E-Learning 3.0: anyone, anywhere, anytime, and *AI*

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The concept of e-Learning 2.0 has become well established and widely accepted. Just like how e-Learning 2.0 replaced its predecessor, we are again on the verge of a transformation. Both previous generations of e-Learning (1.0 and 2.0) closely parody the prevalent technologies available in their kin Web versions (1.0 and 2.0, respectively). In order to acquire a better perspective to assess what technologies will be available in the Web 3.0 and therefore e-Learning 3.0, we take a historical glance at the previous generations of e-Learning and the Web. We then survey some existing predictions for e-Learning 3.0 and finally provide our own. Previous surveys tend to identify educational needs for e-Learning, and then discuss what technologies are required to satisfy these needs. Educational needs are an important factor, but the required technologies may not reach fruition. Gauging past trends we take the reverse approach by first identifying technologies that are likely to be brought forth by the Web 3.0, and only then looking at how these technologies could be utilized in the learning domain. In particular, we pinpoint Artificial Intelligence (more specifically Machine Learning and Data Mining) as a major driving force behind the Web 3.0. We therefore examine the influence that AI might exert on the development of e-Learning 3.0.

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1 Introduction

In 2005, Stephen Downes [8] published a seminal article describing the next stage in the development of e-Learning, namely e-Learning 2.0. He noted that "e-Learning as we know it has been around for ten years or so. During that time, it has emerged from being a radical idea – the effectiveness of which was yet to be proven – to something that is widely regarded as mainstream." The shift to e-Learning 2.0 was due to the emergence of Web 2.0 and the resulting emphasis on social learning and use of social software such as blogs, wikis, podcasts and virtual worlds [24, 32, 9].

Just like the original concept of e-Learning, e-Learning 2.0 has become a mature and widely accepted paradigm, and like its predecessor before it, is now due for change. If the past is any indicator of the future, then the emergence of e-Learning 3.0 will also be strongly influenced by the technologes that will bring forth the Web 3.0. The concept of Web 3.0 is still in its infancy, but we are starting to see a number of early indicators that Artificial Intelligence (AI) will become an integral part of the Web 3.0.

The Web 2.0 has enabled large scale user-generated content production. However, large parts of this data are simply stored away and are rarely, if ever, utilized by others (e.g. 97% of users never look beyond the top three search results [26], so millions of carefully crafted documents are never even looked at). Clearly this situation needs to be remedied, we beleive that one of the main objectivess of the Web 3.0 would be to enable utilization of this data, and AI will be a perfect tool for accomplishing this.

The paper is organized as follows. First, we briefly outline the influence that web technologies have had on the evolution of e-Learning (Section 2). We then survey the views of other researchers about what e-Learning 3.0 might be like (Section 2.3). Finally we outline new developments in AI and their potential influence on the evolution of e-Learning 3.0 (Section 3).

2 Evolution of e-Learning

E-learning has been evolving alongside the World Wide Web. As new web technologies become available, they find their way into the education domain, which by applying these new technologies makes it possible to both utilize new learning methods, and to enhance the use of the existing ones. Simply put, new web technologies enable the application of learning theories to eLearning. If we can understand this trend, then we can better understand the future of e-Learning. The best way to understand this trend, is to first look at it historically, by taking a quick look at where it has been (Section 2.1, Section 2.2). Then we can better assess existing predictions about where it is heading (Section 2.3), and make our own predictions as well (Section 3).

2.1 E-Learning 1.0

Web 1.0 made content available online. This was a very significant development since it allowed (at least in principle) for easy access to view (or read) information. However, this "access" is often seen as the staple functionality available with the Web 1.0, which is why it is often referred to as the "read-only Web" [27]. E-Learning 1.0 quickly adapted this new technology. The motto "anytime, anywhere and anybody" emphasized characteristics of e-Learning 1.0 – providing easy and convenient access to educational contents [9]. Therefore, e-Learning 1.0 mostly focused on creating and administering content for viewing online. To ensure high quality and usefulness of created "read-only" materials, the concept of a "learning object" was developed. Learning objects could be thought of as Lego blocks that allow for sequencing and organizing bits of content into courses, and to package them for delivery as though they were books or training manuals [8]. In turn, to support the utilization of learning objects the concept of a learning management system (LMS) was introduced. The learning management system takes learning content and organizes it in a standard way, such as a course divided into modules and lessons, supported with quizzes, tests and discussions, and integrated into university's information system [8]. These frameworks allowed not only to provide access to educational materials but also to log and analyze their usage. This in turn, allowed for an for application of a number of learning theories and methods, including instructivism, behaviorism, and cognitivism, each briefly summarized below.

Instructivism focuses on transferring content from teacher to learner [23]. Utilizing the web for content distribution provides an alternative channel to lectures and textbooks. This theory requires the student to passively accept information and knowledge as presented by the instructor, which made it a particularly good fit for rather passive LMS of the Web (and e-Learning) 1.0.

Behaviorism treats learning as a "black box" process, i.e. only the inputs and corresponding outputs are observable quantitatively, and the inner workings of the learning process are assumed to be unknown. It is based on the principle of stimulus-response, and learning is viewed as an acquisition of new behavior through either classical conditioning, where the behavior becomes a reflex response to stimulus as in the case of Pavlov's Dogs, or operant conditioning, where there is reinforcement of the behavior by a reward or punishment [19]. Behaviorism emphasizes performance rather than the reasons that the learner performs a certain way [6]. The interactive capabilities of LMS 1.0 systems were primarily based on the behaviorism. LMS logs were used to observe: "input" through the access logs of learning materials, "output" through the advancement and performance measures, as well as system's attempts at conditioning. Once this data is analyzed the necessary adjustments could be made as to condition the learning process more efficiently.

Cognitivists were not satisfied with treating learning as a black-box process, and by analyzing learning logs tried to gain better understanding of the inner workings of the mind during the learning process [19] . The obtained knowledge was then incorporated into LMS as to take into consideration what has became known about the processes of learning, such as thinking, memory, knowing, and problem-solving.

2.2 E-Learning 2.0

In addition to the ability of reading contents online (provided by Web 1.0), Web 2.0 introduced a capability to write (or save content) and is therefore commonly referred to as the "read-write web" [8, 27]. The capability to write content allowed for the transformation of the web from a passive provider of information to a social platform that allowed people to interact and collaborate with each other by expressing their thoughts and opinions online. Utilizing these new capabilities allowed e-Learning 2.0 to incorporate the social aspects of learning theories [4, 20].

Constructivism views learning as a process of knowledge construction rather than absorption [11, 6]. It is often associated with pedagogic approaches that promote active learning or learning by doing [19]. The use of Web 2.0 technologies allowed incorporation into LMS 2.0 the capability to allow students not only to passively read educational materials, but also to express opinions and to socialize [19]. This functionality made it possible to include ambiguous situations and open-ended questions which further promoted extensive dialogues among students [19, 31]. Overall, this allowed for the embedding into learning environments the cornerstones of constructivist learning: context, construction, and collaboration [14, 31].

Social Constructionism focuses on the artifacts that are created through the social interactions of a group, unlike social constructivism which focuses on an individual's learning that takes place because of their interactions in a group [32]. This motivated the incorporation of wikis and social networking services (SNS) into LMS 2.0, which enabled both the collaborative construction of artifacts and the corresponding examination and analysis of created artifacts [31].

2.3 E-Learning 3.0: Survey of Predictions

The predictions of the future of e-Learning vary due to the differences in opinions of what the Web 3.0 will be like, and which technologies will best suit the needs in the learning domain.

[30] considers that the Web 3.0 will be the "Read/Write/Collaborate" web. E-Learning 3.0 will have at least four key drivers: distributed computing, extended smart mobile technology, collaborative intelligent filtering, 3D visualization and interaction. Distributed computing in combination with smart mobile technology will enable learners to come closer to "anytime anyplace" learning and will provide intelligent solutions to web searching, document management and organization of content. It will also lead to an increase in self-organized learning, driven by easier access to the tools and services that enable us to recursively personalize our learning. Collaborative intelligent filtering performed by intelligent agents will enable users to work smarter and more collaboratively. 3D visualization and interaction will promote rich learning, by making a whole range of tasks easier including fine motor-skill interaction, exploration of virtual spaces and manipulation of virtual objects.

[12] considers that e-Learning 3.0 will be both "collaborative" and "intelligent". Intelligent agents will "facilitate the human thinking greatly". Collaboration will be further improved by tools like Twitter due to a number of its "communicative conceptual characteristics"; a place to share and consume information, a new real-time search engine, a service for Web users, a platform of debate, a tool for listening and analyzing, a perfect traffic generator, an excellent means to meet new people and create new connections, and talk about what you are doing right now.

[21] suggests that in e-Learning 3.0, meaning will be socially constructed and contextually reinvented, and teaching will be done in a co-constructivist manner. The focus of learning will shift from "what to learn" to "how to learn". The technology will play a central role, however it will do so in the background and become invisible. Technology will connect knowledge, support knowledge brokering, and enable translation of knowledge to beneficial applications.

[25] considers that e-Learning concept of "anytime, anywhere and anybody" will be complemented by "anyhow", i.e. it should be accessible on all types of devices. Virtual 3D worlds such as SecondLife are expected to become a common feature of the 3D web, facilitated by the availability of 3D visualization devices. As a result, e-Learning 3.0 will be able to reach a wider range and variety of persons being available on different kinds of platforms/systems, through different tools, where users will have the possibility to personalize their learning and have an easier access to comprehensive information. This situation may turn e-Learning into a cross-social learning methodology since it will be possible to be applied in all contexts, making collaboration easier. To enable this view of e-Learning 3.0 [25] considers that LMS systems need to be capable of representing information through metadata, granting semantics to all contents in it, giving them meaning.

[7] considers that machine-understandable educational material will be the basis for machines that automatically use and interpret information for the benefit of authors and educators, making e-Learning 3.0 platforms more adaptable and responsive to each individual learner.

A number of researchers express concerns about the issues that will arise with the advent of e-Learning 3.0. [3] warns that the evolution of e-Learning management systems significantly enhances ethical dilemmas, and advocate for the adoption of an extension of the "Three Ps" model of pedagogy to become the "P3E" model: personalization, participation, productivity, lecturer's ethics, learner's ethics, and organizational ethics. [17, 12] are concerned that e-Learning will be impacted by some of the challenges of the Semantic Web including vastness, vagueness, uncertainty, inconsistency, and deceit. [2] expresses concerns about the privacy and loss of control, as university integrates into its infrastructure services that are located in a variety of countries, with different privacy laws and principles.

3 E-Learning 3.0: Intelligent Learning

The existing forecasts about where e-Learning 3.0 is heading tend to focus on educational aspects (Section 2.3), and only briefly mention technical aspects. We take a different approach; since from past transformations (e-Learning 1.0 and e-Learning 2.0) we saw its close relationship with the available technologies of the current generation of the World Wide Web. The challenge then is to correctly identify which technologies will be brought forth by the Web 3.0 (Section 3.1). We then hypothesize how these technologies may be utilized in e-Learning 3.0 (Section 3.2).

3.1 Artificial Intelligence

Since the inception of Artificial Intelligence (AI) there has been a lot of hopes riding on it. While AI technologies have succeeded in many areas, in other areas AI has dramatically fallen bellow expectations and resulting in so-called AI winters (characterized by severely reduced funding and interest) during the 1970's and then again in the late 1980's. Most of AI's success so far has been primarily in 'restricted' domains where rules, settings and objectives are well defined, e.g. chess. In more open-ended domains such as education, the success of AI has been limited. This limitation primarily comes from the fact that open-ended domains are inherently more complex and therefore an AI system needs to contain a lot of parameters, which in turn require a lot of data for estimation and as a result require significant amounts of computational power.

We think that this time around AI will be able to succeed and to match a lot of expectations. Crucial components needed for the AI to succeed in more general open-ended domains starting to fall in place. There is a vast amount of data of available, importantly a lot of this data is "open" to a wide audience, i.e. not hidden behind the corporate or institutional walls (Big Data, Section 3.1.1). No matter how vast the dataset is it tends to provide a limited view on the problem. New technologies are allowing to establish links between these datasets as to obtain a more complete picture (Linked Data, Section 3.1.2). The significant infrastructure needed to store and intelligently process this data is now becoming easily accessible and affordable (Cloud Computing, Section 3.1.3) The new scientific framework is becoming available for supporting AI in the process of scientific discovery (Data-driven Science, Section 3.1.4).

3.1.1 Big Data

Recently, vast datasets are becoming openly available due to increase in user generated data brought forth technologies provided by Web 2.0. The type of data that is being generated also differs, larger portions of it are user generated such as blogs, tweets, and wikis. To emphasize the importance of the role that data is expected to play, Tim Berners-Lee has suggested that the next generation of Web should be referred to as "Data Web" [16]. Currently web data is severely underutilized, e.g. 97% of users never look beyond the top three search results [26], so other millions of carefully crafted documents are never even looked at. Web data contains a precious resource – intelligence and is therefore often referred to as "Web Intelligence" [33]. This intelligence needs to be extracted and utilized, and AI is a perfect tool for accomplishing this objective. We consider that the role of Web 2.0 was to enable data production, and the role of Web 3.0 will be to enable utilization of this data.

3.1.2 Linked Data

Web 2.0 Data exhibits different characteristics, it is no longer stored in a central well structured databases, but is in a free-form, fragmented and is spread across the internet. One of the objectives of the next generation web was defined as to create "a web of data that can be processed directly and indirectly by machines"[16]. Semantic Web is often considered a popular choice for accomplishing this task [16]. However, we along with many others e.g. [18] believe that semantic linking is overly ambitious and is yet hard to achieve on the wide and general scale due to inherent ambiguity of natural language. However, this does not mean that the data could not be linked and utilized. In order to widen the linking objectives the concept of "Linked Data" has been recently developed [10]. There has been a number of success of using AI to produce the needed links that even captures some of the semantics e.g. folksonomy [13].

3.1.3 Cloud Computing

Processing and analyzing large quantities of data requires significant computational resources as well as frameworks to make these resources easily accessible. A variety of competitively priced cloud computing services are becoming available, e.g. Amazon's AWS, Google's App Engine, Microsoft's Azure to name a few. In addition a number of supporting frameworks has been developed that made the power of computational clouds easily accessible, e.g. a widely adopted Hadoop/MapReduce, and a more specialized ones such as Mahout, Hive, Pig, Oozie, and Rhipe.

3.1.4 Data-driven Science

Large data sets (Section 3.1.1) can potentially provide a much deeper understanding of both nature and society [1]. As a result, social scientists are getting to the point in many areas at which enough information exists to understand and address major previously intractable problems [15]. As a result, science is becoming data-driven at a scale previously unimagined and is fundamentally transforming the scientific process and is driving new innovations in science [22].

The traditional scientific process has followed a top-down approach of starting with a hypothesis, collecting the needed data, and finally evaluating the hypothesis. Data collection has traditionally been a very expensive and time consuming process. Therefore starting collecting data without having a hypothesis in mind was a very risky endeavor. Recently large number of datasets have become available for little or no cost, in addition collecting your own data has become very inexpensive (e.g. [28] have assembled a dataset of 20 million tweets on various aspects of learning for under $10). Having vast amount of data available, allowed to make scientific process a bottom-up approach, i.e. by first gathering data, and then performing analysis as to discover hypotheses hidden within the data.

Data-driven science is starting to gain a foothold in the education, as indicated by the rapid development and increasing applications in the new areas of educational data mining (EDM) [5] and learning analytics [29].

3.2 Potential AI Utilization by Learning Methods

The traditional approach to constructing e-Learning systems has been a time consuming process requiring an explicit implementation of all the assumptions and rules. Adapting AI in e-Learning may allow us to concentrate more on modeling rather than a tedious implementation of all the rules. Maintenance and adaptation cost will also be reduced, since by using the data-driven approach, the model is able to adapt to the new users and contents, as well as potential changes. However, due to the open-ended nature of learning, applying AI is not always straightforward. In the following paragraphs we outline some possibilities.

Out of all learning theories, application of AI to behaviorism is one of the most straightforward ones. This is because behaviorism treats learning as a "black box" process, i.e. only the inputs and corresponding outputs are observable quantitatively, and the inner workings of the learning process are assumed to be unknown [19]. Behaviorism emphasizes performance rather than the reasons that the learner performs a certain way [6]. This paradigm fits perfectly with AI, as a main goal of AI is to model the dependency between inputs and outputs. Once the model is obtained the inputs needed for the desired response could be obtained by applying methods based on stochastic optimization or control theory.

Cognitivisim in a way similar to behaviorism takes an objective approach by assuming that knowledge and learning tasks can be identified and performance can be measured, and the objective of education is to analyze and influence thought processes [31]. Given these similarities, AI methods could be applied to cognitivism in manner that is similar to behaviorism, but in addition, the explicit assumptions of cognitivism on how we store and manipulate informations need to be incorporated which could be achieved by utilizing existing cognitive models.

Unlike behaviorism, many of the learning theories aim at understanding the inner workings of the learning process; therefore applying black-box models is not suitable. However there are a number of white-box machine learning methods whose inner workings could be easily examined, analyzed, verified and extended, e.g. graphical models such as decision trees and bayesian networks, or rule based methods such as inductive logic or association rule learning.

Social aspects of learning could be thoroughly studied thanks to the data available from e-Learning and Web 2.0 tools. Moreover since collaborative tools are often used in an informal, self-driven manner, it allows to better understand collaborative behaviors outside of confines of classrooms and formal educational institutions; which previously was difficult if not impossible to do. There is a multitude of methods which could be applied to better understand collaborative behaviors. Network analysis could be used for examining structural dynamics of collaboration; natural language processing along with network flow models could be used to better understand knowledge diffusion.

Constructivism considers that learning and teaching is an open-ended process, unlike objective methods such as behaviorism and cognitivism [31]. Open-ended and vague nature of constructivism makes it difficult to analyze. Since there are no clear objectives, traditional supervised learning methods are not applicable. However, unsupervised learning methods do not require an explicit objective and therefore are applicable in these settings. By using unsupervised methods it is possible to find and analyze patterns that may allow to further enrich constructivst view of learning.

Having e-Learning systems that are AI and data-driven, by no means precludes from utilizing and including existing pedagogical knowledge. Quite the opposite, existing knowledge can and should be incorporated into e-Learning systems. However, its influence on systems decision and its interdependency with others parts of the model should be estimated and verified based the data, rather than try setting these parameters via "educated" guessing. A possible way of incorporating existing knowledge is by providing data on features that are considered important in the learning process (e.g. difficulty level of learning materials, student's learning type, etc.). If the data on the feature is already available it could be simply fed into the AI system; if not, feature mapping too can be learned from the data.

4 Conclusion

The Web 2.0 has enabled the generation of a substantial amount of data, both by users and about users. While this data holds substantial value, it is often severely under-utilized, by simply being stored away or even worse – discarded. We believe that the Web 3.0 will help users to sift and sort this mass of information by utilizing AI. In the domain of e-Learning, AI will likely be used not only for assisting learners, but also for gaining a deeper understanding of the learning process.

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