will fail if the learning materials cause a cognitive overload.

> *By simultaneously considering the structure of information and the cognitive architecture that allows learners to process that information, cognitive load theorists have been able to generate a unique variety of new and sometimes counterintuitive instructional designs and procedures* (Paas, Renkle, & Sweller, 2003, p. 1).

From that we can say that the CLT is built on the understanding of how the human mind works. It is also based on the interaction between the information and the human cognitive abilities to process the information.

The CLT assumes that short-term memory, which is also referred to as working memory, is limited in capacity and duration which can hinder learning (Mayer, Heiser, & Lonn, 2001). This means working memory cannot process a huge amount of information at the same time. It also cannot keep information for a long time. I remember the example that my Second Language Acquisition professor at SIT, Dr. Francis Bailey, gave to explain how working memory is limited in duration. He said: Imagine you are going to the library and you meet a friend on your way. You stop to chat with your friend for a while. After that, you may forget that you were going to the library. That is because this kind of task is processed through your working memory. You forgot that you were going to the library because working memory is limited in duration. Another example was also given by Dr. Francis Bailey to show that working memory is limited in capacity. He said that he would show us some writings on the screen for seconds and that we should try to memorize as many words as we could. We noticed that we couldn't memorize all the writings. Even those who could memorize some words couldn't hold them in their memory for a long time. Also, the number of words that the students in the class could memorize was different. This example not only explains that working memory is limited in capacity, but it also emphasizes that individuals have different working memory capacities. According to Miller (1956), working memory can only hold about seven items, or chunks of information, at a time.

Working memory interacts with long-term memory which is unlimited in capacity and duration. The processing of information in the human mind goes first through working memory. Then it can be stored in long-term memory. To make this process happen, there are many factors that should be taken into consideration. But the most important is that

the load on working memory should be kept low. Working memory and long-term memory will be further discussed in the next chapter.

Making Connections

Before the reforms that were conducted in the field of education in Jordan, starting from 1999, neither the instructional designers nor teachers took into account these facts about the human cognitive system. The amount of information that students had to process in class exceeded the limits of their cognitive abilities, which is what hindered their learnings and overwhelmed them.

This also explains why students forget all the information they studied at school a few days after their exams. They spend long hours and even days memorizing before their exams. Then after the exams, all the information vanishes, since it was stored in working memory, which is limited in duration.

As I mentioned in this chapter, there are some factors that should be taken into consideration in order to store information in long-term memory. I mentioned that the load on working memory should be low. I may also add that practice and presenting the information in different formats by the teacher are also important factors that can contribute to transferring information from working memory and storing it in long-term memory.

The reforms that were conducted in Jordan shed light on these facts. They included the educational materials that were changed to allow for more interaction between the teacher and students. Teachers were also included in these reforms. They had to attend training courses organized by the Ministry of Education on how to present information to students in different formats.

Chapter 3

Human cognitive architecture

The effectiveness of instructional materials, which greatly depends on considering the characteristics of the human cognition system, has been the interest of instructional designers. The understanding of the human cognition system will lead to a successful learning environment. To know why the understanding of the human cognitive system is important for instructional designers and teachers, I will now explore the Human Cognitive Architecture in detail.

The Human Cognitive System

The human cognitive system processes information and directs the actions of humans. In spite of the fact that there are individual differences in cognition abilities, the structure of the human cognitive system is the same. That structure determines how humans respond to learning and how information is processed. According to Sweller et al (2006, p. 370), "As a natural information processing system, human cognition is hardly likely to be unique."

Characteristics of the Human Cognitive System

According to Lourdes Ortega (2009, p. 83), "information processing psychologists made

several assumptions about cognition:

1. *Human cognitive architecture is made of knowledge and the retrieving of*
   knowledge.
2. *Mental processing is dual*
3. *Cognitive resources are limited."*

Knowledge is stored in the human mind and can be retrieved when needed. The

retrieving of the stored knowledge can be automatic or controlled. When we use our

native language, we don't think of how we build the sentence, because this is an

automatic retrieving of the knowledge. But when beginner learners of a foreign language

want to produce a sentence, they need to think of how to produce the sentence correctly.

This process is called the controlled retrieving of knowledge. Because of this, the

automatic retrieving of knowledge doesn't require a lot of effort, while the controlled

retrieving of knowledge does.

Moreover, the controlled retrieving of knowledge is limited in capacity. This means that

if the human is using the controlled retrieving of knowledge, he will not be able to focus

on more than one task at a time. Dr. Francis Bailey at SIT (2010) used a metaphor with

his Second Language Acquisition students to further explain this characteristic of the

human cognitive architecture: "If you are an expert car-driver, you will not need to think

of how to drive the car because this process is automatic. And while you are driving, you

can do some other tasks like making a phone call. But if you are learning driving, you

will be focusing only on how to drive since it is a controlled retrieving of your knowledge

of driving. Because of this, you will not be able to focus on more than one task which is

driving the car."

Taxonomy of Memory

As I mentioned in the previous chapter, there are two types of human memory; short-term

memory (working memory), and long-term memory. They have different functions and

characteristics. I believe that it is necessary for educators and instructional designers to

understand the functions and characteristics of each of these types.

The following chart by (Schumann, 2004) shows the elements of the human memory
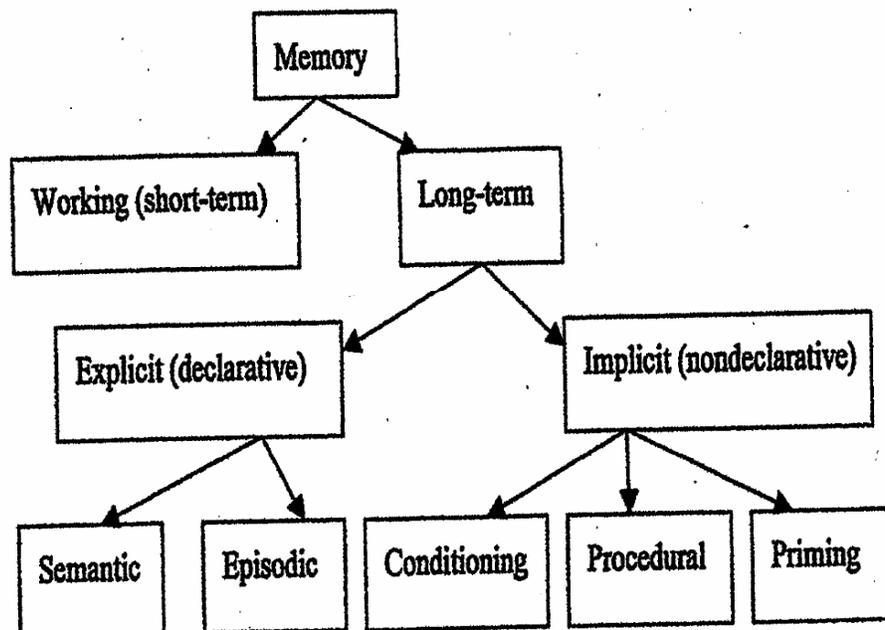
system.

Figure 1: Taxonomy of Memory (Schumann, et al., 2004, p. 4)

However, there is an interaction between working memory and long-term memory. This interaction occurs when the human mind retrieves information stored in long-term memory. In this case, there will not be any cognitive overload on the human memory. The problem starts when the human mind processes novel information. In the case of novel information, only working memory will be involved in information processing. This causes cognitive overload if it exceeds the limits of working memory.

Working Memory

Working memory is:

1. Limited in capacity and duration.

According to Kirschner, Sweller, & Clark (2006), when humans process information,

they are able to process two or three items at the same time based on the type of

processing needed. Also, Driscoll (2005) found that information can be retained in

working memory for 15 to 30 seconds. After that it is lost if not practiced.

2. Responsible for processing novel information.

Sweller, et al (1998), explained that when students are learning new material, they must

process the information in working memory before it can be stored in long-term memory.

3. Connected to consciousness.

According to Sweller, et al (1998), humans are conscious of the information held in

working memory, but are unconscious of the enormous amount of information stored in

long-term memory.

Long-Term Memory

Long-term memory is unlimited in capacity. It is the place where knowledge is stored.

According to Schumann, et al, 2004, p. 4), there are two kinds of long-term memory:

explicit (declarative) and implicit (non-declarative). According to Lourdes Ortega (2009,

p. 87), "The explicit memory supports recollection of facts or events. The Implicit

memory supports skills and habit learning."

However, the schema theory assumes that information is stored in long-term memory in

schemata which classify information based on how they will be used (Chi, Glaser, &

Rees, 1982). Schemas can make the retrieving of knowledge from long-term memory to

working memory easier. As a result, the load on working memory will be reduced. This

can also increase the capacity of working memory. This happens when the human brain

processes information that is related to knowledge stored in long-term memory.

Sweller (2004) stated that schemas stored in long-term memory effectively raise the

capacity of working memory. That makes the relationship between working memory and

schemas more important than the limitations on working memory.

Making Connections

I believe that the characteristics of working memory explain why the huge amount of

homework and long hours of study that students in Jordan used to do overwhelmed them.

It is because their working memories were "overloaded." It is because the amount of

information that their brains had to process exceeded the limitations of working memory.

According to Cooper (1998), cognitive load is the amount of mental activity that is

processed by working memory at a certain time.

In addition, most of the information that students had to process is novel information.

That means that it is processed through working memory and that long-term memory

doesn't have any part in that process. Since working memory is limited in capacity and

duration, it cannot process all that amount of information.

Based on that conclusion, I believe that the new information introduced to students

should be given with connection to previously learned information. In other words,

students will be using their long-term memories to process and understand the new

information. This way will reduce the load on working memory, which will facilitate

learning and make it more successful.

Also, I believe that this issue of reducing the load on working memory doesn't only

facilitate leaning, it also has a psychological influence on students. Students who

encounter cognitive overload on their working memories may be disappointed. When that

happens, the problem will be even worse since this disappointment will leave a bad

impression about learning. Besides, this will make students unconfident about their

learning abilities. As a result, students will hate school and learning.

Chapter 4

Types of Cognitive Load

For more understanding of what cognitive load is, I believe I should go deeper and

explore the types of cognitive load. According to the Cognitive Load Theory, there are

three types of cognitive load related to the cognitive processing: (1) Intrinsic, (2)

Extraneous, and (3) Germane.

> *Intrinsic, extraneous, and germane cognitive loads are additive in that, together, the total load cannot exceed the working memory resources available if learning is to occur. The relations between the three forms of cognitive load are asymmetric. Intrinsic cognitive load provides a base load that is irreducible other than by constructing additional schemas and automating previously acquired schema* (Paas et al., 2003, p. 2).

Intrinsic Cognitive Load

According to the Cognitive Load Theory, intrinsic cognitive load depends on two factors:

the number of elements that must be simultaneously processed in working memory on

any learning task and the prior knowledge of the learner. In other words, "Intrinsic

cognitive load through element interactivity is determined by an interaction between the

nature of the material being learned and the expertise of the learners" (Sweller, et al,

1998, p. 262).

> *Intrinsic cognitive load is the cognitive load due to the natural complexity of information that must be understood and material that must be learned, unencumbered by instructional issues such as how the information should be presented or in what activities learners should engage to maximize learning... The level of intrinsic cognitive load for a particular task and knowledge level is assumed to be determined by the level of element interactivity* (Sweller, 1998, p. 124).

This type of cognitive load is NOT related to "understanding", it is connected to the number of elements that must be processed in working memory at the same time, which is referred to as "element interactivity." For example, when a learner of a foreign language is learning a number of vocabulary words of that language, the task is difficult for the learner because of the huge number of vocabulary words that the learner must learn, even though this task doesn't require a lot of understanding. Consequently, the load on working memory is light. But when the learner of a foreign language is learning the grammar of that language, in this case, element interactivity is high. The learner must use the vocabulary words to be able to produce grammatically correct sentences. As a result, this requires understanding. So, the higher the element activity is, the higher working memory load and intrinsic cognitive load are.

This problem can be solved by teaching elements one at a time without teaching students how these elements interact. In this way, learning will occur, but not understanding. This can continue until elements are processed in working memory. Then, learners can be taught how these elements interact. By using this method, the load on working memory will be kept low because there was not a need for understanding when teaching learners the material elements.

The following is another example from my experience that provides a further explanation of how that solution can be implemented in teaching. When I teach my students a text for reading comprehension, I usually don't give my students that text from the beginning. I start with introducing the vocabulary words with examples and activities on the vocabulary words to explain their meanings and how they can be used. When I am

confident that they have processed the vocabulary words, I introduce them to the text, which will be much easier to understand after the vocabulary words have been introduced to the students.

Extraneous Cognitive Load

Extraneous Cognitive Load is also known as Ineffective Cognitive Load. According to Sweller (1994), extraneous cognitive load is caused by instructional techniques that make learners engage in working memory activities that are not directly related to schema construction or automation. This applies when working on novel information that is not stored in long-term memory. Some instructional materials are designed in a way that introduces the learner to enormous amount of information at a time. These instructional designs don't leave enough cognitive resources for schema construction and automation. When that happens, there will be an overload on working memory. As a result, the learning process will suffer.

The connection I can make from that conclusion is that the traditional teaching approach that was used in schools in Jordan does not take into consideration leaving enough space for working memory and long term memory to function properly. A lot of information is provided. And this huge amount of information cannot be processed by students' working memories at a time since there is no connection between the novel information provided and schemas in the long-term memory. This takes us back to the intrinsic cognitive load

that refers to element interactivity. This also happens in the extraneous cognitive load. It also refers to element interactivity, but under instructional design.

Another example is discovery-based learning. This type of instructional design depends on giving the learner minimal instructions. Then, the learner should search for the rule. This will place a heavy load on the learner's working memory because the learner will be exposed to a huge amount of interactive elements. As a result, there will be a cognitive overload on the learner's working memory. Also, since the primary goal of instructional design is to add more knowledge to the information store (Long-term Memory), and that this method of teaching doesn't comply with this principle, learning will suffer.

That makes sense to me. But I believe that discovery-based learning can be a very good approach of teaching IF the teacher limits the sources that learners must use to discover the rule. I learned this through my experience at INTERLINK Language Centers at Al Yamamah University in Saudi Arabia, which uses project-based learning. This approach is very similar to the discovery-based approach. At the beginning of my work at Al Yamamah University, I used to not limit the sources that students had to use to discover rules of the language. I discovered later that most of the students were lost. They worked without notable advancement in their language proficiencies. Then I tried to limit the sources that students must use. That worked well with students.

Germane Cognitive Load

This type of cognitive load, which is also known as effective cognitive load, is directly related to the intrinsic and extraneous cognitive loads. If the intrinsic and extraneous

cognitive loads are low and leave sufficient cognitive resources, the germane cognitive load will automatically increase. The increase in the intrinsic and/or extraneous cognitive loads has a negative influence on learners' cognitive resources, while the increase in the germane cognitive load has a positive influence on learners' cognitive resources. This is because learners will use the cognitive resources that the intrinsic and extraneous cognitive loads left in extra learning processes. That means the effects of the germane cognitive load are very few.

> *It refers to the working memory resources that the learner devotes to dealing with the intrinsic cognitive load associated with the information... Assuming constant levels of motivation, the learner has no control over germane cognitive load* (Sweller, 1998, p. 126).

In conclusion, I believe that instructional designers should consider keeping intrinsic and extraneous cognitive loads low to leave enough cognitive resources for the germane cognitive load which can contribute to learning.

<u>Summary</u>

The following quotation from Sweller's book (*Cognitive Architecture and Instructional*

Design, 1998) summarizes the three types of cognitive load and how they affect each

other.

> *If intrinsic cognitive load is high and extraneous low, germane cognitive load will be high because the learner must devote a large proportion of working memory resources to dealing with the essential learning materials. If extraneous cognitive load is increased, germane cognitive load is reduced and learning is reduced because the learner is using working memory resources to deal with the extraneous elements imposed by the instructional procedure rather than the essential, intrinsic material. Thus, germane cognitive load is purely a function of the working memory resources devoted to the interacting elements that determine intrinsic cognitive load... Germane cognitive load does not constitute an independent source of cognitive load. It merely refers to the working memory resources available to deal with the element interactivity associated with intrinsic cognitive load* (Sweller et al, 1998, p. 126).

Chapter 5

Measuring Cognitive Load

The Cognitive Load Theory is centered on the problem that when the total amount of processing of information exceeds the resources of the human working memory, working memory will be overloaded and, as a result, learning is impaired. The question that arises here is how can the load on working memory be measured?

According to Plass, et al (2010, p. 182), there are two ways to measure cognitive load: (1) learners can be asked to rate their perceived cognitive load subjectively, and (2) objective measures can be used. In this chapter, I will explore these methods in detail.

Subjective Measures of Cognitive Load

This is the most common way of measuring cognitive load, due to its simplicity. It is based on rating different variables such as difficulty and fatigue. This can be done in two ways:

1- Subjective Rating of Perceived Mental Effort

2- Subjective Rating of Perceived Task Difficulty

Subjective Rating of Perceived Mental Effort

In this way, learners are asked to answer questions about the mental efforts they exerted in a specific situation. This can be done by rating their cognitive load. The following is an example of such questions:

I invested . . . mental effort

    1- Low

    2- Very low

    3- High

    4- Very high

(Paas, et al, 1993)

This method of measuring cognitive load has three problems:

    1- This assessment is done after learners have finished the learning task. Consequently, it will not be known which part of the task caused the load.

    2- During a learning task, learners perform many processes in their working memories and long-term memories. It will not be known which of these processes caused the cognitive load.

    3- It is hard to determine which type of cognitive load caused the problem. It can be intrinsic, extraneous or germane.

Subjective Rating of Perceived Task Difficulty

In this way, learners rate the difficulty of the task. This measures the intrinsic and

extraneous loads. However, this method has the same problems of the subjective rating of

perceived mental efforts.

Objective Measures of Cognitive Load

According to Plass, et al (2010, p. 184), the following variables are tested as objective

measures of cognitive load:

1- *Learning Outcomes*

2- *Task Complexity*

3- *Behavioral Data, which includes:*

    a. *Psychological measures*

    b. *Time on task*

    c. *Information retrieval*

    d. *Dual-task*

Chapter 6

Conclusion

As I have stressed throughout this thesis, cognitive load theory is of great value. Ignorance of human cognitive abilities can lead to serious problems that can impair learning. Teaching isn't only a process of providing information; it is much more than that. Many factors interfere in the learning process. And instructional designers and teachers should be aware of these factors.

I believe that the Ministry of Education in Jordan should care more about quality rather than quantity. As I have outlined in this thesis, human cognitive abilities are limited. Thus, humans cannot process huge amounts of information at the same time. If teachers provide their students with a huge amount of information, students will not be able to process it. Consequently, the learning process will suffer. Even if students are able to memorize the provided information, they will not be able to retain the information for long, since information is stored in working memory, which is limited in duration and capacity.

I also believe that the Ministry of Education in Jordan should introduce teachers and instructional designers to the cognitive load theory. They should be introduced to the human cognitive architecture and the types of cognitive load. This is important for them to know how humans process information. If they learn that, they will know how to introduce information to their students. They will also know the amount of information their students can process so that they don't overload their students' memories.

In addition, I believe that teachers, after introducing novel information to their students, should use methods of teaching or activities to allow their students to practice what they learned. This is important for students to construct schemas and transfer information from their working memory to long-term memory. Consequently, students will retain information for a long time. That will solve the problem that I identified in the beginning of the thesis that students are being taught more than they are learning.

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