The Theory of Connectivism: Can It Explain and Guide Learning in the Digital Age?

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Educators are scrambling to address the impact of advanced web technologies on learning and to determine a theory to explain and guide teaching and learning as the digital age evolves. This paper maps the theory of connectivism to the predicted impacts of Web 3.0 on education and explores its relevance.

INTRODUCTION

Since the 1990s, computers have been used to facilitate learning, and today, universities around the world are racing to offer distance education courses and other computer-supported learning aids to increasingly "wired" students. Internet technology has been integrated into learning in higher education, even in face-to-face classroom environments. Web 2.0 tools like Wikis, Facebook, blogs, tagging, LinkedIn, virtual reality, social bookmarking, mashing, rss, podcasts, folksonomies, ePortfolios, chatrooms, and similar technologies are now widely used as part of course work, and have become the norm. Furthermore, today's "digital natives," for whom the Internet, cell phones, and social media have always been an integral part of life, have different expectations about how, where, and when learning can take place (Brown, 2000; Prensky, 2001; Roberts, 2005; Thompson, 2008).

Change is fast and ubiquitous in the digital age, and further technological advances will soon make Web 3.0 semantic web technologies available that promise to revolutionize learning and knowledge management. Serious consideration is needed of a pedagogical paradigm for teaching and ensuring learning in this fast-moving technological environment (Downes, 2006; Siemens, 2005b; Brown & Adler, 2008; Cormier, 2008).

This paper presents the theory of connectivism as a potential guide for teaching and learning as the digital age evolves. These principles are then put side-to-side with the changes in education that are predicted with Web 3.0. Finally, concerns about Web 3.0 are presented, as are questions about the impact of Web 3.0 on teaching and learning in higher education, and connectivist teaching practices.

THEORIES OF LEARNING FOR WEB 1.0 AND WEB 2.0

As new technologies have expanded the horizons of teaching and learning over the past 40-50 years, educators have proposed theories to both describe and guide these new learning environments. In the era of Web 1.0, teachers posted coursework online for students to complete, but the impact on learning in the traditional classroom setting was minimum. The theories of behaviorism and cognitivism were used to explain how learning occurs. Behaviorism (Watson, 1928; Thorndike, 1932; Skinner, 1976) emphasizes

the importance of changes in observable behavior as evidence of learning, considering internal thoughts (the black box) to be of lesser importance, since it is impossible to understand them. Cognitivism views learning as the input of information into short term memory, where it is coded for future recall--a sort of input-output process (Miller, 1956; Mayer, 2001; Miller, 2003). In both of these theories, students are seen as passive recipients of knowledge.

With Web 2.0, students gained the ability to create and share information and to collaborate online, anytime and anywhere. While both behaviorism and cognivitism had viewed knowledge as something external from the learner which the learner must internalize, a new learning paradigm was developed to describe this new, expanded learning universe—constructivism (Vygotsky, 1980; Dewey, 1910; Garrison, 1997; Kanuka & Anderson, 1999; Driscoll, 2000; Garrison 2000). According to constructivism, learners themselves actively and often proactively create knowledge themselves, based on interaction with the world and with other learners (Driscoll, 2000; Downes, 2005; Alexander, 2006; Anderson, 2007). Web 2.0 tools enable learners to seek, create, and share knowledge in any setting, at any time. The constructivist view challenged the concept of knowledge as a finite body of information that could be transferred from instructor to student, and identified an active and proactive role for learners.

OVERVIEW OF WEB 3.0

As will be demonstrated in this section, Web 3.0 represents a quantum leap forward from Web 2.0 that will impact knowledge acquisition and management. While Web 2.0 focuses on the front-end aspects of the Internet and its ability to bring people together and to share knowledge, (Naik & Shvalingaiah, 2008), Web 3.0 will concentrate on upgrading the back-end, by maximizing communication and interoperability between and among web sites and electronic devices, so that computers themselves will have the capability of searching for, organizing, and finding connections among pieces of information (Strickland, 2008). Web 3.0 will not replace Web 2.0; indeed, the social aspects of Web 2.0 will still play an important role, and information on blogs, social networks, and wikiis will be made more accessible by smart Web 3.0 browsers. The increasing connectivity of information provided by devices and other objects that are part of daily life is evolving into to what has been called the "Internet of Everything" (Evans, 2012).

The following are the key elements in Web 3.0 Technology:

Information Tagging

Today's web browsers have only limited capacity for discovering connections among pieces of information that might be useful or valuable for users (Ohler, 2008; Spalding, 2014). A standard Google search yields hundreds of results, many of which are either irrelevant or marginally relevant to user needs. HTML, the language used to create the vast majority of current web pages, was designed for simplicity with a fixed set of tags that provide a word-to-word translation of a search key word. Broken links, a fixed set of tags, formatting constraints, and inefficient search results are limitations of HTML (Ohler, 2008).

With Web 3.0, web site developers will use international World Wide Web Consortium Standards to create structured online content, using tags or fields with descriptors like "last name" or "fax number" that enable a web browser to identify, understand the meaning of and integrate information on web sites more readily (MacManus, 2009; 4imprint.com, 2010). This will require the translation of billions of bits of online information into micro contents that enable more accurate searches in which smart search engines can recognize and avoid the confusion presented by linguistics issues like homonyms and synonyms (Naik & Shivalingaiah, 2008).

Web 3.0 will use languages specifically designed for data, such as Resource Description Framework (RDF) and Extensible Markup Language (XML) (4imprint, 2010; Spalding, 2014). While HTML can describe documents and the links between them, RDF and XML Web 3.0 languages provide coding to data within documents and link them to data from other databases or web sites, so that they can be read and understood by computer applications. Content managers will use machine-readable "metadata"

descriptions that add meaning to web site content and describe the structure of existing knowledge about it, making it possible for a computer to process knowledge using human-like deductive reasoning and inference. Because of the emphasis on computers being able to understand the meaning behind text in web content, Web 3.0 is often referred to as the semantic web.

As a result, Internet content will be efficiently searchable, interconnected, and retrievable (4imprint.com, 2010). Keats & Schmidt (2007) write that Web 3.0 represents the return of experts and authorities to the web, because of the monumental task of determining and applying semantic standards to all Internet content. For this reason, Web 3.0 is not expected to be functional until 2020 (Bikakis et al., 2013).

Ontologies

The tagging of information described earlier will enable the use of ontology inference rules and data organizational tools to provide logic and structure that can discover meaning and synthesize information on web pages and create ontologies—domains of pre-organized knowledge on different topics that can be updated on an ongoing basis (Ohler, 2008; Devedzic, 2006; Ghaleb et al., 2006; Yu, 2007; Verizon, 2010). An ontology describes the concepts and relationships in a particular knowledge domain, including the associated vocabulary and computerized specifications for the meaning of terms used in the vocabulary (Ohler, 2008).

Web 3.0 will have natural language search capabilities that enable users to ask a complete question, rather than using noun phrases in isolation. Currently, users often must work hard to crystallize their search entries into what has been called "keywordese" (4imprint.com, 2010, p. 4) in order to obtain relevant results. Web 3.0 search engines will be able to interpret and process complete sentences. Barney Pell, President of Powerset, Marketing and Web 3.0 remarked that "Search engines…train us to become good keyword searchers. We dumb down our intelligence so that it will be natural for the computer. The big shift…is that instead of moving human expressions and interactions into what's easy for the computer, we'll move computers' abilities to handle expressions that are natural for the human" (4imprint.com, 2010, p. 4). "Common definitions, inference rules, and ontologies will turn the web from a series of information containers into an ecosystem in which the parts of the web are interrelated" (Ohler, 2008, p. 8). Ontologies will increase interoperability between various systems, languages, and formats, providing a common ground for understanding, conceptualization, representation and interpretation of domain concepts, and are subject to change and evolution (Stojanovic et al., 2003).

A DIFFERENT THEORY FOR LEARNING IN WEB 3.0

The impact of Web 2.0 on learning was significant and represented a major change from the traditional teacher-student relationship to a student-centered learning environment. As Internet technology continues to evolve, so does the nature of learning in the digital age.

Now, as educators consider how to use the semantic web technologies of Web 3, it has been argued that the evolving technology-driven environment of learning requires a new paradigm to explain the impact on learning of these advanced technologies. Such a paradigm must take into account several realities of learning and knowledge acquisition in the digital age:

- The fluidity of knowledge: The half-life of current knowledge, or time between when a piece of knowledge is introduced and when it becomes obsolete, is becoming increasingly short (Gonzalez, 2004).
- The world's knowledge has doubled in the past decade and now doubles about every 18 months. Internet content has grown and evolved with input from individual people, businesses, and organizations all around the world. The amount of information globally is so huge that it has surpassed the capacity of people and organizations to process or evaluate it (University of California at Berkeley, 2003; Arroyo & Dicheva, 2004; Gantz, 2007).
- Open sources of information are now made available on the Internet by universities and research facilities (Bell, 2011; Kop, 2011). The relationship and interplay between the individual's

knowledge and that of the organization (i.e., the institution of higher learning) needs to be explored and clarified. (Brown & Adler, 2008). Universities no longer control knowledge, as students can access information anytime, anywhere and do not have to rely on the university library, instructors, or even textbooks to access knowledge related to their coursework (Kop, 2011).

- Today's students can expect to change jobs or even professions up to six times during their lifetimes—thus the importance of lifelong learning (Siemens, 2006) and of creating and maintaining the connections, personal, professional, and knowledge connections that are needed to remain current (Pettenati & Cigognini, 2008; Kesim, 2008).
- Formal education now represents only a fraction of the learning in which any one individual engages. Informal learning occurs throughout the day via networks of colleagues, personal relationships, and multi-media (Bell, 2011). Vaill (1996) said, "learning must be a way of being—an ongoing set of attitudes and actions by individuals and groups that they employ to try to keep abreast of the surprising, novel, messy, obtrusive, recurring events" (p. 42). "As more and more learning activities go online and beyond the garden walls of VLEs [universities' virtual learning environments], we can see them escaping the classroom" (Bell, 2011, p.100).
- Technology has changed the way we approach learning and reshaped and extended the horizons of what is perceived as possible (Brown & Adler, 2008; Bessenyei, 2008; Bell, 2009). Cognitive information processing, which was once thought to occur only in the learner, can now be performed by and/or supported by, computer technology. In *Smart Machines* (Kelly & Hamm, 2013) John E. Kelly III, director of IBM Research, and Steve Hamm discuss computer systems with cognitive abilities that will help businesses and government deal with the vast amount and complexity of data.
- Skills like knowing how to do something or the possession of factual knowledge are diminishing in importance in comparison to expertise in finding needed knowledge. (Siemens, 2003). Since knowledge is fluid and increasing in quantity success depends on expertise in seeking and evaluating new information from multiple sources and media.

Connectivism (Siemens, 2003; Siemens, 2005a; Siemens, 2008) has been proposed as a more useful and appropriate guide for learning in the ever evolving digital age. The following are the major principles of connectivism (Siemens, 2003), which integrate concepts from network (Illich, 1971; Barabarsi, 2002), chaos (Gleick, 1987; *Science Week*, 2004), complexity (Morrison, 2006; Mason, 2008), and self-organization theories (Rocha, 1998; Wiley & Edwards, 2002):

- Learning and knowledge rest in diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in non-human appliances.
- The capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning.
- The ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.
- Decision making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate that impacts the decision.

Hussain (2013) developed the following table (Table 1) to suggest how the connectivist principles outlined by Siemens are compatible with and can be used in tandem with Web 3.0 technologies.

TABLE 1
WEB 3.0 AND HIGHER EDUCATION

Web 3.0 Technologies Used in eLearning	Basic Principles of Connectivism
Social semantic networks, openness, and interoperability	Learning and knowledge rests in diversity of opinion.
Big data or global data repository, linked data, cloud computing, extended smart mobile technology	Learning is a process of connecting specialized nodes or information sources. Currency of knowledge is important.
Machine learning, artificial intelligence, personal avatars, 3D visualization and interaction	Learning may reside in non-human appliances.
Semantic web, control of information	The capacity to know more is more critical than what is currently known
Semantic web, collaborative intelligent filtering	The ability to see connections between fields, ideas, and concepts is a core skill.
Semantic web, collaborative intelligent filtering	Nurturing and maintaining connections is needed to facilitate continual learning
Semantic web, intelligent filtering	Decision making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.

The following paragraphs present ideas proposed for ways in which Web 3.0 technology can be used to implement each of the principles of connectivism:

Learning and knowledge rest in diversity of opinions.
Web 3.0 smart engines will search, organize, and present reports that include diverse sources and multi-media elements and present them to the learner. Reports will be multimedia and drawn from many sources—web sites, scientific repository articles, textbooks, blogs, YouTube videos, cell phone stored information, virtual reality content (Ohler, 2008). Web 3.0 reports will also compare and contrast the information presented, and allude to different arguments, as well as alerting the user to related topics, books, and lectures/events local that relate to the topic.

Head & Eisenberg (2010) write that students become frustrated with Internet searches, because they often yield unrelated information, and students feel that they can never do a search that is exhaustive enough. The customized search capabilities that will be possible with Web 3.0 will yield only information that fits criteria specified in advance by the user. Students will also be able to access bodies of knowledge on various topics for which ontologies have been created that include relevant information from diverse web sites and media types (Green, 2011; Devedzi, 2006; Reynard, 2010). Smart search engines will use linked data to provide a search report that can include lecture notes, resources, videos, journal article, blogs, television programs, and social networking content (Ohler, 2008; Loureiro & Barbas, 2012).

The availability of open source software and code will enable any user, including students, to develop web pages in which linked content is accessible to Web 3.0 smart searches. Open Graph protocol will enable people to "mark up web pages with RDF, to make information on a web page more searchable (The Open Graph Protocol, 2010). UNESCO's Open Education Resources, adopted in 2002, aims to engage educators and researchers in the development of resources that are available globally (UNESCO 2002; UNESCO, 2007).

Learning is a process of connecting specialized nodes or information sources.

Web 3.0 will also provide users links to relevant multimedia information, such as virtual worlds, augmented reality, and 3-D environments (Green, 2011; Ingle, 2012). Second Life, for instance, facilitates real-time collaboration and interaction in a virtual environment (Ellis & Anderson, 2011; Ferguson, 2011; Dalgarno & Lee, 2012). Augmented reality overlays computer-generated materials onto real-life objects to enhance real world experience of them (Yuen et al., 2011; Zhou et al., 2008; Gerstein, 2013; Spalding, 2014). Students will be able to create their own Personal learning Environments, which will use smart browsers that seek knowledge that relates to their interests (Wheeler, 2009).

Connectivist learning has been described as rhizomatic, because of the absence of linearity and "start to finish" nature of this type of learning Cormier (2008). A rhizome is a plant that sends out roots and shoots from its many nodes in multiple directions, in contrast to a tree, which has a root system that grows linearly and in a hierarchical fashion, from beginning to end (Deleuze & Guattari, 1980). Web 3.0 will enable students to pursue a limitless number of new sources of information and make connections with experts in the field of interest, as well as peers who are exploring this topic.

Learning may reside in non-human appliances.

Personal learning agents will search for information related to a learning goal and will only report relevant information (Ohler, 2008). The semantic web will be a focused information resource that can be tailored for specific content area objectives. Location-based services can sense a user's location and send appropriate information that is useful to the user in this location.

Virtual worlds and augmented reality will provide new dimensions to learning content that may improve student learning, and will enable students to study at their own pace (Mayer, 2001; Carmigniani et al, 2010; Yuen, et al 2011; Chen et al., 2011;). Virtual reality and 3D games will enable students to visit realistically portrayed simulations of places in time (an historic period) and space (an inaccessible geographic location) to which they otherwise do not have access (Chisega-Negrila, 2013). Bidarra & Cardosa (2007) write that the use of virtual reality in education enables students to visit places/times/scenarios that are not otherwise accessible, reduces stereotypical thinking by encouraging role playing of different societal roles, promotes collaboration, and enables assessment through project-based learning.

Web 3.0 will make more use of artificial intelligence to enable programs and applications to become capable of understanding higher logic and reasoning, and making decisions in a more effective manner. These programs will be self-learning, which means that they can learn and evolve on their own, by r tracking habits of users and then, providing search results that suit their preferences.

The number of everyday devices that will be connected to the Internet will increase to include sensor-equipped and networked devices such as energy-using household appliances, office equipment, web-enabled printers, vehicles, and even natural objects like trees and crops for scientific analysis. Connectivity will be provided by IPv6, the Internet protocol that provides an addressing schema and IP-based platform that will connect devices and components and enable user searches access to data and information on a wide number of devices (Evans, 2012). When Web 3.0 makes knowledge accessible to software tools, they will be able to understand, think, and create knowledge, becoming in a word, intelligent devices (Spivak, 2007). The ability able to glean information from a number of devices and media types has led to Web 3.0's being referred to as "The Internet of Everything" (Evans, 2012).

Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality in which what is true today may not be tomorrow. The capacity to know more and remain current is more critical than what is currently known.

An answer or conclusion that is correct today may not be tomorrow, because the underlying information has changed. This explains why, in the digital world, learners must know how to seek information, on an ongoing basis, that explains and enriches their knowledge. Knowing more than is known now reflects the lightening-fast evolution of knowledge and the importance of keeping up with it (Wesch, 2009). Students can set up a cell phone to beep whenever new information on a topic of interest

becomes available. Reports will update themselves as new information is available, giving students more time to absorb, think, and participate (Bradford, 2008). Students will, thus, have access to real-time information.

The ability to see connections between fields, ideas, and concepts is a core skill.

Students will spend less time gathering and integrating knowledge and more time on higher level thinking--synthesizing information, constructing new knowledge, and applying what they learn (Ohler, 2008; Reynard, 2010). They will be able to learn anywhere and anytime if they have access to the Internet through mobile devices; and will acquire knowledge and distinguish between facts and fiction through interactions with one another, rather than from a teacher. (Bell, 2011).

Keats & Schmidt (2007) give the following description of education in the Web 3.0 world: "Education 3.0 is characterized by rich, cross-institutional, cross-cultural educational opportunities within which learners themselves play a key role as creators of knowledge artifacts that are shared, and where social networking and social benefit outside the immediate scope of activity play a strong role. The distinction between artifacts, people, and process becomes blurred, as do distinctions of space and time" (p. 2).

Nurturing and maintaining connections is needed to facilitate continual learning.

Wikis, Facebook, blogs, tagging, LinkedIn, virtual reality, social bookmarking, mashing, rss, podcasts, folksonomies, ePortfolios, chatrooms, and similar technologies that are considered Web 2.0 will remain important and will play a key role in Web 3.0.

Each Web 3.0 user will be able to enter his/her preferences and interests, and the computer will customize and provide information for him/her that fits these criteria. Each user can, in effect, have a personal profile, called an Open ID (Pablo's Blog, 2009), which will guide the browser as it searches for relevant information. User profiles will function like a virtual avatar that represents them and their interests online. PLE (personal learning environments) will help students interact with diverse systems, tools, and services to access content and collaborate with others. Students will have more control over their learning experience (Buchem, et al., 2011). The control of knowledge and knowledge management will move from the university to the student, as students can access information anytime, anywhere and don't have to rely so much on obtaining knowledge from the institution, i.e., via instructors.

THE ROLE OF EDUCATORS IN WEB 3.0/CONNECTIVIST ENVIRONMENTS

Educators have proposed several different roles for teachers in the technologically-wired classroom of today. Brown (2006) suggests that a connectivist classroom be like an atelier, an open space in which students pursue their work, with opportunities for the instructor to make suggestions from which all of the students can benefit. The teacher would provide expertise and guidance to students, but would not direct their learning. Bonk (2007) suggests that a teacher be like a concierge, directing learners to resources or connections they might not have considered in exploring the topic of a course. Siemens (2008) proposes that teachers should be both sources of expertise in their field and creators of learning resources, as well as guides for students as students pursue connections that will help them develop expertise in the concepts of a particular domain. Ruiz sees the role of the Web 3.0 instructor as a mentor or facilitator, "…establishing social media sites or immersive learning environments; monitoring communication and interactions within the sites/environments; and guiding learning (as themselves or as an avatar within a virtual environment) by posing questions and providing directions or information that provides action/investigation, thought, and collaboration" (Ruiz, 2014, p. 1).

All of these educational theorists would agree that, instead of handing students a syllabus that defines the content covered in the course and assessing students on this pre-defined knowledge piece, the Web 3.0/connectivist teacher would suggest an idea and then guide students to search for diverse takes on the same idea, using multi-media and multiple sources; share the new connections they made and what they learned from them with other learners and the teacher; and create knowledge content that can be reused

by others. Instead of putting limits on what students should learn in the course, the possibilities for learning are expanded and limitless. The next group of students who take the course can then build on what the first group produced (Dron, 2006). In such an environment, learners also teach teachers and each other, in an evolving learning environment (Siemens, 2008).

To create an effective Web 3.0/connectivist learning environment, instructors should use a variety of pedagogical methods that facilitate the following: self-expression (blog, journal), debate and dialogue (listserv, discussion forum, open meetings), search of archived knowledge (portal or web site), learning in a structured manner (course, tutorials, when appropriate), and communicating new information about the topic area (news, research) (Siemens, 2005a; Siemens, 2008). Smart Web 3.0 digital agents for teachers will communicate with students' agents, track student progress, provide lists of resources, and assisting in scheduling.

Several critical strategies have been suggested for preparing teachers and students for Web 3.0/connectivism—become fluent in expressing oneself appropriately in various settings and multitasking; build on the knowledge of the past; create and collaborate; conceive of work and play as seamless (Armstrong, 2009); and develop digital literacy skills, including critical discrimination and management of online information (Ingle, 2012).

CONCERNS ABOUT WEB 3.0 AND CONNECTIVISM

Despite the excitement around the benefits of Web 3.0 and connectivism, concerns and doubts remain. The following discussion covers issues related to Web 3.0 technology itself that need to be resolved. Following this, concerns about specific impacts on student learning and the feasibility of connectivism are discussed.

Disagreement Regarding How to Create the Semantic Web

Decisions must be made about who will decide which information is tagged (MacManus, 2009), and who will perform the tremendous amount of coding necessary to achieve Web 3.0. Insights into human nature point to the likelihood that developer bias and perspective will impact information tagging. Even subtle tweaks could eliminate some relevant information and/or include other information that is important according to a particular developer (Ohler, 2008). Individual users who upload content may not use standard content protocols. If their content is not coded, it may not be picked up by Web 3.0 browsers and thus may not become part of the content knowledge of a specific subject area. Another challenge is that of devising ways for knowledge to be described in ways that are useful for interactions with diverse systems by smart computer search engines as well as for human-to-human interaction (Anderson & Whitelock, 2004).

Furthermore, Web 3.0 developers and educators around the world are creating knowledge in their own languages, so semantic web software systems will need to have the capability of performing text translations, understanding the nuances of concepts in different cultures, and incorporating evolutions in language use over time (Anderson & Whitelock, 2004; Wheeler, 2009; Montiel-Ponsoda, 2011). The global nature of the Internet, differences in privacy laws in countries around the world, invalid input, and lack of oversight create ethical problems that will have a growing impact and contribute to a lack of control over the quality and accuracy of information posted on the Internet (Weippl & Ebner, 2008); Al-Khatib, 2011; Alves, 2013). User preferences and online behavior can be inaccurately interpreted and used by smart agents to filter their future information needs in directions that users did not intend (Anderson & Whitelock, 2004).

Regarding eLearning systems development, content developers and instructional designers often lack commitment to Web 3.0 or to using XML-based metadata. Familiarity with knowledge engineering technology is required and often lacking (Pahl & Holohan, 2009). Developers of eLearning software, which is used in many universities for distance education courses, are struggling with the issue of data and content exchange among eLearning applications. The necessary interoperability requires semantic conceptualization and ontologies, common standardized communication syntax, and service-based

integration of educational content and deliverance (Brooks et al., 2006; Jovanic et al., 2009; Sampson & Kallonis, 2011).

Impact on Student Learning

Siemens identified the following skills as essential for student success in a digital learning environment (Siemens 2006):

- Stay focused on tasks despite distractions.
- Manage and navigate the flow of knowledge and extract important elements.
- Connect with others through network-building.
- Stay current and informed.,
- Relate at a human level to form social spaces.
- Know how to determine the value of knowledge and ensure validity.
- Be able to recognize patterns and trends.
- Accept uncertainty.
- Be confident, independent, and disciplined in accepting responsibility for participation in online coursework.

Wheeler (2009) questioned if students are prepared to be autonomous learners, as required by Web 3.0/connectivist learning, and whether teachers are ready to transfer so much instructional control to technology—and to students.

Not all learners have enough background in a knowledge domain to be able to pursue a connectivist approach to learning in it (Kop & Hill, 2008; Hall, 2008; McLoughlin & Lee, 2008; Dron & Anderson, 2009). Indeed, Chisega- Negrila (2013) found that students asked about their attitudes toward online learning in general and proposed Web 3.0 learning tools in particular expressed concern about security issues, resistance to change, lack of interest in innovation, lack of access to computer technology, apprehension about relying on virtual assistants and virtual reality environments, distrust of information provided, and a preference for human interaction and personal decision making (Chisega-Negrila, 2013). Another major concern is the diminished teacher/student interaction, structure, and support for students in the learning process (Noll, 2002; Anderson & Whitelock, 2004; Kop, 2011).

Implementations of connectivist methods by Siemens and Downes have begun to provide valuable feedback about connectivism. Since 2008, the two educators have offered massive open online courses (MOOCs), which are open for enrollment and free to students all over the world (Fini, 2009; Mackness et al., 2010; Kop, 2011). Students who participate receive course materials through wikis; forums on Moodle (an Open Source Learning Environment); blogs; Elluminate, an online classroom with video chat and a shared interactive board; UStream.tv, Second Life, and other web resources. All of these channels are integrated daily in a newsletter and aggregated in a course tag. The results of the first MOOC, CCK08, whose topic was Connectivism and Knowledge in a MOOC environment, was studied by two different researchers (Fini, 2009; Mackness et al., 2010). Fini (2009) found that the majority of participants consulted daily summary reports instead of participating in interactive discussion forms and blogs. Students indicated that they had to decide for themselves if they would rely on the daily summary reports or if they were willing to sift through the vast amounts of unfiltered information available. Participants commented that such a course would be difficult for a teacher to run. Fini noted that, even though the course presented ample opportunities to network (2009), students seemed to have preferred a more traditional course.

Mackness et al.'s (2010) conclusions about student experiences in the CCK08 were similar. They wrote that the autonomous, diverse, and open nature of the course, which was expected to benefit learning, lacked the necessary structure, support, and monitoring of student activity that students find in traditional online courses. A number of students felt uncomfortable with the forum format, because some participants engaged in negative "trolling" behavior. For this reason, some students preferred participating in their own blogs and found other like-minded students, with whom they communicated, instead of

interacting with the general student population in the course. Only 14% of the students enrolled participated actively in the course forums and interacted with each other. Many students did not like the degree of autonomy in the course. Their degree of dislike for this aspect of the course depended on their English fluency, expertise with the technologies offered in the course, need for assessment, learning style, and the degree to which they were distracted by the negative "trolling." "Openness, in the sense of open communication and free sharing, can therefore be compromised by lack of clarity about the purpose and nature of the course, lack of moderation in the discussion forums, which would be expected on a traditional course and the constraints…under which participants worked. The more open the course, the more potential for barriers to emerge" (Mackness et al., 2010, p. 272). Similar concerns about the lack of teacher/student interaction and structure have been expressed by numerous other researchers and educators (Noll, 2002; Anderson & Whitelock, 2004; Hall, 2008; McLoughlin & Lee, 2008; Dron & Anderson, 2009; Kop & Hill, 2008; Kop, 2011).

Kop (2011) described a second study of a connectivist MOOC that focused on four challenges to connectivist learning: the need for critical literacies, the presence of power relationships on the Internet, the level of learner autonomy, and the level of social presence. The course was built around the four basic activities in connectivist learning: aggregating information and resources, reflection on them, creation of a digital artifact based on them, and sharing this creation with others. Results of the study pointed to the importance of self-direction, computer literacy, and confidence for learners in this learning context, As reported in Fini's (2009) study, only a minority of students completed the creation stage of learning. Kop concluded that the lack of social presence of the facilitators and other students may have lessened students' confidence in their ability to be successful in the course and to complete the required creation phase. Karsenti's (2013) review of literature about MOOCs came to the same conclusions about student interaction and participation in MOOCs.

As described earlier, Web 3.0 learning tools are still a work in progress. The large enrollment in these MOOCs courses, often 1,000 to 2,000 or more, may have exacerbated the impact of the amount of material generated daily by students, the lack of guidance and supervision from the facilitators, and student unwillingness to participate actively in course forums. These issues would be much less serious in a connectivist course delivered in a standard class of 30-40 students, where students could learn independently, but have the teacher available for necessary guidance. The author also notes an issue related to Web 3.0 that may not be compatible with the principles of connectivism. Students' spending less time gathering and integrating knowledge and more time on higher level thinking have been described as benefits of Web 3.0 (Reynard, 2010; Ohler, 2008). However, one could argue that gathering and integrating knowledge are important steps in the learning process, and that simply presenting students aggregated information that has already been synthesized eliminates the critical thinking, evaluation, and argument building that are crucial in the educational process. Similarly, the introduction of calculators, for instance, was expected to free students from manual computations so they could concentrate on the solution of higher-level mathematical questions. When introduced too soon, calculators can impede the development of basic mathematical skills. Since connectivism emphasizes the importance of students' actively seeking sources of information and making connections among them, Web 3.0 smart engines, which can be asked to gather and analyze information, could actually usurp this valuable part of the learning process.

The idea of connectivism as a theory of learning has also been criticized, and connectivism is considered by some to be more appropriate as a guide for teaching and curriculum (Verhagen, 2006) that helps in the development of new pedagogies in learning situations where control has shifted from the teacher to that of the learner (Kop & Hill, 2008). Others argue that a new theory must replace an older one. As discussed above, both connectivism and Web 3.0 will make use of Web 2.0 tools. For this reason, connectivism is not considered by some to be a replacement for the earlier theory (constructivism), but merely an extension of it. (Fini, 2009; Mackness et al., 2010; Kop, 2011). Mackness et al. (2010) and Bell (2011) argue that connectivism is just a phenomenon; in order for it to be considered a theory, rigorous studies are needed to test its effectiveness in practice (Bell, 2010).

CONCLUSIONS

Web 3.0 promises to integrate Internet data in a way which will make Internet searches more focused and customized to gather and present information from various types of media in a format that is relevant and fits user needs. This change will depend on careful coding of web site content using Web 3.0 markup languages that insert coding into web site content that links bits of data on them and makes this information accessible. Web 3.0 markup will also enable the development of ontologies or structured collections of information about a particular topic that can be automatically updated as new data is posted. Individual users will have the opportunity to establish and use one online identity that enables them to access information without having to log in each time.

At the same time, Web technology has changed the nature of learning, from teacher-center to student centered, and new theories are being sought to explain and guide today's computer-enhanced learning. Connectivism, a proposed theory of learning for the digital age, views learning as making and continuously updating connections with others and with knowledge sources. Connectivism has been implemented in large MOOCs. The author suggests that the problems that arose in these courses—student reluctance to participate and the lack or structure and guidance from the instructor—would be manageable issues if students met in a traditional classroom where students participated in a MOOC, but the teacher could step in to give guidance, if and when needed. As expressed earlier, the author is also concerned that, by being presented information they seek in a pre-organized format, students will miss the opportunity to develop their own powers of analysis and evaluation.

Admittedly, the arguments presented in this paper about Web 3.0's and connectivism's role in higher education are still speculative, but as Web 3.0 tools become more available and if connectivism is embraced as an effective learning methodology, educators will seek to put the appropriate pedagogical methods and student support in place to maximize benefits to student learning. Questions like the following need rigorous examination:

- What skills do teachers and students need to succeed in a connectivist/Web 3.0 learning environment?
- How do the various Web 2.0 and Web 3.0 tools impact learning, and which combinations are them work most effectively?
- What kinds of support and scaffolding do students need to succeed in this learning environment?.
- How do learning outcomes from a Web 3.0/connectivist online course compare to that of a traditional distance education course?
- What can teachers do to maintain the "presence" that has been shown to be necessary for many students, while at the same time, challenging students to become autonomous learners?

As distance education and classroom technologies become ever more important to teaching and learning in the 21st century, it remains to be seen if and when the potential educational benefits of Web 3.0 and connectivism will be realized.

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