Connectivism: A Literature Review for the New Pathway of Pandemic Driven Education

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Abstract:- The Covid-19 pandemic has brought physical distance among people and forced every aspect of life to change including education. The educators all around the world who had already been trying to adapt the digitalization to be compatible with the demands and needs of today's learners that are also called the digital natives found themselves in an entirely new world order for education as no face-to-face classes were freely available. As previous learning theories were developed for the education that takes place face to face in schools and there hadn't been a reason to transform education into a completely distance way, at least up to higher education, educators might feel faltered trying to follow principles of behaviorism, cognitivism and constructivism. Connectivism which aims to explain the learning that takes place within the digital environment by learners' forming networks with other learners and even digital sources such as Wikis, blogs, data clouds etc. is a new theory for the 21st century education that is covered by the technology. This paper tries to summarize the theory in order to provide a guidebook for the teachers having confusion caused by unexpected and quick transformation after pandemic started to drive educational applications.

Keywords:- Connectivism, Distance Education, Distance Learning, Digitalization In Education, Connective Learning.

I. INTRODUCTION

In recent years, the development of technology has brought pedagogical advances in the field of education at all levels. The integration of technologies - especially Information and Communication Technologies (ICT) - forces traditional learning and teaching environments to change and allows them to have multiple teaching modes where there is a continuous increase in knowledge acquisition. As a result, the coherence of education is strengthened, the quality of it is increased and a more participatory and interactive learning environment is offered through the transforms. One of the most obvious indicators of this change is the increase in the number of students taking online courses. It is estimated that close to six million students worldwide took at least one online course in the fall of 2010 alone. Then, almost one in three students in higher education takes at least one online course (Hogg & Lomicky, 2012). As technology dominates and transforms education, new theories are emerging to

explain learning and teaching frameworks in the digital age. Some of these notable learning theories include self-determined learning, collaborative learning with peers, and a post-modernist approach that recognizes the differences of learners and the[1] existence of multiple pathways to learning, an approach called "Connectivism" by George Siemens.

While the knowledge from the past is divided into two as qualitative and quantitative, Siemens proposed a third type of information (Hung, 2014): connective. According to Siemens, behaviorism, cognitivism and constructivism theories have some limitations. First, these learning theories approach learning from an individual perspective. Second, they ignore the learning that can occur outside of human beings. Third, these theories focus on how to learn and ignore the value of what is learned (Chetty, 2013). Moreover, the rapid growth of knowledge makes it a dynamic phenomenon, and new ways of producing and sharing knowledge reveal the necessity of more than one way of looking at information (Clarà & Barberà, 2013). Accordingly, learners have to actively participate in the education process; a role for the learner that only passively receives and stores information and is dependent on the lecturer is a thing of the past. Instead, today's learners help decide not only when and how to learn, but also how to interact with and shape information according to their context. While traditional learning focuses on the gathering of facts for knowing and learning, today's learners must discuss and construct meaning through constructivist and connectivist approaches. This is a process where knowing is no longer a fixed object to be acquired, but rather a process where knowledge is acquired and used to create meaning and problem-solve in the context in which the learner should act (Grooms & Reid-Martinez, 2014).

II. CONNECTIVISM: EXPLANATIONS, PRINCIPLES AND CRITICISMS

Prensky (2005) defines today's students as individuals who are not interested in learning environments that do not reflect their life in the real world and cannot learn in such environments. Students come to the classroom with their mobile phones, laptops and tablet computers and they are in touch with the changing world thanks to the continuous

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[1] This study is summarized from the literature part of the PhD. Dissertation prepared by the first author under the supervision of the second author.

information exchange these tools provide; they are motivated and ready for it. It has become impossible for educators who are thinking of providing education through blackboard and chalk to reach these students. Outside the school, students' lives have a rich life in terms of media, communication and creative opportunities (Darrow, 2009). Learning in online environments changes the dynamics of power. Self-directed consumption reveals a sense of flexibility, freedom and control that supports reflective "deliberate learning actions" and being part of the whole in participatory environments. Therefore, the age of Connectivism includes the power of technology that normalizes behaviors in flexible learning environments (Abrams, 2013).

As a learning theory, connectivism provides a perspective on the dynamics of networks, environments and ecologies that support a continuous learning process. According to this view, learning is a highly network-based process in which learners see external resources from a holistic perspective (Marhan, 2006). In general, as the need for learning from the teacher increases, the lesson should rely on traditional teacher-centered education. However, as learners benefit from individual exploration and reflection, there is a trend towards the constructivist approach in the lesson. When learners acquire knowledge through their interactions with other learners and networks, the course tends towards the connectivist understanding (Figure-1). These three paradigms should not be considered completely independent. In the real world they can coexist and exist.
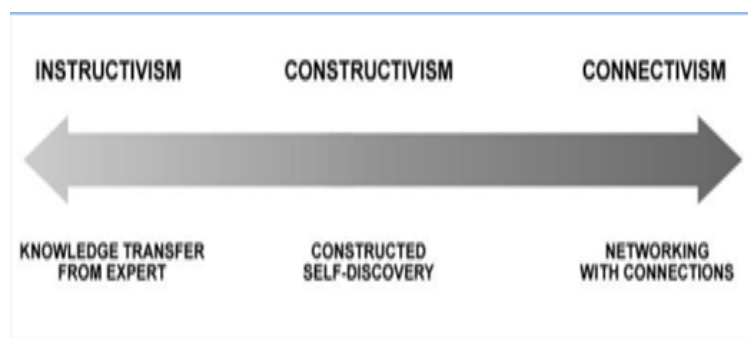

Figure-1 Learning Theories at a Level (Crosslin, 2016)

Connectivism is an epistemological approach based on interactions in networks both in the individual's mind and in the outside world. At this point, it differs from approaches that focus on what to do (behaviorism), what to think (cognitivism), and how to make sense (constructivism), and it provides an epistemological basis, especially in Mass Open Online Learning (MOOC) environments (Barnett, McPherson, & Sandieson, 2013). In the period called Web 2.0, the selection, organization, distribution and control of information by the authorities left its place to the management of information according to current needs. As a result, the importance of official intermediaries and institutions decreases. In the networks of today's groups, the utopia of collaboration, learner-centeredness, and self-regulation can become a reality. For the "download generation", the Internet has ceased to be a tool for learning; it has turned into a platform and center for self-study. Reasons such as the development of social networks and various software supporting them brought this change along. As availability of the Internet has increased significantly and similarly, our know-how is constantly increasing thanks to accessible mobile devices and the proliferation of free available content; content management has become cheap and simple by the emergence of tools such as blogs, wikis, file exchange programs.

(Bessenyei, 2008). This brought a learner profile that can reach out the excessive amount of data on his own and every try of reaching sources online (making connections) has the potential to teach the learner.

Behaviorism, cognitivism and constructivism are the most frequently used learning theories in the creation of learning environments (see Table-1 for a short comparison of them including connectivism principles). However, these theories were developed in times when learning was not influenced by technology (at least as much as it is today). In the last two decades, technology has changed how we live, communicate and learn. Learning needs and theories defining learning processes and principles should reflect the underlying conditions of the social environment of the current situation (Khatibi & Fouladchang, 2015). The thought that guides the connectivism theory is that decisions are made on constantly changing foundations (Yi, Lei, & Jian, 2014). Therefore, the ability to discern and choose what is important becomes necessary. Likewise, the ability to realize when new information will change old ones, reorient information and rebuild learning comes to the fore (Loureiro & Bettencourt, 2010).

Table-1 Comparison of Learning Theories (Balcescu & Bârsan, 2015)

Questions	Behaviorism	Cognitivism	Constructivism	Connectivism
How does learning take place?	Black box - main focus on observable behavior	Structured, computer logic	Social, meaning created by each individual	Distributed within a network, supported by technology, recognizing structures
Which factors affect learning?	Reward, punishment and stimulus	Current knowledge, previous experience	Participation, social, cultural	Diversity in the network
What is the role of memory?	Hardware where repetitive experiences are mostly retained rewards and punishments	Coding, storing, recalling,	Mixing prior knowledge with current context	Adaptive structures, representation of the current situation, existing in networks
How does the transfer take place?	Stimulant, response	Developing the knowledge structures of the "knowing" person	Social, complex	Complex learning, rapid change, diversified sources of information

The availability of online Web 2.0 materials and resources is assumed to improve learning. One of its most important advantages is that it allows learners to easily follow their own progress. Moreover, peer feedback and collaboration have increased significantly with the use of Web 2.0 technology. These elements are thought to contribute to learner participation and self-regulation, so learners are more actively involved in the process in a way that increases motivation and ultimately performance. Social media, especially online cloud-based social platforms such as Facebook and Google+, are closely associated with the use of Web 2.0 technology in education. Researchers and lecturers have created online application communities using Web 2.0 technology to increase learner performance. Doolan emphasizes the importance of social context in learning by defining it as one of the basic elements of learning. By adding a social element to learning, active learning and therefore learner participation, learners' interaction with each other, with the teacher and with learning resources are promoted. Therefore, learning is within social activities, culture and context through the creation of meaning through dialogues (Conradie, 2014). The importance of social communication increases the impact of learning within the digital age. In the digital world, the effects of being a digital citizen are important in research matters. The digital age and computer-based communication have enabled a rethinking of collaborative learning and experience-based learning. In this context, the use of social networks is within the scope of connective learning theory in terms of bringing together many factors such as awareness, asking and critical looking in creating groups for dialogue development (Aksal, Gazi, & Bahçelerli, 2013).

Connectivism is a learning theory that can be applied to corporate e-learning management. Networks, multiple data sources, knowledge sharing, critical decision making, and virtual learning communities are central concepts in connectivism theory. Within the scope of Connectivism, the application of e-learning program supports critical thinking and problem solving, and activities that support and direct large amounts of information (Ghofrani & Hollister, 2011). Connectivism or distributed learning is a more appropriate theory for the technology age, where action can be taken using information from external sources before learning occurs (Mattar, 2010).
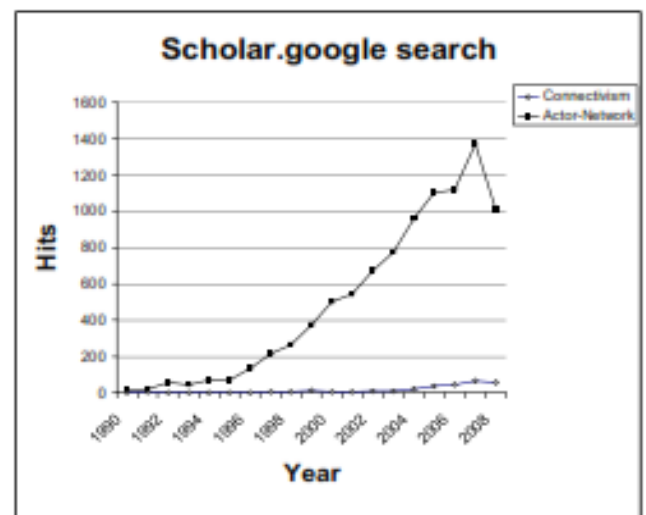

Figure-2 Hits on Connectivism in Google Search

Connectivism is the latest emerging among the distance education pedagogies. Its popularity gradually increased in the 2000s (check Figure-2) (Bell, 2010). Canadian George Siemens (Siemens, 2005a, 2005b, 2007) and Stephen Downes (2007) have written papers describing this approach and explaining learning as creating networks between knowledge, relationships and resources and applying them to real problems. Connectivism emerged in an information age surrounded by networks (Castells, 1996) and is based on access to networked technologies from anywhere. In this approach, learning focuses on making up-to-date and flexible connections that can be applied to existing and emerging problems. In the understanding of connectivism, knowledge is unlimited and the role of the learner is not to memorize or understand everything but to have the capacity to access and apply information when and where it is necessary. A large part of cognitive processes and problem solving can and should be

left to machines, which is expressed by Siemens (2005) as "learning can also occur in non-human beings" (Anderson & Dron, 2011). Siemens explained the principles of connectivism as follows (Siemens, 2004): i) learning and knowledge lies in a variety of ideas; ii) learning is the process of making connections between specific circuits and sources of information; iii) learning can be found in non-human devices; iv) the capacity to know more is more important than what is currently known; v) building and maintaining connections is essential for continuous learning; vi) seeing connections between fields, concepts and ideas is an essential skill; vii) current and accurate information is the underlying element of all connectivist learning activities; viii) decision making is a learning process in itself. Deciding what to learn and the meaning of the information is part of the learning process. Rooting these principles, Al-Shehri explained what connectivism means and how it can be applied for mobile learning as shown in Table-2:

Table-2 Connectivist Principles in Mobile Learning

Principles of Connectivism	Meaning	Guide
1. Learning and knowledge comes from a variety of ideas	• Students come with different backgrounds. • Students are already connected to different networks.	• Students should be encouraged to discuss and exchange ideas over networks. • The background of the students, the variety of content and uploaded materials should be highlighted in the discussions. • Different data sources such as other networks used by students, Wikipedia, websites, online or offline dictionaries should be used.
2. The capacity to know more is more important than what is already known	• Students should be familiar with the best tools and resources associated with the required knowledge.	• Social networks and social media alone are not good enough sources of information. • Social networks and mobile phone access should provide better access to different sources of information.
3. Learning can also come from non-human factors.	• Students should try to reach information from sources other than teachers in order to reveal student-centeredness. • Students should understand their role as knowledge producers. • Learning occurs inside and outside the classroom.	• Content is the main source of information; the lesson and the teacher are there to trigger learning. • Social networks and mobile phones are tools to connect with content and process information with other members of the group. • The teacher is a member of the network who can help others and even learn from them.
4. Establishing and maintaining connections is essential to stimulate learning.	• Students need external networks and connections with the same interests.	• Students are supported in communicating with people outside the network for further learning. • Internal links or group members are the main sources of information. • External sources are additional sources of information.
5. Knowledge is constantly increasing and changing. Therefore, students should abandon old and unnecessary information and learn new and important information.	• Conceptual knowledge constantly changes and differs according to time and place.	• Information about the context students are in should be constantly updated. • Students should cooperate in identifying current and outdated and / or relevant and unrelated information. • Students should distinguish between program and contextual information in a pragmatic fashion.
6. Any information in the database should be linked to the right people to the right extent.	• Students should determine which resource is suitable. • Students should have the skills to organize information according to its importance.	• The teacher is not the only source of guidance / information; students / scope can provide much more valuable information on its own. • Social networks such as Facebook should help students organize information and make it easier to categorize different sources. • Pragmatism in classification: students should be able to distinguish between relevant and unrelated information. • Mobile social networks should be linked to other networks in order to identify and utilize original / contextual sources of information.

In connectivism, network refers to a series of circuits connected by relationships. Hence, networks consist of circuits that are interconnected in one or more ways. In the example in Figure-1, the network consists of four circuits (A, B, C and D) and a connection. The transferor intent is everything that can be contacted by himself. Connectivism defines three types of circuits: neural, conceptual and extrinsic. At the conceptual level, the network includes concepts such as similarity and positive relationship connected by conceptual connections, ideas and thoughts. On the external level, the network consists of people, books, websites, programs or databases connected by the Internet, intranet or direct contact (AlDahdouh, Osório, & Caires, 2015). According to this theory, the starting point of learning is the state in which knowledge is activated by connecting and participating in a learning community. Learning communities are defined as clusters with similar interests that allow interaction, sharing, dialogue and thinking together (Siemens 2005). As a result of participation, communication occurs between learners and more knowledgeable members of the community. This communication in the web 2.0 environment includes not only words but also images such as video and multimedia. With advances in technology such as Web 2.0 and 3.0, learners can create personal learning environments, which means that learning resources are not only consumed but also produced by learners (Gerard & Goldie, 2016). The concept of personal learning environment is not really new; according to Wikipedia, it first appeared in the 1970s. However, it has been reinvented and consolidated with the advent of Web 2.0 technology, also called social networking, which allows users to control their online presence. Personal learning environments are explained as in Figure-3. Accordingly, personal learning environments consist of a combination of content and interaction. While communication channels and cloud resources create information and content; Internet applications and social media memberships also provide contacts and services with individuals (Gillet, 2013).
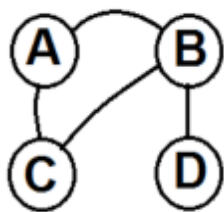

Figure-3 Network and Node in Connectivism

The underlying idea of connectivism is that learners connect to a learning community and provide them with information while learning from this community. The learning community is a group of people who constantly communicate and learn together because of their similar interests. The community is seen as one of the nodes in a wider network. Different but interconnected networks support independent, diverse and creative knowledge development. Information is constantly changing and it is necessary to constantly check its validity and reliability through new information. There is an interdisciplinary link in the information production process in the internet environment (Boitshwarelo, 2011).

Connectivism has emerged from the fact that advances in technology, especially in the way of reaching information quickly and widely via the Internet, have made the ideas of existing philosophies outdated. These theories do not explain learning that develops outside of humans (for example, learning driven and driven by technology). Siemens stated that, due to the speed of the digitalizing world, the facts that make up the information are constantly being rewritten and updated. The main idea of the theory is not to acquire or develop knowledge, but to find it in a system or organization when it is needed - to determine whether it is still valid or acceptable - and to recognize the links in meta-information (Brill, 2008).

Connectivism has been conceived as an approach to information literacy and accepted as a more relevant learning theory than more traditional theories such as constructivism because of its emphasis on thinking of information in a networked society (Brooks, 2015). As a theory, Connectivism is based on autonomy and diversity in networks and assumes that the community achieves learning through the interaction of different perspectives. The term connectivism can be explained as a form of knowledge and pedagogy that knowledge is dispersed across connections in a network and learning lies in the ability to establish and pass through these networks. Encouraging participants to make their own choices about what they read helps them gain a unique perspective that they can bring to dialogue (Downes, 2008). Connectivism is explained as a reflection of the ever-changing society. Societies are getting more complex; socially connected; it has been globalized and is being replaced by continuous advances in technology. Combining complex ideas in harmony, it is connected to a network to create certain sets of information. The different ways to know are due to the variety of ideas. The individual has no control; rather, there is a collaboration of ideas already owned when viewed from the present reality. The basic skill is to see the connections between sources of information and to maintain these connections in a way that enables continuous learning. Continuous updating and displacement of information can occur outside of the learner, for example in a database or other special information sources. It is more important for the learner to be in contact with this external information than the current state of knowing. Connectivism's primary focus is on the individual. Personal knowledge includes a system that includes an organization and consists of networks. The individual continues the cycle of knowledge development by entering and exiting the system (Duke, Harper, & Johnston, 2013). According to the Connectivist theory, learning occurs when learners make connections between ideas found in personal learning networks made up of numerous sources of information and technology. Knowing occurs when the learner becomes aware of the connections between the concepts, ideas and perspectives that he reaches through Internet technologies such as electronic databases, internet search engines and online information resources. Therefore, connectivism sees networked information technologies as an important element of the learning process (Dunaway, 2011) and Foroughi (2015) explains how Web 3.0 tools that are currently in use in nearly all levels of education is indeed related to connectivist principles (see Table-3).

Table-3 Web 3.0 and Higher Education within Connectivist Principles

Web 3.0 Technologies Used in E-learning	Basic Principles of Connectivism
Social networks of meanings, openness and interpersonal operability	Learning and knowing lie in a variety of ideas.
Big data or global data storages, connected data, cloud computers, extended smart mobile technologies	Learning is the process of relating specific circuit and information resources. Information validity is important.
Machine learning, artificial intelligence, personal avatars, 3D visualizations and interactivity	Learning can be found in non-human tools.
Networks, control of information	The capacity to know more is more important than how much is already known.
Networks of meanings, collaborative intelligent filtering	Seeing the relationships between domains, ideas and concepts is essential.
Networks of meaning, collaborative intelligent filtering	It is necessary to establish and maintain connections to ensure continuous learning.
Webs of meanings, intelligent filtering	Decision making itself is a learning process. Deciding what to learn and the meaning of the incoming information are situations that need to be viewed from the perspective of constant change. Although it is a correct answer now, it may be wrong due to future changes in the information environment that affect the decision.

Connectivism theory is still under development and has been criticized by some for having uncertain aspects as a learning method. However, the evolving profile of social network learning in both formal and non-formal learning situations cannot be easily ignored. The main challenge for educators is to use social networks for classroom participation while maintaining coherence (Jennings & Weatherly, 2013). There are also other criticisms of this theory. Verhagen (2006) criticizes this theory for staying at the level of an educational program rather than the level of an educational institution and states that it is not a learning theory. Therefore, for him, connectivism is a pedagogy rather than a learning theory. Kerr (2007) also supports this criticism and explains the situation as something interesting, but not at the level of a learning theory. Moreover, Kerr states that problems arise in this theory when it comes to things that cannot be learned randomly, such as reading and writing. According to another criticism, connectivism is incompatible with other theories, unlike other theories, and it can even be thought to reject other learning theories (Al-Shehri, 2011). Despite the criticisms made, the concept of connectivism seems to be suitable for the learning approach in the digital age (cited in Garcia, Brown, & Elbeltagi, 2013).

III. CONCLUSION

The age of modern technology forces education, which includes both social and daily life, to radical changes. The role of the school as a social environment and learning environment, stuck in limited space and time, takes a new shape with approaches independent of time and place such as online education environments and courses / lessons. Both formal and non-formal education can be provided to more people under more favorable conditions with the facilities offered by the internet and computers. Therefore, there is no argument as to whether education benefits from technology or not. What needs to be discussed now is how the technological possibilities and limitations should be arranged in accordance with the education. The idea of connectivism was put forward by Siemens (2005) for this purpose. The solution of the

problems that arise or may arise in education-technology integration and the pedagogical approach required to understand this phenomenon have been tried to be described. According to this theory, the accumulation of the knowledge that constantly evolves and changes as it develops can be stored in resources such as online databases rather than individuals' minds and individuals reach this information when they need it using mobile technologies. With a pragmatic point of view, he / she can distinguish between needed and unnecessary information and solve problems using the information he / she reaches. Moreover, the interactions s/he establishes in the internet environment will provide opportunities to learn and teach others what s/he knows. As constructivism, which emphasizes the individual's making sense of information on his own and social constructivism which defends the idea that the individual is actually a social entity, thus reveals the meaning in a social environment and in interaction with other individuals lack the role of technology in education, connectivism has incorporated this new variable into the work with a more contemporary approach. Today, the individual has become unthinkable independent of the technological existence he has, so it is necessary to consider the individual together with this opportunity in education. Connectivism, which can be thought to combine social constructivism with technological pedagogy, also gains importance at this point. It is natural that the studies on connectivism, which is very young as a learning theory, have been mainly carried out in a qualitative design and with a literature review, because learning theories should be sufficiently supported by theoretical knowledge. It is natural that there are still gaps regarding connectivism in the literature, but this problem will disappear as the studies increase. Currently, the number of studies on learning processes in accordance with connectivism understanding is quite limited in the literature. As it will take time to fully establish the theoretical infrastructure, the reflections in practice will be limited and will remain open to criticism to a great extent.

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