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Surveying the Expanding Cyberscape of New and Evolving Digital Learning Technologies

—A Review of Recent Advances in Three Creative Focus Areas of Digital Learning Design and Development Impacting the Field of Education

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Abstract

This article presents an overview and review of recent advances in digital teaching and learning technologies—advances that collectively represent an emergent period of *breakthrough* "*digital innovation*" *leadership* in the field of education. These digital education technologies are creating new career learning and advancement opportunities for people around the world through expanding and enhancing their access to globally connected learning. Three specific "creative focus areas" of digital learning design and development are identified for review. The article includes a discussion of salient features and design thrusts of major research, development, and practical application activities currently being conducted within each creative focus area. Some of the most innovative learning programs being developed by researchers, designers, and education leaders engaged within each of these creative focus areas are highlighted, along with an assessment of the impact of these programs on educational practice.

Keywords

Digital Learning Technologies Design and Development, Digital Learning Creative Focus Areas, Technology-Integrated Learning Tools, Digital Innovation, Globally Connected Learning

1. Introduction

Technological advances in recent decades have spawned multiple innovative breakthroughs in digital multimedia design and development that are resulting in the emergence and growing utilization of new forms of *digital teaching and learning technologies*. Indeed, the dawn of the Internet age (beginning in the

early 1990s) coupled with ongoing advances in multimedia design and development have ushered in a new creative era of "digital innovation leadership" in teaching and learning technologies—particularly so in the field of education. Importantly, this newly emergent period of *breakthrough* "*digital innovation*" *leadership* in education and the various new forms of digital teaching and learning technologies this period of creative educational leadership activity has generated have served as a powerful positive force for creating new educational opportunities for people throughout the world, both in terms of wider access to knowledge and career-track preparation and an expanded ability to engage in life-long learning and self-fulfillment.

Key features of this new digital era—defined by the Internet and the growing proliferation of internet-enabling multimedia and information-searching tools and resources—are *connectivity*, *accessibility*, *scalability*, and *collaboration*. Today, the World Wide Web is continuing to generate multiple, varied forms of "online learning communities" that are being initiated and maintained by large groups of people who are enthusiastic about tapping into the Web's capacity for empowering and enabling people to connect and share knowledge and information, and to work together collaboratively to identify and solve meaningful problems (Rheingold, 1993, 2012). Even more so now than ever before, as we approach the end of the second decade of the twenty-first century the World Wide Web is emerging as the "new digital classroom"—a fully online environment within which creative educators and instructional designers are *reimagining teaching and learning* in the new digital era.

This article identifies for reviewing three specific "creative focus areas" of digital learning design and development, namely: 1) simulations and virtual worlds; 2) Massive Open Online Courses (MOOCs) and open education; and 3) the Semantic Web and intelligent agent learning technologies. Researchers and designers working today within each of these three creative focus areas are continuing to generate impressive advances in *digital learning technologies design and development*—advances that are collectively impacting in positive ways ongoing research and practice in the broad field of education. The author completed the research for this review study by conducting an in-depth survey of pertinent literature and practical application activities associated with each of the three identified creative focus areas that are highlighted and discussed in this article. As such, the author of this article is only directly involved as a practicing researcher in the first creative focus area (i.e., simulations and virtual worlds) that is highlighted and discussed in Section 4.1.1 of the article. For the other two creative focus areas highlighted in the article (i.e., MOOCs and open education, and the Semantic Web and intelligent agent learning technologies—see Sections 4.2.1 and 4.3.1 respectively), the specific design and development work of other researchers, designers, and organizational entities who are directly involved in these two creative focus areas are recognized and discussed.

2. Purpose and Significance of the Present Review Study

In this review study article three identified "creative focus areas" of digital

learning design and development that are currently impacting the world of education in positive ways are highlighted and discussed: 1) simulations and virtual worlds; 2) Massive Open Online Courses (MOOCs) and open education; and 3) the Semantic Web and intelligent agent learning technologies. Notably, the design innovations and new technological tools and resources being developed in these three focus areas are continuing to significantly up-end and transform "education programming and instructional design" *thinking* in the broad field of education—both in digital learning technologies research and development and in applied educational practice. This substantive transformation is occurring to a large degree through the ways in which these design innovations and new digital tools and resources are redefining (and broadening) the nature and scope of what constitutes "teaching and learning *environments*", and through the manner in which they are advancing the prospect of dramatically expanding "globally-connected learning *opportunities*" for the world's populations of learners. Indeed, the innovations in education programming and instructional design thinking occurring within these three creative focus areas are contributing to the development of an expanding "cyberscape" (i.e., web-based "virtual landscape") of new and evolving digital learning technologies and related digital instructional practices that is transforming how instructional designers, educators, and learners approach the "teaching and learning" enterprise. Thus, these three "creative focus areas" are particularly noteworthy in that they are: 1) generating multiple new and innovative digital teaching and learning *tools and resources*; and 2) transforming teaching and learning *practices* in the field of education.

The sections below provide a brief literature-based review of the historical development and significance of each of the three identified "creative focus areas", followed by a discussion of salient features and design thrusts of major research, development, and practical application activities currently being conducted within each focus area.

3. Review of Pertinent Literature Related to the *Three Creative Focus Areas* of Digital Learning Design and Development Surveyed in This Article

The "reimagining of teaching and learning" in the web-enabled digital era has manifested itself in a number of digital learning design and development "creative focus areas". For example, within the creative focus area of *simulations and virtual worlds*, the interactive learning power and impact of multimedia simulations and educational games as rapidly evolving "virtual world" digital learning technologies and platforms have already been well documented by researchers (Gee, 2003, 2005; Martens, Gulikers, & Bastiaens, 2004). Educational researchers, in particular, have conducted a substantial amount of research in the past two decades on the appropriateness of simulations and games as "virtual world" learning tools in educational contexts (Huang & Cappel, 2005; Rosas, Nussbaum, Cumsille, Marianov, Correa, & Flores, 2003; Steinkuehler, 2004). Additionally, educational researchers have investigated the kinds of *cognitive learn-*

ing and *higher-order thinking skills development* considerations that are routinely addressed by instructional program designers in developing these digital learning tools (Rice, 2007). Intriguingly, researchers conducting studies in the field of education have also focused their attention on examining the ways in which educators have worked: 1) to reconceptualize their pedagogical philosophies and practical classroom teaching strategies in response to the increasing availability of educational simulation and gaming tools (Taleb, 2007; Zull, 2011); and 2) to use various simulations and games in multiple kinds of classroom teaching contexts as appropriate learning tools to address specific learning objectives included in curricula and to enhance classroom experiences for students (Childress & Braswell, 2006; Delwiche, 2006; Hamalainen, 2008; Rice, 2007). Moreover, these learning objectives and the educational "virtual world" simulations and games that address these objectives often incorporate a decided focus on "authentic learning"—that is, *problem-based* learning that seeks to involve students in identifying, investigating, and solving real-world problems using scientific methods that require the active use of open-ended inquiry, higher-order thinking skills, and metacognition (Rule, 2006) and that mimic the work of real professionals (Sheninger, 2014: p. 37). Indeed, educational futurists scrutinizing the probable trajectory of education in the upcoming decades predict that instructional designers and professional educators working in elementary and secondary education environments, as well as in the world of higher education, will increasingly seek to create a *melding of the virtual and physical worlds* of teaching and learning in which schools have the potential "…to become 'hubs of design knowledge'—providing a venue for students to engage in project-based learning that contributes to their local communities" (Berry, 2011: p. 84). In these schools of the future that function as "hubs of design knowledge", students, teachers, and community members will engage collaboratively in investigating and solving real-world problems of significance to their communities using both "virtual learning" and "traditional learning" tools and resources (KnowledgeWorks Foundation, 2010). Importantly, moving forward into this future world of educational practice, instructional program designers—building on the past two decades of impressive developmental progress in the simulation/gaming genre of digital learning technologies—are continuing to leverage the power of simulation and gaming interactive platforms and tools to create increasingly effective immersive "virtual world" learning environments that are rich in cognitive complexity and that challenge and extend users' collaborative problem-identification and problem-solving capabilities, especially involving ill-structured problems (Hong, 1998; Kapur & Kinzer, 2007).

The past two decades have also witnessed some impressive advances within a second identified creative focus area of digital learning design and development: *Massive Open Online Courses* (*MOOCs*) *and open education*. Efforts within this second focus area center on the creative design, development, and delivery of digital learning instructional programs and courses by a variety of learning organizations and digital learning platform service providers who are working on

developing and disseminating professional career preparation and ongoing, job-related training and development programs using *web-enabled distributed learning* (Allen & Seaman, 2013; Bonk, 2009; Bonk et al., 2015; Bowen, 2013; Gibney, 2013; Hanley, Schneebeck, & Zweier, 1998; Hanley, 2001; Hill, 2013; Hiltz & Goldman, 2005; Leber, 2013; Martin, 2008; Regalado, 2012; Selingo, 2014; Walsh, 2011). In particular, universities interested in making available their higher education degree and certification programs and courses to large numbers of "distance education" students, along with corporate business entities interested in providing specific, job-related training and professional development to their employees, have been investing actively in the development and use of various *distributed learning program delivery models and modalities* to maximize access by their student clients and employees to fully online and easily accessible higher education learning and career advancement opportunities. Within the past several years, these kinds of distributed learning programs have progressed rapidly from initial *blended delivery* configurations that provided instruction to students and employees using some combination of both "online" and "on-site" instruction, to *fully online* instructional programs that, in higher education institutional environments in particular, have become widely referred to as "Massive Open Online Courses", or MOOCs. Today, increasing numbers of higher education institutions around the world are now investing heavily in leveraging the dissemination power of the World Wide Web to make available *fully open and accessible* web-based learning opportunities to their distance education students through designing and offering MOOC-driven programs and courses (Bonk, 2009; Bonk et al., 2015). Interestingly, the phenomenon of MOOCs as a "web-enabled distributed learning" instructional modality has benefited directly from ongoing developments in recent years in information and communications technology (ICT) and the pedagogy of online and distance learning. In particular, the capacity of MOOCs to function as a "massive" online course learning delivery modality is directly tied to relevant ICT advances in the areas of: 1) *infrastructure and software services* that enable MOOC providers and users to store, index, and remotely access very large amounts of digital content (such as contained in YouTube, Google Books, digital libraries, cloud computing archives); 2) *secure registration and identification* of very large numbers of users (functions that are needed for social media); and 3) *robust*, *reliable*, *and secure software and services* for simultaneous access by very large numbers of users to the same Web pages and media (as often occurs with social media) (Klobas, Mackintosh, & Murphy, 2015: p. 3).

Research and applied development work involving the intensive design and delivery of MOOC online learning programs have tended in recent years to center around two specific kinds of "web-enabled distributed learning" providers: 1) elite university *institution-based providers* of open learning educational resources; and 2) online learning platform *business entities* (i.e., online platform services companies that "partner" with multiple universities and organizations). Some of the most notable university providers of web-enabled distributed learning programs and courses include the Massachusetts Institute of Technology

(MIT) and Harvard University in the United States and the Open University (OU) of Britain. Some of the more prominent "for profit" companies providing online platform services to higher education and business enterprises include Coursera and Udacity in the United States and Iversity in Germany. Additionally, there are also a growing number of "not-for-profit" companies that specialize in providing MOOC platforms and online learning program services to university and business organizations, such as edX and Open2Study in the United States, and Futurelearn in Britain. These companies offer a wide variety of online learning program "instructional design development and support" *services* and "partnership" *approaches* to meet the specific client-service needs of individual learning organizations (Haywood & Macleod, 2015: pp. 47-48). In the broad context of the educational development and social learning support needs of an increasingly globalized and interconnected twenty-first-century society, "web-enabled distributed learning" digital learning technologies such as MOOCs can be viewed as one important manifestation of the continuing emergence and development of new forms of *digital information access*—part of the same trend that has seen the proliferation of new digital information access tools, such as Google search, Wikipedia, and the plethora of online social media tools, that are becoming readily available and openly accessible on the World Wide Web.

Finally, a third creative focus area that has produced some particularly noteworthy advances in digital learning design in recent years involves the conceptualization of the *Semantic Web* and associated recent research and development work focused on the design and use of *intelligent agent learning technologies*. Following the pioneering efforts of Tim Berners-Lee in 1989 in implementing the first successful communication between a Hypertext Transfer Protocol (HTTP) client and server via the Internet (Berners-Lee et al., 2001), which was the inaugural "web-based digital communication" demonstration event that ushered in the emergence of the global World Wide Web, the World Wide Web (or, Web) has substantively impacted the global economy and societies around the world and has dramatically transformed the ways people access information and communicate with each other (Hendler et al., 2008; Pejic-Bach et al., 2015). Importantly, the Web has evolved rapidly in the past two decades as Web architects, designers, and users continue to explore the potential of the Web as a *global digital information sharing and communications tool*. Essentially, the World Wide Web has progressed through three stages of evolution thus far. The first stage of the Web (i.e., Web 1.0) in the early 1990s focused on the development and online posting of *document-based resources* that enabled people to access and consume static, read-only information presented in hypertext format. Thus, the initial "Web 1.0" iteration of the World Wide Web was essentially a "web of documents". However, following this initial breakthrough in the ability to access document-driven static information via Web 1.0, global Web users quickly became interested in exploring the potential of the Web as a "tool for interactive communication" between and among users. This user-driven interest spawned the development of the second stage of the Web (i.e., Web 2.0). The emergence in the middle and late 1990s and early 2000s of Web 2.0 technologies

ushered in a new "web-enabled digital communications era" in which Web users became more centrally interested in leveraging the Web as a *digital tool for interactive communication* between and among multiple Web users. This Web 2.0 iteration of the World Wide Web—engendering the rapid development of the Web as a global platform for "online community" information sharing and collaboration—has brought to the forefront the *global interactive communication* and *communal connectivity* possibilities facilitated through online (Web-based) social networking (Rheingold, 1993, 2002). In essence, this second "Web 2.0" iteration focused on the World Wide Web as a "web of people".

Most recently, the third iterative developmental stage of the World Wide Web (i.e., Web 3.0) has involved an intensive focus by web researchers and developers on the potential of the Web for evolving into a global "web of data". The emphasis in Web 3.0 design efforts is on developing a "global distributed network" of interconnected data in which information is given *well-defined meaning* (giving rise to the term: the "Semantic Web"). The ongoing development of the Semantic Web as a third "Web 3.0" iteration of the World Wide Web is focused specifically on leveraging the potential of the World Wide Web as a *data-driven digital networking tool* that better enables computers and people to work together cooperatively (Berners-Lee et al., 2001: p. 30). Web researchers and developers have focused their design efforts in recent years on developing a variety of semantic and heuristic data-networking tools and strategies (including designing and using digital avatars, 3-D interfaces, and artificial intelligent agents) that can be leveraged in creative ways to provide Web users with technologically advanced means to further refine and support their online digital information seeking and sharing activities and cooperative learning and decision-making. Web 3.0 platforms being developed in a number of fields today—including computer science, communications, robotics, sales and marketing, and education—utilize the power of new Semantic Web technologies to refine data connectivity, streamline digital information searching and retrieval for research, enhance data-driven cooperation, and better support collaborative decision-making (Barassi & Treré, 2012; Garrigos-Simon et al., 2012). These Semantic Web technologies include Web 3.0 digital tools such as "large-scale networking applications" that can network multiple digital technologies to better support human cooperation, as well as "intelligent agent technologies" that manipulate data and multiple applications from a variety of online sources. Thus, the third "Web 3.0" iteration of the World Wide Web—a third evolutionary stage of the Web that is still very much "in development" today—focuses on the potential of the Web for becoming a "web of integrated data" (i.e., through creating a new level of networked data integration that enables the creation of new meaning) and a "digital tool for global cooperation" (Fuchs et al., 2010; Hall, 2011; Hall & Tiropanis, 2012). This newest stage of web-enabled, data-driven human cooperation focuses on further developing and leveraging the World Wide Web as a powerful *interconnected-data resource* for global communication, sharing, and innovation (Cardoso, 2007; Garrigos-Simon et al., 2012).

4. Discussion of the *Three Creative Focus Areas* of Digital Learning Design and Development

The three *creative focus areas* which I have identified as a means to frame my review of noteworthy twenty-first-century "digital learning technologies" and "digital learning design developments" that are currently expanding and enhancing learning opportunities for globally connected learning—namely: 1) simulations and virtual worlds; 2) MOOCs and open education; and 3) the Semantic Web and intelligent agent learning technologies—are discussed in detail in the subsections below. I have selected these three specific focus areas for discussion because these three particular "creative focus areas": a) are at the forefront presently of innovative design work in learning technologies being conducted around the world; and b) represent to many the cutting edge of innovative "digital learning technologies" and "digital instructional design" research and development activities taking place today in the broad field of education. Importantly, each of these areas has spawned both "creative innovations" and noteworthy advances in technology-integrated teaching and learning "educational best practices" in the past two decades. Moreover, these three areas are continuing to demonstrate marked promise as productive avenues for further creative research and design developments that could conceivably result in the generation of additional new learning technologies and learning technology applications that could contribute in positive ways to enhancing teaching and learning practices.

In the subsections below I provide an overview of notable digital learning technology design and development work taking place in each of these three creative focus areas, and highlight innovative programs and practices of researchers, designers, and education leaders around the world who are currently engaged in creative activities within each of these focus areas.

4.1. Simulations and Virtual Worlds

The present environment of *computer-based simulations* and *educational gaming* as twenty-first-century learning technologies in the field of education—within both elementary/secondary education and higher education settings—has emerged and benefited from a rich background of creative research and development work. This multi-faceted research and development activity has evolved in dynamic ways and generated a variety of instructionally customizable (i.e., inter-disciplinary and multi-disciplinary) learning tools over the past two decades that have practical applicability in education settings. Indeed, multiple simulation-game platforms have been designed and developed that are now widely available for use within a number of educational content areas and instructional environments. For example, a number of individual- and multi-player simulation games have grown out of this multi-decade, creative research and development activity that are now widely utilized by educators in elementary and secondary school settings to motivate and engage students in "high-immersive" inter-disciplinary and multi-disciplinary learning. This *simulation gaming* learn-

ing technologies genre currently includes simulation games that are designed to address learning goals and challenges within a number of content-specific learning categories, including: 1) "strategic life simulation" games such as *The Sims* (The Sims, 2000-2008, 2012-Present) and its various renditions (*The Sims Online*, *The Sims Stories*, *MySims*, *The Sims Carnival*, *The Sims Medieval*, *The Sims Social*); 2) "fictional-world graphic adventure" video games such as *Myst* (Myst, 2013-Present); 3) "urban planning and development/municipal engineering" simulations such as *SimCity* (SimCity, 1989-Present); and 4) immersive "historical learning/adventure" educational simulations such as *Oregon Trail* (Oregon Trail, 2013) and *Westward Trail* (Westward Trail, 2013). These individual-player and multi-player simulation games offer rich, interactive digital learning environments within which users can explore a variety of social, organizational, engineering, and management challenges integrated into multi-dimensional, online "virtual-world" simulations. As growing numbers of elementary and secondary educators are becoming increasingly familiar with these simulations as "digital learning tools" and are experiencing first-hand their positive learning enhancement value, the use of computer-based simulations and simulation games as powerful learning technologies in classroom teaching and learning environments will continue to expand in elementary and secondary education settings.

Simulation gaming has also been actively embraced as a powerful learning technology in higher education contexts. Indeed, a variety of immersive digital learning tools and interfaces are now being used in multiple higher education learning contexts (e.g., business, economics, political studies, science and engineering, languages, education) to increase student engagement and retention and to stimulate learning. The "simulation game" digital learning tools utilized in higher education contexts encompass a broad array of creative simulation/gaming designs, including serious games, multiple role-play, whole-enterprise simulations, video simulations, augmented reality, robotics laboratories, and virtual learning environments—all of which are structured to enhance higher education students' *active learning* and encourage *interactive reflection* (Nygaard et al., 2012). Importantly, professors teaching in multiple content-specific fields and disciplines in higher education settings can employ these games, simulations, and virtual worlds to engage learners dynamically within interactive digital environments that are highly immersive, collaborative, and focused on real-world problem solving (Shiratori et al., 2005).

Multimedia Case Simulations for Collaborative School Leadership Development: The Power of School-University Partnerships

My own research agenda over the past thirty years has included involvement as lead researcher and principal investigator on a number of funded research and development projects to design *multimedia case simulations* as professional learning tools for school leaders in elementary and secondary school (i.e., middle/junior high and high school) settings. Throughout the 1990s and early 2000s I led a team of digital case design colleagues in multiple public school district

and university "collaborative partnership" endeavors to create multimedia case simulations about school leadership "teaching, leading, and learning improvement challenge areas" identified by school leaders working in schools and districts in the state of Texas in the southwestern United States (Claudet, 2011, 2012, 2013). These case simulations were developed as a new "technology-integrated, interactive learning platform" to support multiple school leaders (school principals, assistant principals, classroom teachers, instructional coaches, counselors, curriculum specialists, instructional program directors, etc.) in their efforts to extend and deepen their professional learning and collaborative leadership development. This multi-project research and development effort—i.e., the School Leadership Case Simulation (SLCS) Initiative and Multimedia Lab—resulted in the design, development, and piloting of multiple "school leadership *multimedia case simulations*" that have since been adopted and used by multiple regional education service centers and school districts in Texas as "collaborative leadership development" resources and technology-integrated professional certification/recertification tools for school leaders. The case simulations were designed specifically as technology-integrated *collaborative learning tools* to enable groups of education stakeholders (teachers, principals, instructional support staff, parents, and other school community leaders) to become involved together in an immersive way in the collaborative identification and examination of their context-specific school community organizational challenges through producing video case scenes of their own school (i.e., campus-level) leadership and learning improvement challenge area situations.

A key feature of each school community case simulation development project conducted within the overall School Leadership Case Simulation (SLCS) Initiative involved the new kinds of *immersive collaborative learning* that school community stakeholders (teachers, principals, instructional coaches, counselors, parents, and community members in the individual campus-based contexts) participating in each case simulation project experienced as a result of their sustained involvement in project development work. School community stakeholders participating in each case simulation development project engaged together as a collaborative "case development team" in an intensive process involving: 1) clearly identifying specific "critical aspects" of their school community's own particular learning improvement dilemma challenges; and then 2) storyboarding, writing, and producing the various individual "video case scenes" that were developed for inclusion in the school community's case simulation. An important aspect of the *immersive collaborative learning* dimension of case development project activities involved school community stakeholder team members taking on and playing "acting roles" (i.e., assuming a stakeholder "acting role" in case scenes that was *different from* the school community stakeholder role they played in real life) in the actual shooting of the individual "video case scenes" that were developed for inclusion in the overall multimedia case simulation. This was done purposely to challenge school community team members to work to internalize and think reflectively about the "core educational beliefs" and

"learning improvement perspectives" of *other* school community members regarding the school community's "learning improvement challenge" critical issues—and the multi-perspectivist conflicts between and among various stakeholders and stakeholder groups that often surfaced and intensified regarding those issues—that were fueling the school community's persistent dilemma situation challenges. As part of their work to produce video case scenes depicting their own school community's context-specific "learning improvement challenges" in a particular area (e.g., closing the achievement gap for disadvantaged learners, as reflected in state teaching and learning accountability measures; addressing the instructional support needs of special needs students; increasing parental involvement in school learning programs), school stakeholder case development participants in each campus were encouraged (by the university multimedia support team members working with these school stakeholders at their individual campus sites) to work together, as an integral part of participants' case development activities, to probe and identify the *root causes* of their identified school dilemma situation (i.e., learning improvement) challenges. Through doing so, campus stakeholders were able to gain new insights regarding the multiple—and, often conflicting—teaching and learning perspectives that various stakeholders held regarding their school's learning improvement challenges. Most importantly, as a result of participating (as an integral part of case simulation project development work) in intensive and sustained *collaborative dialogue* regarding their own multiple learning improvement perspectives and the school community leadership challenges these multiple perspectives presented, the various school stakeholder teams involved in each campus-based case simulation development project were empowered to develop new collaborative leadership team *shared perspectives* and *reflective insights* on their school improvement dilemma challenges that ultimately advanced their group's "consensus-building skills" and enhanced their "collaborative leadership capacity" for engaging in organizationally effective, data-driven instructional decision making.

Intriguingly, the School Leadership Case Simulation (SLCS) Initiative itself was, in essence, a *cross-disciplinary* research and development endeavor, in that the multimedia case simulation project development "design concept"—i.e., the notion of engaging and immersing multiple school stakeholders directly in the in-depth exploration of their own school community "context-specific learning improvement challenges" as a means to help these stakeholders develop and refine their collaborative team-centered and data-driven "school improvement decision-making skills"—emerged at the intersection of four areas of inquiry, namely: organizational psychology, applied sociology, computer-based multimedia video production, and school leadership. Building on the *cross-pollination of ideas* generated from these four areas of inquiry regarding "individual and collaborative learning" and the "leadership dynamics and socio-politics of multiple stakeholder groups" that informed SLCS initiative design thinking, SLCS university project designers then leveraged the *interactive learning power*

of multimedia authoring software and video production and post-production tools as technological means to implement and realize this multimedia case simulation project development "design concept" in practice—through working synergistically with large groups of school community stakeholders in schools and districts throughout Texas. The multimedia case simulations developed through this multi-year university and school district partnership endeavor [i.e., the School Leadership Case Simulation (SLCS) Initiative] serve as one example of the new kinds of *technology-integrated*, *collaborative learning tools* that are being designed and utilized currently by educators around the world working in various elementary/secondary and higher education contexts. These kinds of "case simulation" development initiatives—such as the SLCS Initiative—are designed and implemented specifically to extend and enhance school leaders' own *organizational leadership team capacities* for collaborative learning and development. These case simulation designs and initiatives accomplish this through immersing school community stakeholders directly and intensively in "authentic" simulated leading and learning environments as a means to enable these stakeholders to: 1) critically examine their own school community learning improvement challenges from multiple stakeholder perspectives as a means to build leadership team consensus; and 2) learn how to mine, analyze, and leverage their own school community teaching and learning data to promote effective instructional planning and decision making.

4.2. MOOCs and Open Education

A second creative focus area that has emerged in recent years that is having a growing impact on the field of education is the design of massively open and accessible course learning programs and learning environments, typically referred to as MOOCs (i.e., Massive Open Online Courses). The evolution of MOOCs as a twenty-first-century learning technologies phenomenon has garnered considerable media attention in the past few years. Of course, the ability of MOOCs to accommodate massively large numbers of students (i.e., to be "massive" as an educational delivery modality) reflects recent robust developments in both information and communications technology (ICT) and pedagogy. For example, there have been a number of recent ICT advances that have combined in synergistic ways to enable and support MOOCs, including: 1) increases in infrastructure capacity and software services to store, index, and remotely access large amounts of digital content (e.g., through such information content services as YouTube, Google Books, digital libraries, cloud computing archives); 2) the ability of massively online course providers to securely register and identify very large numbers of online social media users; and 3) the emergence of robust, reliable, and secure software and online services that can enable large numbers of users to access the same Web pages and social media simultaneously and efficiently. In addition, an array of complementary advances in online and distance learning from several branches of pedagogy and educational technology have also emerged recently that have provided positive "instructional capacity sup-

port" for MOOCs, including: Web-based learning, learning management systems (LMS), e-learning, computer-supported collaborative learning (CSCL), open and distance learning, and computer-based education and training (CBT) (Klobas, Mackintosh, & Murphy, 2015: p. 3). In terms of the broad evolution of educational learning technologies, the arrival of MOOCs represents a natural and logical further development in the ongoing push by universities, corporate entities, and other learning providers to leverage proactively the knowledge and training *dissemination power* of the Internet to "open up" education globally to larger numbers of individuals. Earlier distributed learning technologies and modalities—such as a number of distance learning models utilized by multiple universities and colleges in the past fifteen years or so that combined various percentages of online and on-site instruction in "blended delivery" configurations—have certainly served as important precursors and contributors to the evolution of MOOCs as a sophisticated distributed learning technology. These various kinds of distance learning models (in both "blended delivery" and "fully online" configurations) are continuing to play important roles in the ongoing push by universities and other learning providers to design and deliver academic learning and career development programs to people across the globe. As a natural extension of these kinds of distance learning models, multiple varieties of MOOC learning platforms are now also becoming a burgeoning presence in the online education environment—and, importantly, are helping to further positive progress toward realizing a twenty-first-century "learning society" in which people throughout the world can benefit from open access (i.e., open and online) to *globally connected learning*.

Recently, Fred Mulder and his research associates (Mulder & Janssen, 2013; Mulder, 2015) at the Open University of The Netherlands have put forward a conceptual model elucidating the "supply-side" and "demand-side" forces informing and driving the development of open and online education, including MOOCs. In Mulder and colleagues' five "Components of Open Education" (5COE) model, three components define the "supply side" of open, online education, namely: educational resources; learning services; and teaching efforts. The first "educational resources" supply-side component of the model refers to the standard teaching, learning, and research materials in both digital and non-digital form (either residing in the public domain or available through open license) that can be used, adapted, and redistributed for educational purposes. The second "learning services" supply-side component covers the wide variety of both online and virtual educational services that online education programs can provide to clients, such as instructional feedback and support, synchronous and asynchronous course/seminar meetings and advisement sessions, presentations, learning team collaboration sessions, testing/examinations, and other individual and group instructor/client learning opportunities. The third "teaching efforts" component on the supply side of the model refers to the important "human contribution" element in open, online education program delivery. This human contribution element refers to the broad range of instructional services that can

be provided by teachers, instructors, and trainers, but also includes the online program design and development work engaged in by developers as well as the range of instructional support provided by online program staff. The "demand side" of the 5COE model includes two demand-side components: learners' needs; and employability and capabilities development. The fourth "learners' needs" demand-side component simply represents the desire of learners for educational services and opportunities that are "open" (open entry; freedom of time, place, and pace; open programming; open to people and target groups) and that facilitate "life-long learning", such as recognition of prior learning or practical experiences and professional credentialing. The fifth component of the 5COE model, "employability and capabilities development", refers to the ability of open and online education program services to be able to adapt to the continuously changing labor and career market demands of a globalized society through providing learners with a range of twenty-first-century, real-world knowledge and skill sets that can enhance their marketability/hiring potential and personal growth and development success. This 5COE "open education" model suggests that the educational program design, development, and delivery efforts of open, online education program developers and instructional delivery providers can be positively informed through conscious consideration of the *synergistic relationships* that exist between and among the "supply-side" and "demand-side" components of this open education model.

Intriguingly, the explicit focus and intent of MOOCs—i.e., making readily available *open and online information access*—directly complements and is serving to accelerate the global "social networking" phenomenon. Indeed, MOOCs can be viewed as simply one component of the broader Internet-enabled online information dissemination and sharing "global social learning network" that the world is evolving into in the early decades of the twenty-first century. In these initial formative decades of the new *digital era*, which began in the early 1990s with the emergence of the Internet, the very "idea" of learning—including *how* knowledge and learning is produced and *who* has access to this knowledge and learning—is being dramatically up-ended as the Internet (i.e., the World Wide Web) continues to function as a powerful *democratizing force* for moving human society toward the realization of universal access to education and life-long learning as an attainable goal for people throughout the world. Indeed, there have been a number of historic "watershed moments"—i.e., turning points in the history of human progress—that have occurred during the incremental development of human civilization in which new *breakthrough learning technologies* emerged that provided the impetus for a dramatic expansion in people's ability to formalize and disseminate knowledge and, through doing so, to expand their capacity *to learn*. Some of these new "learning technologies" that have proved to be especially impactful in accelerating the pace of human knowledge sharing and learning have included: 1) the invention of cuneiform writing; 2) the development and use of papyrus as a formalized means for information and knowledge documentation and sharing; and 3) the subsequent

reinvention and refinement in the fifteenth century of the European version of metal movable type (initially invented in ancient China using porcelain ceramic type in the eleventh century) along with innovations in the casting of the metal type (i.e., Johannes Gutenberg's metal movable-type press). Each of these breakthrough technologies served as a powerful *leveraging tool* that dramatically increased people's access to knowledge and learning, moving the overall "human knowledge and learning access" continuum in a positive direction from "more restricted" access to knowledge and learning to "more open" access to knowledge and learning. The emergence of the Internet in the early 1990s and the rapid development and proliferation of social media tools and services that followed are the most recent (and, arguably, most potent) manifestations to date in human history of these kinds of "breakthrough learning technologies" that are again serving as powerful democratizing forces—technologies that are dramatically expanding people's access to knowledge and learning and, importantly, moving global society toward the realization *during the twenty-first century* of universal access to education and life-long learning for all people.

From a sociological perspective, it is useful to consider the notion of *social capital*—a sociological term with broad applicability in a wide range of socio-organizational arenas, including education, politics, civil society, business/corporate management, etc.—as a means to frame and assess the impact of MOOCs and other related knowledge and learning digital access tools on education in a twenty-first-century, globally-connected society. In very practical terms, "social capital" refers to the network of information, mentoring assistance, and professional career contacts (individuals who can serve as career models and advisors on selecting and pursuing professional career tracks) that young people have access to in their personal (i.e., socio-relational, economic) social sphere. Social capital networks can generate real-world value to people through the information flows and cooperative support, as well as feelings of trust and reciprocity, that people receive through active participation in these networks. Moreover, an individual's social sphere—i.e., their "social capital"—in many cases can play a substantial role in assisting a young person in gaining access to important career path information and developing critical mentoring contacts that can provide supportive avenues to future job opportunities. In recent years, writers surveying the incremental development of new social access and learning opportunities becoming available in the emerging digital era have commented on the positive impact the emergence of the Internet/World Wide Web, online connectivity, and the proliferation of readily available and easy-to-use online social media tools have had on redefining traditional notions of social capital to now include "*online* social capital" (Rheingold, 2012: p. 216). Indeed, the Internet/World Wide Web and open access to multiple online learning and collaboration networks have resulted in expanding significantly the array of "social capital networks" now available to young people.

In connection with these developments, the critical importance of today's young people actively cultivating their "social capital"—including "*online* social

capital"—as a means to access positive learning and career advancement "support networks" that enable them to acquire the knowledge, skills, and professional contacts necessary to successfully pursue twenty-first-century professional careers has been highlighted by a number of education researchers. Notably, Monica Martinez and Dennis McGrath have recently examined the central role that "social capital networking" plays in the creative curriculum redesign and learning program implementation efforts of education change leaders in several innovative American secondary schools today who have embraced the concept of "deeper learning" (Martinez & McGrath, 2014: p. 184). A hallmark of these deeper learning schools is the notion that educators in these schools have realized that truly effective twenty-first-century teaching and learning environments must be those that emphasize the value of *digitally connected learning*. Educators embracing "digitally connected learning" are committed to nurturing teaching and learning environments and creative learning program initiatives that are grounded firmly in a number of interconnected "deeper learning principles", including the importance of: 1) nurturing and facilitating collaboration; 2) supporting active competency-driven and immersive project-based inquiry learning; 3) networking beyond traditional classroom walls; and 4) customizing learning experiences to meet the learning styles and needs of individual students (Martinez & McGrath, 2014). All of these deeper learning principles are designed to work together synergistically in secondary schools that have implemented deeper learning curricula as a means to help young people internalize the value of leveraging the power of "social capital networks" to enhance their competency-driven *real-world applied learning.* As a central feature of their deeper learning curricula these secondary schools focus their students' problem-based learning efforts on developing practical, life-long learning skills that will serve these young people well in the twenty-first-century job market. Intriguingly, this idea of integrating a dynamic *problem-based learning curriculum model* with the human relationship-building power of *social capital networks* is currently gaining considerable positive momentum in the US and other countries through the vigorous school-community reinvention efforts of a number of education foundations and enterprises, such as the KnowledgeWorks Foundation (KnowledgeWorks Foundation, 2010; website: http://www.knowledgeworks.org/), the NewTech Network (NewTech Network, 2017; website: https://newtechnetwork.org/), and EdVisions Schools (EdVisions, 2017; website: http://www.edvisions.com/custom/SplashPage.asp).

Importantly, these same kinds of "*applied learning*" *centered* and "*social network*" *conscious* deeper learning principles guiding the curriculum redesign efforts of education leaders in secondary/college readiness education settings will also play an important role as central curriculum design thrusts guiding the ongoing learning platform development and refinement efforts of MOOC learning environment developers in multiple higher education and other education contexts around the world focused on designing and delivering cutting-edge career development and life-long learning programs to twenty-first-century learners.

As larger and larger numbers of people living in multiple geographic regions across the globe (including remote regions far from urban centers) are continuing to become "digital learning enabled" via internet connectivity, MOOCs—both in their present iterations and as more refined varieties of MOOC learning environments proliferate—will continue to offer dramatically expanded access to knowledge acquisition and learning and career development opportunities for people around the world. The expanding and deepening "online social capital networks" that MOOC learning environments engender will continue to be a positive force in nurturing authentic *globally-connected learning opportunities* for people of all ages in an increasingly digitally interconnected world.

MOOCs in Higher Education: The Realization of *Open Learning* Educational Resources

There presently exists considerable variability in the ways learning organizations, such as universities and corporate/business entities, decide how they want to engage in the development and provision of "open learning" educational resources (i.e., MOOCs) to their clients, employees, and constituents. For example, Coursera, Inc. (Coursera, 2017; website: https://www.coursera.org/) is a well-established *online learning platform* business entity that partners with multiple universities and organizations worldwide to provide open access to the world's best education opportunities through offering online course learning opportunities in multiple specializations and content areas, including: business, computer science, engineering, social science, and language learning. As stated on its website, Coursera's mission is "to provide universal access to the world's best education". The Coursera learning approach combines four integrated online learning program *design elements*: 1) the proven effectiveness of online learning as a positive contributor to life-long education; 2) the use of "mastery learning" (i.e., providing immediate feedback and randomized versions of course assignments to ensure students master individual content topics before moving on to more advanced topics); 3) utilizing "peer assessments" (in which learning peers can review, evaluate, and provide feedback on each other's course work); and 4) capitalizing on the advantages of "blended learning" (enabling partner institutions to adapt and integrate Coursera's online learning platform with their own on-campus student learning programs). Coursera presently has 149 partner institutions across 29 countries and regions. Countries participating in Coursera's global "partner institution network" include: Argentina, Australia, Belgium, Brazil, Canada, Chile, China, Colombia, Denmark, France, Germany, Hong Kong, India, Israel, Italy, Japan, Mexico, the Netherlands, Russia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Turkey, the United Kingdom, and the United States. Additionally, some of Coursera's partner institutions around the world include: Universidade de São Paulo in Brazil; University of Science and Technology of China in China; University of Copenhagen in Denmark; The University of Tokyo in Japan; and Duke University, Johns Hopkins University, University of California—San Francisco, University

of Michigan, University of Pennsylvania, and Stanford University in the United States. Working in collaboration with its 149 partner institutions, Coursera currently provides over 1800 course offerings that are available in Coursera's online catalog.

In contrast to the Coursera-style online learning platform "business-university partnership" approach, the Massachusetts Institute of Technology (MIT) can serve as an example of a long-standing *institution-based provider* of open learning educational resources. The Massachusetts Institute of Technology (MIT), an educational institution in the United States founded in 1861 and historically dedicated to advancing knowledge and educating students in science, technology, and other areas of scholarship, has been a world institutional leader in offering large numbers of its courses in open and freely accessible modalities on the World Wide Web. Through edX (edX, 2017; website: https://www.edx.org/school/mitx)—an online destination and MOOC provider founded by Harvard University and MIT in 2012—MIT now offers over 1200 free MITx online courses, as well as multiple masters-level, professional, and content area-specific online program certificates. Available MITx online courses extend across a wide range of fields and disciplines, including: arts and culture, biology and life sciences, business and management, computer science, data analysis and statistics, economics and finance, electronics, engineering, environmental studies, humanities, language, literature, math, medicine, physics, and social sciences. In addition to its two founding education institutions (Harvard University and MIT), edX has also established partnerships with a growing number of additional "contributing member" education institutions around the world, including (to name a few): the Australian National University and the University of Queensland in Australia; Peking University in China; The Hong Kong University of Science and Technology; Kyoto University in Japan; The University of Edinburgh in Great Britain; the University of Toronto in Canada; and CalTech, Columbia University, Cornell University, Dartmouth College, the Georgia Institute of Technology (Georgia Tech), Princeton University, and the University of Michigan (among others) in the United States.

Similarly, the Open University (OU) of Britain (Open University, 2017; website: http://www.open.ac.uk/) is a public distance learning and research university operating in the United Kingdom. As stated on its institutional website: "The Open University's mission is to be open to people, places, methods, and ideas. We promote educational opportunity and social justice by providing high-quality university education to all who wish to realize their ambitions and fulfill their potential. Through academic research, pedagogic innovation, and collaborative partnership we seek to be a world leader in the design, content, and delivery of supported open learning" (http://www.open.ac.uk/about/main/mission). The Open University awards undergraduate and postgraduate degrees as well as non-degree certificates and continuing education units. With a current enrollment of over 250,000 students in addition to attracting more than 50,000 overseas students to its distance learning

programs and certificates, the Open University ranks as one of the world's largest universities. Indeed, since the Open University's founding in 1969, over 1.7 million students have enrolled in its "distance learning" courses and programs. The Open University offers distance learning courses in a wide array of fields and disciplines, including: arts and social sciences; business; law; science, technology, engineering, and mathematics (STEM); education and language studies; and knowledge media. The Open University also maintains a number of discipline-specific and interdisciplinary Learning and Institutional Research Centers and Institutes that offer courses and programs to distance students, including: Institute of Educational Technology (IET), Knowledge Media Institute (KMI), Center for Inclusion and Collaborative Partnerships (CICP), and Center for Research in Education and Educational Technology (CREET).

Another prominent "online learning services" business entity provider in the *online learning platform* category is NovoEd. NovoEd, Inc. (NovoEd, 2016; website: https://novoed.com/) offers itself as a "software-as-a-service" *design platform* to multiple kinds of organizations, including learning institutions and business enterprises. As NovoEd states on its software company website: "NovoEd serves organizations around the world that need a better way to teach online—whether it's employee training, partner enablement, executive education, or university programs" (http://www.novoed.com/company/). NovoEd's online learning services design platform provides its educational and business enterprise clients with a comprehensive suite of NovoEd online collaborative learning products and services. The "software-as-a-service" online learning design platform developed by NovoEd enables multiple kinds of organizations to "design" their own customized learning and training programs to meet the specific needs of their clients and personnel. NovoEd's online learning platform includes access to NovoEd online learning program "design architects" and "instructional delivery consultants" who can assist organizations in developing and fine-tuning their customized learning and training programs in ways that leverage NovoEd platform's distinctive social learning features. In addition, NovoEd's *professional services and consulting* support system offers a substantive array of "expert advice and support functions" to help education and business organizations achieve their learning and productivity enhancement goals. These design platform expert advice and support functions include: 1) *strategy and needs assessment* to help client organizations assess their learning program and training needs and identify appropriate learning objectives tied to performance gaps; 2) *instructional design guidance* to assist organizations in developing their customized program curricula, individual and team-based learning architectures, and learning support plans; 3) *project management support* in end-to-end project management of course development work-streams, stakeholder management, etc.; and 4) *course construction professional design expertise* to guide client organizations through the complete process of designing, building, and implementing customized learning platform content (https://novoed.com/services).

The above are a sampling from the growing list of "online learning programs

and services" business platforms and institutional providers that, collectively, are offering a diverse array of "open learning" online courses, professional development seminars, and training programs to increasing numbers of learners around the world. Collectively, these "open access/open learning" platforms and programs—through the *flexibility*, *scalability*, and *customizability* that are the distinguishing characteristics of these distance learning designs—are creating new kinds of digital learning experiences for large numbers of twenty-first-century learners. Importantly, these institution- and business-based online learning program providers are serving the learning needs of ever-increasing numbers of globally connected learners who are interested in obtaining "flexible and open" access to twenty-first-century kinds of online learning and career advancement opportunities that: 1) are more social, collaborative, and experiential; 2) are tied to real-world professional careers; and 3) produce better job outcomes.

4.3. The Semantic Web and Intelligent Agent Learning Technologies

The World Wide Web can be described in purely technological terms as a transformative new digital information access technology, but it can also be analyzed usefully in terms of its *sociological impact* on global society—that is, through focusing on the *social dynamics* and *social network connectivity potential* inherent in the World Wide Web. In recent years, scholars focusing on the sociological aspects of the World Wide Web have developed varied techno-social frameworks for comprehending the incremental development of the World Wide Web. One especially useful conceptualization recently put forward by Christian Fuchs and colleagues (Fuchs et al., 2010; Raffl, Hofkirchner, Fuchs, & Schafranck, 2009) uses such a techno-sociological lens to build a developmental model describing, in their view, the initial "three-phase" evolution of the Web. This three-phase model is grounded in a foundational conception of knowledge processing that begins with *cognition*, and then progresses to include functional considerations of *communication* and *cooperation*. Employing this three-phase model, Web 1.0 is viewed as being primarily a "tool for cognition"—the initial iterations of the Web (Web 1.0) involved the development of document-based resources that enabled the widespread consumption of static, read-only information presented in hypertext format. As the World Wide Web continued to evolve, users became more centrally interested in leveraging the Web as a "tool for interactive communication" between and among multiple users, with numerous "user groups" and "special interest communities" sprouting up online—all facilitated by the expanded social bookmarking, collective tagging, and related social networking tools that were rapidly becoming available. The progressive evolution of the Web as a global platform for "online community" information sharing and collaboration has been chronicled by a variety of technology commentators in the 1990s and early 2000s (see, for example: Rheingold, 1993, 2002). This Web 2.0 manifestation of the World Wide Web has clearly brought to the forefront the *global interactive communication* and *communal*

connectivity possibilities facilitated through online social networking. The third phase of web evolution highlights the "networked digital connectivity" aspects of the Web that enable the World Wide Web to function as a "tool for *cooperation*". In Web 3.0 environments, as envisioned in Fuchs and colleagues' (2010) three-phase web evolution model, a variety of evolving semantic and heuristic tools and strategies (e.g., avatars, 3-D interfaces, artificial intelligent agents) will continue to provide users with the advanced digital means to further refine and support their information seeking and sharing activities and cooperative decision-making work.

Of course, the ongoing generative evolution of the World Wide Web, including its Web 1.0, 2.0, and 3.0 iterations and the internet-enabled global communication initiatives that the Web continues to spawn today, builds upon the pioneering innovative contributions of a number of early computer engineering design and information technology "change agent leaders" whose visionary leadership and engineering innovations paved the way for today's interactive web environment. Notably, one of the most influential of these early innovation pioneers and seminal design thinkers was Douglas Engelbart (1925-2013). Engelbart was a computer engineering and information technology visionary whose pioneering vision of a "fully networked, interactive computing system" resulted in the development in the late 1960s and early 1970s of the initial prototypes of multiple, new mouse-controlled "interactive computing" techniques, including: collaborative real-time text editing, shared screen video conferencing, teleconferencing, word processing, hypertext (both in text and in graphics), hyperlinking, hypermedia, object addressing/dynamic file linking, bootstrapping, and multiple windows screen environments with view control flexibility. Engelbart's pioneering vision of a fully networked, interactive computing system in the 1960s presaged in strikingly accurate ways today's ubiquitous digital connectivity and global-interactive web environments. All of these prototype computer interface inventions served as enabling technologies that have continued to evolve into the essential interface design components and social interaction features that characterize today's internet-driven global information sharing and social communication environment. Indeed, I have highlighted myself in a recent multiple case study of visionary social change agents (Claudet, 2016) the incisive *breakthrough leadership thinking* that characterized Douglas Engelbart's singularly innovative vision that proved to be such a driving force enabling and supporting the evolution of the present global web environment. Working as he was at the dawn of the personal computing era (during the 1960s and 1970s), Engelbart clearly recognized the *leveraging power* of social-interactive networked computing as a means to transform the ways in which people could share information and communicate with each other in networked environments and work collaboratively to solve important societal problems.

Notably, the Web 2.0 iteration of the World Wide Web (the Web online social networking developments that focused on dramatically expanding *global interactive communication* and *communal connectivity*), particularly in the last dec-

ade or so, has had an immense impact on the global societal environment through its empowerment of the individual and through the Web's ability to expand and energize the propagation of numerous online social communities. Intriguingly, the World Wide Web in the past several years—enhanced by its Web 2.0-driven interactive communication and connectivity capabilities—has also become a boon to education developers interested in promoting a variety of *global learning initiatives*. These global initiatives can include education programs centered on "competency-based early childhood to adult (EC-21) learning" that typically focus directly on providing "targeted content learning" to students—such as through developing and disseminating *global STEM learning programs* delivered via Internet-enabled means. These internet-enabled programs often utilize creative online-learning components as part of their program designs, such as virtual classroom interactions and exchanges and global academic competitions. One example of this kind of global learning initiative is the Global STEM Education Center, Inc. based in Massachusetts in the United States (Global STEM Education Center, 2014: "Welcome to Our Journey", retrieved at: http://www.globalstemcenter.org/welcome.html). The Global STEM Education Center has "global STEM partnerships" currently operating between US schools and schools in France, the United Kingdom, Russia, Ukraine, Mexico, the Netherlands, and Norway, and is in the process of establishing additional partnerships with schools in a number of other countries, including Mexico, New Zealand, Australia, China, Greenland, Iceland, Norway, and Sweden. In addition to the kinds of "global STEM partnership" initiatives being developed and nurtured by the Global STEM Education Center, other education-centered global outreach organizations focus their efforts on designing and implementing *entrepreneurial-based education programs* in various regions throughout the world to make online-supported job skills training and work-related leadership preparation opportunities available to the next generations of the world's young people. One notable example of these kinds of global "school-to-work" education programs is the entrepreneurial-based Big Picture Learning organization (Hannon et al., 2013). Big Picture Learning programs provide high school students with project-based internship experiences in various work settings that make *applying core conceptual content directly to the real world of work* a fundamental part of learning. As such, Big Picture Learning offers high school students in various countries unique opportunities to enhance their STEM content learning and English/language arts and social studies skills development through contextualized, online-supported "project-based learning experiences" connected to the real world of work. Big Picture Learning organizations have emerged in recent years in several countries around the world, including Australia, Canada, the Netherlands, and the United States.

Following on the developmental advances in global interactive communication and communal connectivity occurring during the Web 2.0 phase of the World Wide Web, the most recent Web 3.0 iteration of the World Wide Web has caused web designers and developers to conceptualize a newer notion of the

web as the "Semantic Web". The *idea* of the Semantic Web, initially put forward by Tim Berners-Lee in 2001, represents Berners-Lee's second significant conceptual contribution to our collective understanding of the information-processing *adaptability* of the Internet in supporting human-computer cooperative problem solving (Berners-Lee, Hendler, & Lassila, 2001). This second contribution follows Berners-Lee's pioneering efforts in 1989 in implementing his first significant contribution: the first successful communication between a Hypertext Transfer Protocol (HTTP) client and server via the Internet. In recognition of his trailblazing efforts, Berners-Lee was hailed as the "inventor" of the World Wide Web. The "semantic web" follows logically as an evolutionary development consistent with the Web 3.0 phase of the World Wide Web as conceptualized by Fuchs and colleagues (Fuchs et al., 2010; Raffl, Hofkirchner, Fuchs, & Schafranck, 2009). As Berners-Lee and his research associates explain: "The Semantic Web is an extension of the current web in which information is given *well-defined meaning* [emphasis added], better enabling computers and people to work in cooperation" (Berners-Lee et al., 2001: p. 30). Additionally, as further described by Allemang and Hendler (2011): "The main idea of the Semantic Web is to support a distributed Web at the level of the data rather than at the level of the presentation [i.e., individual web page]. Instead of having one web page point to another, one data item can point to another, using global references called Uniform Resource Identifiers (URIs). The Web infrastructure provides a data model whereby information about a single entity can be distributed over the Web… The single, coherent data model for the application is not held inside one application but rather is part of the Web infrastructure… This *single*, *distributed model of information* [emphasis added] is the contribution that the Semantic Web infrastructure brings to a smarter Web" (Allemang & Hendler, 2011: p. 6).

Importantly, from the practical standpoint of the computer user, the Semantic Web seeks to deepen the synergistic relationships between humans and computers through enabling computers to leverage *heuristic reasoning protocols* to better understand the "web of texts and pictures", which constitute the core information data banks that humans relate to and use. Heuristic reasoning in the context of the World Wide Web essentially involves computer applications making "educated guesses" about a user's information search and retrieval needs based on that user's previous web usage data. Computer applications utilizing heuristic reasoning analyze web users' past information search and data retrieval histories to make intelligent predictions and to enhance users' rule-based decision making. Thus, the Semantic Web can be best understood as the present, continuously evolving iteration of the World Wide Web that focuses on developing the web's unique *human-computer cooperation capacities* using artificial agents and heuristic reasoning. Intriguingly, the systematic use of information-based, artificial intelligence agents (individual agents and multi-agent systems) and heuristic reasoning as a means to better meet the continually growing demands of massive data searching, semantic data alignment, and accurate data

retrieval is creating new opportunities for education learning program designers and developers interested in applying semantic web and e-learning technologies to the field of education.

Multi-Agent Systems Use in Higher Education: Research and Development Initiatives and Practical Applications

In assessing the practical, real-world evolution of the Semantic Web and intelligent agent learning as a third "creative focus area" of digital learning design and development impacting the field of education, it is noteworthy that there are presently a number of research universities that are investing substantively in long-term research and development (R&D) program initiatives to develop and implement web-based, multi-agent systems using Semantic Web information search and data alignment/retrieval applications. For example, from the very inception of *artificial intelligence* as a field of research inquiry, Carnegie Mellon University in the United States has been and continues to be actively involved in conducting research in the application of artificial intelligence and digital computing to human problem solving. As a pioneering institutional leader in artificial intelligence research, Carnegie Mellon University has been in the forefront of progress in multiple artificial intelligence and multi-agent systems application areas, including generating breakthrough innovations in: 1) data representations and algorithms; 2) intelligent digital libraries; and 3) job-embedded robotic applications. Within the framework of artificial intelligence research as applied directly to the design and development of computer science systems, multi-agent systems technology has emerged as a specific area of "applied systems research" that holds considerable promise for expanding the abilities of computer software programs to solve complex problems. In multi-agent systems, *agents* or *agent-based systems* are essentially: "…sophisticated computer programs that act autonomously on behalf of their users, across open and distributed environments, to solve a growing number of complex problems. Increasingly, however, applications require multiple agents that can work together. A multi-agent system (MAS) is a loosely coupled network of software agents that interact to solve problems that are *beyond the individual capacities or knowledge of each problem solver* [emphasis added]" (Carnegie Mellon University Robotics Institute, 2012: Carnegie Mellon University School of Computer Science website "multi-agent systems" overview, retrieved at: https://www.cs.cmu.edu/~softagents/multi.html).

Carnegie Mellon University researchers highlight the fact that multi-agent systems research has a wide range of *real-world applications* in a number of areas, including: aircraft maintenance, electronic book buying coalitions, military demining, wireless collaboration and communications, military logistics planning, supply chain management, joint mission planning, and financial portfolio management (Carnegie Mellon University School of Computer Science). Carnegie Mellon's research and development project efforts in artificial intelligence design have focused primarily in two specific areas: 1) multi-agent systems and game theories; and 2) search, plan, and knowledge representation. In the

area of "multi-agent systems and game theory", Carnegie Mellon researchers have developed research projects focused on machine design, peer-to-peer negotiation, coalition formation, multi-agent reinforcement learning, and solving games. Other Carnegie Mellon research projects centered in the second area of "search, plan, and knowledge representation" include project initiatives focused on homeland security, distributed and probabilistic planning, learning domain-specific planning, and knowledge representation. Carnegie Mellon researchers have embraced a decidedly *interdisciplinary approach* in designing and conducting artificial intelligence and multi-agent systems research, as their research projects typically span across multiple university departments, including Carnegie Mellon's Computer Science Department, the Robotics Institute, the Machine Learning Department, and the Language Technologies Institute (along with other university departments, institutes, and learning centers).

In addition to research activities being conducted in the United States, researchers working in the Knowledge Media Institute (KMI) at the Open University of Britain are actively pursuing a number of "research themes" related to conducting applied research and investigating practical applications of the Semantic Web, intelligent agent learning technologies, and multi-agent systems (MAS) in multiple knowledge and learning domain areas, including: the future Internet; knowledge management; multimedia and information systems; narrative hypermedia; new media systems; Semantic Web and knowledge services, and social software (Open University Knowledge Media Institute, 2017; website: http://kmi.open.ac.uk/technologies/theme/semantic-web-and-knowledge-services/list/hot). These Open University KMI applied research activities include ongoing Semantic Web projects such as: 1) the "Annomation Project", focused on investigating the application of optimal Web 3.0 agent-based techniques for semantically annotating (using concept-based hyperlinking) the wealth of motion video—both full-length videos and segments of video—that is now ubiquitously available on the World Wide Web (Youtube videos, Hollywood movies, TV programs, iTunes University podcasts, etc.); 2) the "NewsRoom" project, centered on developing a modular platform for online television broadcast news capture, automatic segmentation, indexing, and browsing that leverages the information-organizing power of the Semantic Web and intelligent agent technologies to record, segment, and index online news for browsing, searching/finding, reading, and listening; 3) the "uBase Project", a multimedia and information systems project involving the use of intelligent agent technologies to enable the creative development of a web-based image and video navigation browser with a "unified interface" for enhancing content-based multimedia retrieval; and 4) "KMi Planet", a Semantic Web and Knowledge Services "online newspaper", powered and managed entirely by intelligent agent software, that digitally integrates the multiple tasks of soliciting, gathering, and formatting news stories and alerting readers on stories of interest. These applied research projects, along with many other projects engaged in by KMI researchers, concretely operationalize the Knowledge Media Institute's mission "…to be at the

forefront of research and development in a convergence of areas that impact on the Open University's very nature: Cognitive and Learning Sciences, Artificial Intelligence and Semantic Technologies, and Multimedia" (Knowledge Media Institute mission statement: http://kmi.open.ac.uk/).

The pioneering and ongoing project-based research and development efforts undertaken by higher education researchers at Carnegie Mellon University in the United States and the Open University of Britain are presented here simply as two examples of the kinds of leading-edge research and development activities that are being engaged in by multiple researchers and research teams at various universities and research centers around the world in the area of *artificial intelligence and multi-agent systems*. Importantly, these research activities in digital learning design and development in the area of computer science systems represent a significant *practical application* of artificial intelligence and intelligent agent learning technologies within and across several interdisciplinary fields of inquiry as a means to expand and enhance human problem-solving capacity in multiple learning domain areas and contexts.

5. Conclusion

In this article I have sought to highlight three "creative focus areas" that are continuing to drive innovations in digital learning technologies *design*, *development*, *and practical application* in the field of education. These three creative focus areas—namely: 1) simulations and virtual worlds; 2) MOOCs and open education; and 3) the Semantic Web and intelligent agent learning technologies—have already produced impressive innovative breakthroughs in digital learning designs and applications that are continuing to transform the ways in which people interact and learn together. These "twenty-first-century learning tools"—part of an expanding cyberscape of new and evolving digital learning technologies transforming the field of education—are empowering and enabling people of all ages to engage dynamically in technology-integrated and immersive learning projects that are enhancing their learning experiences while at the same time exponentially increasing their opportunities for *globally connected learning*.

In terms of their collective academic and practical social impact on the field of education, the new and evolving digital learning designs and applications that are emerging in the three creative focus areas highlighted in this article are significant for a number of important reasons. First, as a result of the wide applicability and adaptability of these new digital learning designs and applications, these new digital learning tools are directly impacting the scope and structure of curricula as well as instructional practices in multiple academic content areas in the field of education, including the humanities, social sciences, and STEM (science, technology, engineering, and mathematics) content areas. Secondly, these digital learning designs and applications are helping educators creatively expand their palette of useful instructional tools, and are encouraging educators to work proactively to explore the substantial "instructional application potential" of these digital tools as a means to further develop and turbo-charge their

twenty-first-century pedagogical skill sets. Thirdly, and more broadly, the evident usefulness of these new digital learning designs and related educational applications for expanding and enhancing quality learning opportunities for youth and adults is motivating professional educators across the elementary, secondary, and higher education spectrum to work diligently to reassess their own professional conceptions of the nature and purpose of teaching in the twenty-first-century "global classroom", including working to redefine—both in their own minds and in the minds of the students and education community constituents they serve—what constitutes authentically meaningful and effective *twenty-first-century teaching and learning environments*. As a result, educators in many countries around the world today are responding in positive ways to the availability of these new digital learning designs and applications through working actively to incorporate these digital tools and resources in context-appropriate ways into their instructional delivery strategies to further develop and refine their professional teaching practices. Finally, and perhaps most importantly, the hallmark attributes of these new kinds of digital learning designs and technologies—namely: *enhanced connectivity*, *accessibility*, *scalability*, and *collaboration*—are enabling these digital tools to facilitate a dramatic expansion in learning and career growth opportunities for both teachers and students.

Based on the promising developments that have already been achieved to date in each of these three "creative focus areas" and looking toward the future, it is anticipated that multimedia/web designers and developers will continue to leverage their design knowledge and skills to envision and realize yet even more exciting future iterations of these kinds of twenty-first-century *digital learning technologies*. Importantly, these twenty-first-century learning tools hold considerable promise as powerful means for continuing to expand the availability of robust, interactive teaching and learning opportunities for the world's growing populations of globally-connected digital learners.

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