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Use of the Distributed Cognition Theory in a Lesson Plan: A Theory, a Model and a Lesson Plan *

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Abstract

Distributed Cognition Theory (DCog) approaches the cognition holistically and argues that knowledge come into existence not only inside the human mind but also in the world. It is theoretically related to cognitive and social theories. Simply, DCog takes information processing model into account and applies it to a computational functional system. DCog theory is generally used in the field of human-computer interaction (HCI) to find adequate answers to the design questions of HCI. But, there are few studies inspired from DCog in educational sciences. One of such studies is CTOM (connection, translation, off-loading, and monitoring) framework proposed by Martin (2012) that regard learning as "coordination" between systems in the natural settings. To increase the coordination, all of the components of the framework need to be employed in a learning setting. The framework also includes learning activities that can increase the technology use in education. In this regard, the main purpose of this study is to elaborate the use of Distributed Cognition (DCog) Theory and accordingly the CTOM framework in a lesson plan. To do so, firstly theoretical orientations of DCog was explained. Then, CTOM framework was criticized by considering the pedagogical functions of DCog. Finally, a lesson plan was prepared based on the CTOM framework according to Gagne's nine events of instruction. Consequently, the current study can be used in further empirical studies to test the effectiveness of the model in terms of educational outcomes.

Keywords: Distributed Cognition Theory, DCog, CTOM framework, lesson plan.

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Dağıtık Biliş Teorisinin Ders Planında Kullanımı: Teori, Model ve Ders Planı [*]

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Öz

Dağıtık Biliş Teorisi, bilgi işlemeyi bütüncül olarak ele alır ve bilginin sadece insan zihninde oluşmadığını, insanın çevresiyle etkileşiminden ortaya çıktığını savunur. Teorik olarak bilişsel ve sosyal teoriler ile yakından ilişkilidir. Basit ifadesiyle, dağıtık biliş bilgi işlem modelinin, bireyin içeresinde olduğu sosyal bir ortama uyarlanmasıdır. Genellikle, insan-bilgisayar etkileşimi alanında tasarım sorularına doğru cevap bulmak için kullanılır. Fakat eğitim bilimleri alanında dağıtık bilişle ilgili çalışmalara çok rastlanılmamaktadır. Martin (2012) tarafından CTOM modeli adında teorinin eğitime uyarlaması yapılmıştır. Bu modelde öğrenme, doğal ortamdaki iki sistemin koordinasyonu olarak ele alınmıştır. Bu koordinasyonun dolayısıyla da öğrenmenin artırılabilmesi için modeldeki bileşenlerin öğrenme ortamında kullanılması gerekmektedir. Model aynı zamanda eğitimde teknoloji kullanımını artırmaya yönelik aktiviteler de içerir. Bu bağlamda bu çalışmanın amacı dağıtık biliş teorisi üzerinden CTOM modelinin ders planında kullanımını incelemektir. Bunun için ilk olarak teorinin, teorik temelleri açıklandı. Ardından CTOM modeli, dağıtık bilişin pedagojik işlevleri bakımından değerlendirildi. Son olarak, CTOM modeli temel alınarak, Gagne' nin dokuz öğretim basamağı doğrultusunda bir ders planı hazırlandı. Bu çalışma ampirik olmamakla birlikte, dağıtık bilişin ve CTOM modelinin eğitsel anlamda etkisinin test edilebilmesi için yön gösterici niteliktedir.

Anahtar kelimeler: Dağıtık biliş teorisi, dağıtık biliş, CTOM modeli, ders planı.

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1. Origin of Distributed Cognition Theory

The origin of Distributed Cognition (DCog) theory takes its roots from an ethnographic study conducted by Edwin Hutchins about "naturally situated cognition" in the 1980s (Hutchins, 1995a). He argues that instead of observing subjects within an experimental condition, it is a requirement to monitor individuals in their natural setting to understand cognition better (Hutchins, 1995a; 1995b). Thus, he spent much of his time by investigating the ship navigation in the American Navy. Then, he organized his research results on “Cognition in the Wild”, which is his famous book regarding the emergence of theory.

Hutchins conceptualizes the distributed cognition theory within the properties of a particular system named as a cognitive system. A Cognitive system could be any unit of analysis like a cockpit (Hutchins, 1995a; Hutchins & Klausen, 1996), navigation of a ship (Hutchins, 1995b), an air traffic control (Halverson, 1995), and an engineering system (Rogers, 1993). Properties of the particular system include certain tasks to be accomplished by the individuals. These properties can be changed according to the selected unit of analysis. Hutchins (1995a), for example, takes the following concepts as system properties in the unit of analysis of a ship navigation; distribution of knowledge, decomposition of tasks, the horizon of observation, learning from errors, and social formation. That is, in a DCog learning environment, there exists a knowledge sharing and certain tasks to be accomplished. Individuals in the setting observe everything around them and try to complete tasks assigned by trial and error. All these occur in a social context in which artifacts and individuals interact. However, what Hutchins argued is that instead of considering any human mind as a cognitive system, we need to embed the cognitive science to a social context.

DCog theory is mainly related two main paradigms of learning approaches: cognitive and situated or social learning theories (Rogers, 1997). Firstly, cognitive theories explain learning based on the internal processes in the human mind (Driscoll, 2012). Every individual has different kinds of minds and intellectual skills (Gardner, 1999) causing the different type of proceeding of information. Nevertheless, a widely accepted memory model was suggested by Atkinson and Shriffin (1968) to account for the complicated diversity of information processing in human mind. In this regard, DCog does not propose a new cognitive perspective (Harris, 2004), rather it adapts Atkinson and Shriffin’s memory model to a larger system called as a computational functional system (Hutchins, 1995a; 1995b). Hutchins explains how he applied classical cognitive science with little modification to a cockpit system that is larger than human mind (Hutchins, 1995b). According to him, a cockpit consists of individuals (in this case those are pilots who are communicating each other within the system) and different artifacts such as speed card booklet, airspeed indicator and the like. All the activities being occurred inside the whole system called as “memory” by Hutchins (1995b). While doing that, he attributed some roles to artifacts and individuals in the cockpit like speed card booklet as "long-term memory" and decision process of pilots as "working memory." Therefore, because much of the workload of memory occur outside of the human (Norman, 1993; Hutchins, 1995b) instead of focusing on just human mind, he regards the whole systems as “memory” and attempts to understand what is occurring inside the systems. Consequently, DCog theory is the representativeness of cognitive science on a larger system.

Secondly, DCog is also related to the situated or social learning theories. Unlike, “information processing theory, situated learning theories rely more on social and cultural determinants of learning” (Driscoll, 2012, p 62). Therefore, in a situated learning setting the indicator of learning is the participation of learners in the community activities (Driscoll, 2012) through sharing a common sense (Wenger, 1999; Wenger, McDermott & Snyder, 2002) and even modeling or imitating some others (Bandura, 1991). The strength of the sociocultural context is the argument that "integrating knowing with doing" (Driscoll, 2012).

In terms of situated learning, the question then arises that how to tie up DCog theory with situated learning? Indeed, DCog utilizes all of the capabilities of situated learning. The DCog takes a whole system as a "memory", then implements the cognitive science to this system by attributing certain roles to the components of the system (Hutchins, 1995a; 1995b). But cognitive science does not give a precise answer the questions like what is occurring in the system? What is the relationship between individuals and artifacts in the setting? In summary, although the whole system (e.g. cockpit system) is the representativeness of cognitive science, the inside of the system (e.g. interaction between pilots, artifacts) is the representativeness of situated learning (see Figure 1).

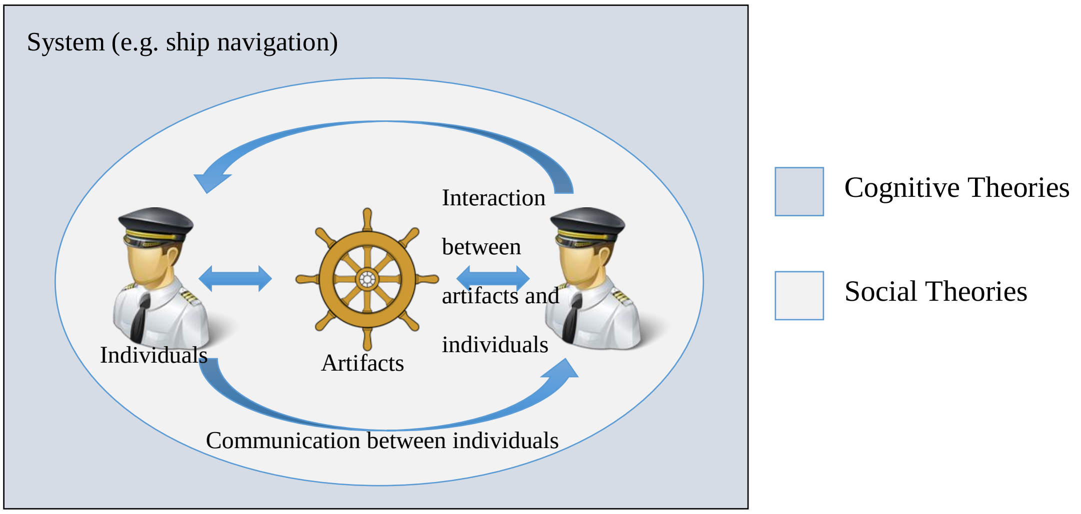

Figure 1. Visual illustration of DCog theory

According to Hutchins (1995b), distributed cognition theory can provide a connection between "information processing properties of individuals and the information processing properties of a larger system" (p. 287). This connection occurs in the sociocultural natural setting. In a learning environment like ship navigation, there exist individuals who have different knowledge and experience and artifact used to navigate a ship. It is expected from an inexperienced novice to become experienced to accomplish any task in this setting. The difference between expected and actual situation of those learners create a "zone of proximal development" (Vygotsky, 1978). Being an old-timer in this environment requires knowledge sharing, observing other individuals, and scaffolding inexperienced individuals' development. From this sociological aspect, DCog also shows similarities with the community of practice theory proposed by Wenger (1999).

2. CTOM Framework

According to Hutchins (1995b) "a complete theory of individual human memory would not be sufficient to understand that which we wish to understand because so much of the memory function takes place outside the individual'' (p. 286). Therefore, he describes the learning as "adaptive reorganization in a complex system" (1995a, p. 289). Hutchins attributes his definition to the sociocultural complex systems in which artifacts and individuals interact in a web of coordination. As a result, it can be concluded that learning is the increased coordination among two or more systems (Martin, 2012)

After defining learning as coordination between systems, it becomes a requirement to consider what kind of activities can facilitate such coordination. Martin (2012) rename the facilitating factors of learning as "pedagogical functions" to provide a general framework that can help to increase learning from a distributed cognition point of view. The suggested a framework involving four components: connection, translation, off-loading, and monitoring (CTOM) (Martin, 2012).

CTOM framework is designed to facilitate coordination among the systems of a distributed cognition environment (Martin, 2012). It is neither a learning nor an instructional theory that aims to explain "how learning occurs" or "how to teach". It is a framework that provides guidelines how to use "technology" in technology-enhanced learning settings (Martin, 2012). According to Martin (2012), CTOM is proposed based on the distributed cognition theory and does not include all of the possible pedagogic functions that can be offered with technology. For example, motivation, attention, collaboration etc. can be increased through technology but they are not within the CTOM framework's scope. Martin argues that it is not a requirement to employ all four components into a learning environment, rather it is more crucial to use these components in the learning setting properly in order to reach learning outcomes.

2.1. Connection

As the name of "connection" implies, it refers at least two connected systems. In other words, there would be a way of passing information between systems either actively or passively (Martin, 2012). The role of technology in this regard is that it provides a possible communication channel to the systems (Martin, 2012). Any technology that enables a system to access a person like social networks or to a non-human system like databases provides the pedagogical function of "connection".

2.2. Translation

This function refers to translation of information from a major source to a system (Martin, 2012) or to a representational system (Kaput, 1992). Technology provides an opportunity to translate information in an effective way. For example, without the help of an electron microscope, it is not possible to observe cellular's inside (Martin, 2012). What microscope (or technology) made here is that it is translating the existing data (inside of cells) to a representation that can be perceived by the scientist (system). In order to ensure whether information has been delivered to the other side, safely, affordances of technology and capabilities of the learner (Martin, 2012) need to be considered.

2.3. Off-Loading

The off-loading function is the accomplishment of subtask that has potential to make learner overloaded when s/he did not use the technology (Martin, 2012). In other words, it is the cognitive resources offered by the technological device to make a person (system) more engaged or more coordinated with the main task.

2.4. Monitoring

Monitoring can be described as assessing the coordination among artifacts and individuals by giving feedback (Martin, 2012). The monitoring function is important because it compensates the missing points in the coordination and gives chance to learn from errors.

CTOM framework, basically, focuses on four pedagogical functions of technology usage in DCog environment. It does not take into account all of the pedagogical aspects of distributed cognition theory. Hutchins (1995a) summarizes pedagogical functions of DCog theory by accounting for the system properties. Although he emphasizes that such system properties cannot be generalized to another unit of analysis due to the complexity of each system, they can provide an insight what to consider in a DCog setting.

According to Hutchins (1995a), in a human system generally, there exists "knowledge sharing" between novice (inexperienced learners) and expert learners. Hutchins named such ongoing process as the distribution of knowledge in which novice becomes more skilled by taking new roles. This argument also supported by the Wenger (1999) in that novice learners become an old-timer by sharing a common sense or knowledge in a social context. However, CTOM framework does not involve a specific component that can allow for distribution of knowledge.

The DCog context consists of certain tasks and structure of these subtasks affects "the efficiency of task performance and the efficiency of knowledge acquisition" (Hutchins, 1995a, p.267). In order to accomplish a target task, the communication between subtask and the knowledge about subtask need to be clear. In this regard, Hutchins addresses to the importance of prior knowledge to complete a task. Accordingly, in the "*transformation* function" of CTOM framework, Martin (2012) highlights that to provide a better communication channel among cognitional systems capabilities of technological devices and characteristics of individuals need to be considered. By means of that, even though he does not focus on task requirements, he makes suggestions about how to provide a better communication within the system.

One of the more important pedagogical functions in the DCog setting is "horizon of observation" (Hutchins, 1995a). Most of the pedagogical activities depend on a horizon of observation in a sociocultural context. Learners gather information by observing the ones who are more skilled and experienced. "Limits on observation of the activities of others have consequences for the process of acquiring knowledge" (Hutchins, 1995a, p.268). Therefore, tasks need to be provided on the horizons of each individual's observation. In other words, the outward boundaries of each task are necessary to be seen or heard by the ones in the team. "Horizon of observation" property of the system proposes two important pedagogical functions: (1) the interaction within the system need to be monitored anyone and (2) suitable tools or artifact (Hutchins, 1995s). However, CTOM framework does not involve any educational function that is referring observation in a social context.

According to Hutchins (1995a), "error is inevitable in a human system" (p.271). Norman (1993) argues that designers consider how to minimize causes of errors by providing an opportunity to the learners to restore the error situation. From this point of view, human systems might be designed to enable learners to learn from their errors (Hutchins, 1995a). In order to detect and learn from errors, Hutchins proposed four issues: access, knowledge, attention, and perspective. In this regard, CTOM framework just focuses on the access issue in the "*connection*" pedagogical function, yet rest of them are not mentioned in the framework.

In DCog system there exists a mutual dependency among the members. Such an interpersonal dependency among the members of the community called as computational dependencies (Hutchins, 1995). According to Hutchins (1995), these computational dependencies consist of the social dependencies and create social consequences in the functional system. Individuals internalize social process around them (Vygotsky, 1978) based on the information processing capabilities. Therefore, instead of focusing on just cognitive aspect of human learning, it is crucial to consider social environments' effect on learning. Such a social setting requires collaborative work, imitation, modeling etc. However, CTOM framework does not emphasize the social aspect of the distributed cognition, it just focuses on the cooperation between artifacts and individuals.

3. Method

In order to apply the components of the CTOM framework in the lesson plan, Gagne's (1985) nine events of instruction was used as a guideline. "Nine events of instructions" was proposed to facilitate the activation of the executive control process in the mind to make learning better (Driscoll, 2000). From this point of view, it builds upon its arguments to cognitive aspect of learning. According to Gagne (1985), the instruction should start first by gaining the attention of learners. Then, the objectives of the instruction are presented to learners. It is important to recall of previously learned knowledge in learning, therefore the instructor should stimulate the recall of prior learning related to the topic. By means of that learners retrieve the prior knowledge to the working memory (Gagne & Medsker, 1996). After that, the content is presented to the learners. Throughout this process, the instructor provides learning guidance to help them to code the content in the mind. In order to understand whether learning occurred, it is crucial to elicit the performance of learners. In doing so, informative feedback should be provided to compensate the missing parts in learning. At the end of the instruction, the performance of the learners is assessed and several tasks are provided to transfer what is learned to the new situations.

In the current study, Gagne's "nine events of instruction" is selected as a guideline to prepare the lesson plan because the distributed cognition is mostly related to the cognitive theories. The components within the CTOM framework was associated with the nine events. The plan was prepared according to the knowledge, comprehension, analysis and synthesis cognitive domains of Bloom's taxonomy (Bloom, 1965) to state the objectives.

4. Lesson Plan

The main purpose of this section is to prepare a lesson plan for "information security" topic of 8th grade in middle school curriculum. For this purpose, information technology and programming course textbook (MEB, 2012) was used.

Grade level: 8th-grade middle school students

Classroom size: Around 23 students (OECD, 2012)

Duration: One 45 minutes' session

Goal: The reason of designing this lesson plan is to help 8th students to discover personal privacy and information security threats and to take precautions for them.

Objectives: Knowledge, comprehension, analysis and synthesis cognitive domains of Bloom's taxonomy (Bloom, 1965) are selected to state objectives for this lesson plan. At the *knowledge* level of cognition, students will be able to labeled information security threats. For *comprehension* level, students will be able to explain the type of information security threats in their own words.

For *analysis* level, students will be able to differentiate the type of threats like viruses versus spyware. For the *synthesis* level, at the end of the lesson students will be able to provide a framework how to protect themselves against the threats coming on the Internet.

Materials to use: A computer for each student, projector, secure Internet connection.

Procedure: In order to make easier to reach learning objectives, Gagne's (1985) nine events of instruction was embedded to the procedure. The management of lesson as follows:

1. *Gaining attention*: Instructor starts to lesson by demonstrating a short documentary about "WikiLeaks", which is an organization that publishes secret information of governments. After watching the video, the instructor asks the question of how WikiLeaks' founders can collect billions of information. By means of that, he tries to gain students attention to information security.
2. *Informing the learners of the objective*: Instructor informs previously explained objectives to the students verbally.
3. *Stimulating recall of prior learning*: Instructor reminds the concept of "data", "information" and "basic information security threats", which were studied at the previous lesson.
4. *Presenting stimulus*: Content of tasks includes the following topics: internet security, viruses, trojans, spyware, worms, keyloggers, spam, tracking cookie, personal privacy in internet and passwords. Before providing the learning activity, the instructor creates groups consisting of two or three students. After assigning each student to a group, s/he gives presented tasks to examine the topics on the selected websites. The main purpose of the tasks is to increase the awareness toward information security and to suggest a framework regarding how to avoid security threats on the Internet. Thus, the instructor wants students to collect information about the selected topic and based on this information they prepare a presentation. To do so, students allowed to use computers that have the Internet connection. Wikipedia and YouTube are the by default information sources allowed by the instructor to complete tasks. However, those who want to use other websites can use them after getting permission by the instructor due to the security issue. While they are examining the topic the first thing they need to do is to open the website. Then by using the search function of the website they enter the topic in the search box. The system generates results and learners then examines the topic presented on the screen. During this process, students are encouraged to study collaboratively on the tasks.
5. *Providing learning guidance*: While students dealing with tasks, a worksheet is presented in advance to help learners to reach objectives efficiently.
6. *Eliciting performance*: In order to encourage students to apply what they learned, the instructor gives chance them to prepare a two-minute presentation verbally.
7. *Providing feedback*: Throughout the process of presenting the stimulus to final stage instructor give feedback to students.
8. *Assessing performance*: When students finished their presentation, they make a verbal presentation to the class. Instructor assesses their performance by using a rubric that is presented based on the learning objectives. Peers in the class also evaluate their students as well.
9. *Enhancing retention and transfer*: After completing all presentations and assessing them, instructor allows students to make a discussion about information security. Additionally,

those who had previous experience about security can also share their experiences with the class. Finally, instructor and students try to provide a suggestion list about how to protect themselves from the threat of information security

5. Detail of Lesson Plan in Terms of CTOM Framework

The main purpose of this section is the clarify relation of CTOM framework with the lesson plan presented above. The CTOM framework was developed within the DCog theory (Martin, 2012), and it requires to the implementation of cognitive science to a system. Since "learning as coordination" is the main argument of the DCog theory, Martin focuses on the coordination of two systems. According to Martin (2012), CTOM framework is more suitable for technology-enhanced learning settings. Thus, he emphasizes the use of technology to meet the pedagogical functions of educational technology.

Since the scope of CTOM is more appeal to technology use, "providing stimulus" part of the lesson plan is directly related to the framework. Students interact the computer by using Wikipedia or YouTube in this phase. As a result, the quality of the interaction increases the coordination between students and websites. How and why CTOM is related with which part of the activity is explained below.

Connection. Without connection, the coordination does not occur (Martin, 2012), thus students open their computers and load Wikipedia, YouTube or any website on their browser. By means of that the first function, *connection*, is satisfied.

Translation. After access to the intended website, students use the search function of the website and then they display the information on the interface. The information on the screen is presented depends on the accuracy of content. Additionally, the display of the screen is presented based on the usability principles that can be controlled by student easily. Both accuracy of the content and usable display design require *transforming* raw information that can be covered by students in an efficient and effective way.

Off-Loading. Off-loading is the additional tasks being provided by the artifacts that can cause cognitive load (Martin, 2012). Apart from displaying content on the screen in an organized way, computers offer different features like when they finished their examination they can organize their finding on word processing software or prepare a presentation. By means of that, students can save their findings without memorizing them. In this case, such additional features offered by the computer address to *the off-loading* function of technology.

Monitoring. Monitoring is typically giving feedback to someone's actions. In the activity presented above, Wikipedia or YouTube provide related links about the topic after students complete their search. These links direct students to additional sources on the website. The links clicked by the learner change their color so that user can understand he or she has visited such link. By means of that monitoring function of the technology also supported as well.

6. Conclusion

The main purpose of this study is to investigate the use of Distributed Cognition (DCog) Theory and accordingly CTOM framework in practice. The DCog is commonly used to understand the design issues of settings in which human and artifacts interact. It is also reasonable to employ such theory for educational purposes. In this study, the CTOM framework proposed by Martin (2012) was taken into account to illustrate the utility of DCog and CTOM in a lesson plan.

The DCog is a cognitive theory but includes the principles of social theories. It provides insights to examine technology-mediated learning settings. However, this requires discovering pedagogical functions of theory. In this regard, CTOM framework takes the learning definition of DCog into account and provides four components that can be used in different settings to increase technology use in education.

Martin (2012) states that CTOM framework might be helpful for designers and researchers to adopt new technologies in education and to contribute the use of existing ones. In this regard, current study adapted all components of such framework in a lesson plan. This study is not an empirical study, but a starting point to investigate the use of DCog in education. Further empirical research might be conducted by taking lesson plans that are prepared according to CTOM framework to explore the effectiveness of DCog in practice.

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