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Chapter 14

Artificial Intelligence in Education:
Current Insights and Future Perspectives

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ABSTRACT

Though only a dream a while ago, artificial intelligence (AI) has become a reality, being now part of our routines and penetrating every aspect of our lives, including education. It is still a field in its infancy, but as time progresses, we will witness how AI evolves and explore its untapped potential. Against this background, this chapter examines current insights and future perspectives of AI in various contexts, such as natural language processing (NLP), machine learning, and deep learning. For this purpose, social network analysis (SNA) is used as a guide for the interpretation of the key concepts in AI research from an educational perspective. The research identified three broad themes: (1) adaptive learning, personalization and learning styles, (2) expert systems and intelligent tutoring systems, and (3) AI as a future component of educational processes.

INTRODUCTION

From a futuristic point of view, AI has emerged as a key feature in what appears to be a science fictional future, one in which users interact and learn with hard and soft technologies. In seeking to gain insight into technology's importance, it is apparent that many AI-based applications have become part of our routines. As underlined by Housman (2018), "AI is capable of two things: (1) automating repetitive tasks by predicting outcomes on data that has been labeled by human beings, and (2) enhancing human

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decision-making by feeding problems to algorithms developed by humans" (para. 50). In other words, AI learns the given commands by performing the tasks repeatedly and manages to somehow generate a decision pathway for humans by offering alternatives.

GENERAL OVERVIEW OF ARTIFICIAL INTELLIGENCE (AI)

Definition of AI

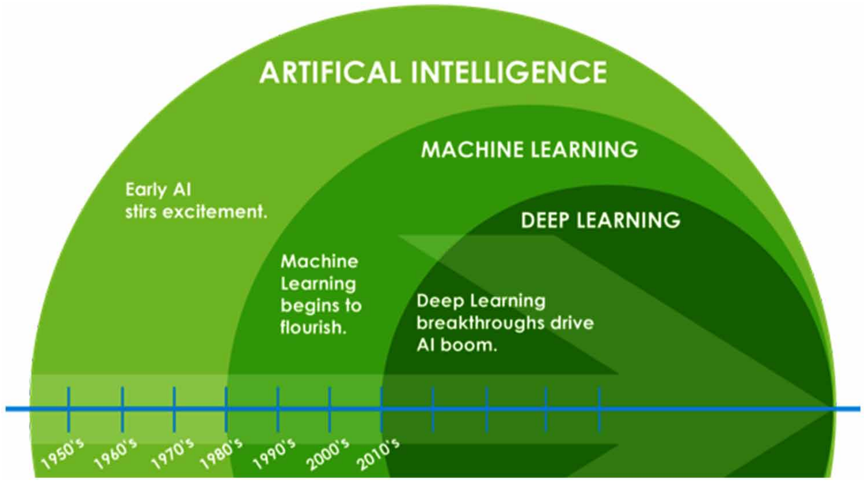
Nabiyev (2010) roughly defines AI as *the ability of a computer-controlled device to perform tasks in a human-like manner*. As indicated by the author, human-like qualities include mental processes like reasoning, meaning making, generalization, and learning from past experiences. Russell and Norvig (2003) describe the term AI as *Machine Intelligence,* or *Computational Intelligence,* that embraces various subfields wherein learning takes place and "specific tasks, such as playing chess, proving mathematical theorems, writing poetry, and diagnosing diseases, can be performed" (p. 2). Nilsson (2014) defines AI as the entirety of an algorithmic construction copying human intelligence. To Nilsson (2014), AI embraces the construction of the information-processing theory of intelligence. In other words, raw data, received from any user, is filtered by a device, made meaningful, and processed before finally becoming *cooked data* capable of meeting the demands of users.

There have been mind-blowing developments in the evolution of AI and the remarkable role it has played in human lives. Recently, there have been some concrete examples of AI being capable of learning how to think like a human. These examples have even demonstrated that AI-based applications, in some cases, can even function as better as humans. For example, in 2016, Google DeepMind's AlphaGo defeated one of the world's most accomplished "Go" players, Lee Se-Dol, a South Korean champion (Sang-Hun, 2016). As the greatest proof of AI's human-like thinking and skills, the result of this match shows that a true artificially-intelligent system is one that can learn on its own (Adams, 2017).

VITAL TECHNOLOGIES THAT SUPPORT THE VISIONS OF AI

The below-given figure presents the chronological development and relation between Artificial Intelligence, Machine Learning and Deep Learning from 1950 to 2010 and beyond. As Figure 1 shows, AI, as a broad and advanced term for computer intelligence, started to be discussed between the 1950s and 1980s, which was followed by the introduction of Machine Learning technology between the 1980s and 2010, where learning through algorithms was brought to the agenda, and finally, after 2010, Deep Learning emerged as a breakthrough technique for implementing Machine Learning via neural networks to complete tremendously complex thinking tasks. In this context, the following sections examine the two vital technologies of machine learning and deep learning to better comprehend and explore the world of AI. In addition, Natural Language Processing (NLP) and one of its best examples, intelligent personal assistants, is discussed in detail.

Figure 1. The relation between artificial intelligence, machine learning and deep learning (Copeland 2016)



Machine Learning (ML)

Artificial intelligence, as an umbrella term, has its sub-branches, like ML. As pointed out by Rob (2017) in his blog, AI is a concept that points to the direction we're headed, not a position we've already reached; therefore, we need to specify it more precisely, with notions like ML. At the most basic level, machine learning seeks to develop methods for computers to improve their performance at certain tasks based on observed data (Ghahramani, 2015). With ML, objects, faces, words and even the value of a stock or who can buy what can be identified (Gürsakal, 2017). Simply put, ML is a system in which existing data is used for future predictions.

ML algorithms seem to achieve more accurate information if they are trained in the right way. According to Brynjolfsson and Mitchell (2017), in many cases, today, "ML algorithms have made it possible to train computer systems to be more accurate and more capable than those that can be manually programmed" (p. 1531). Similarly, Gori (2017) believes that ML is an attempt to construct intelligent agents for a given learning task on the basis of artificial models largely rooted in computational models. To Copeland (2016), ML is an approach that involves steps of learning to reach a final prediction. In this learning system, the machine is *trained*, by parsing data, to discharge a task given by a user. As indicated by Jordan and Mitchell (2015), ML as an aspect of AI, has emerged as "the method of choice for developing practical software for computer vision, speech recognition, natural language processing, robot control, and other applications" (p. 255). Various data are gathered to provide access to information on globally offered products, so everyone can act on it. As specified by Alpaydın (2016), the data is not just numbers anymore; it consists of texts, images, videos, ranks, frequencies, gene sequences, sensor arrays, click logs, and lists of recommendations. In other words, the data received from the users are more complex than is known by most people. However, if more data is collected and analyzed, more accurate decisions can be made. Jordan and Mitchell (2015) noted that "mobile devices and embedded computing permit large amounts of data to be gathered about individuals, and machine-learning algorithms can learn from these data to customize their services to the needs and circumstances of each individual" (p. 257). In effect, this means that it may take time for a machine to understand the structure of a human being. However, even though a hundred percent recognition has not yet been realized, over time, the machine may come to a level where it can imitate humans. Algorithmic-based instructions, created using mathematical and statistical methods and codes that are trained to accomplish a specific task, are used in ML.

Deep Learning (DL)

It is still uncertain how machines can be made to think, reason, and make sense of the world in the same way humans do. However, as machines get more intelligent, serve humanity and appear in many fields, they seem to be more accepted as part of our human reality. Deep Learning (DL), a relatively new technology in the realm of ML, involves the complex attempt to unravel human levels of perception and cognition.

DL is a sub-branch of ML and was first introduced as a concept by Alan Turing in 1950. While the studies that Turing had been conducting during those years were mainly related to neural networks, they helped to give rise to the issue of machines' ability to think. The idea of machines having the same characteristics of human intelligence evokes the sense that we are in a science fiction movie. Living within this frightening state of affairs, where we are unable to decide whether the person with whom we communicate is a real person or a virtual device, is indeed evidence that DL has taken place in science.

As described by Shaikh (2017), "deep learning is a particular kind of machine learning that achieves great power and flexibility by learning to represent the world as a nested hierarchy of concepts, with each concept defined in relation to simpler concepts, and more abstract representations computed in terms of less abstract ones". According to Copeland (2016), DL enables many practical applications of ML, where the variety of tasks is limited. In DL, there are many layers, where all sorts of shapes and images can be taken and input into the layers of the neural network in a particular order. The final output can be produced by passing all the previous tasks into different layers until the final outcome is reached. In one of his podcast series, Will Ramey, NVIDIA Senior Manager for GPU Computing, mentions that DL, unlike ML technology, works on very specific tasks, like classifying different types of images, similar to what Facebook does with its facial recognition, digital marketing, where predictions about what a user may prefer to purchase can be made by the device, and medical imaging, to locate tumors or determine their stage. Therefore, with the rapid adoption of DL, a human level of accuracy has been reached through neural networks that use big data collection.

Natural Language Processing (NLP)

Hirschberg & Manning (2015, p. 261) describe "Natural Language Processing (NLP), also known as computational linguistics, as a subfield of computer science that is concerned with using computational techniques to learn, understand, and produce human language content". Similarly, Nabiyev (2010) sees "NLP as an area of engineering, for designing and implementing computer systems for which natural language analysis is the main function" (p. 431). The assistants are used to perform a task controlled by software which has an expanded and optimized database algorithm. For many algorithms, where a combination of words is involved in the search process, "a collection of knowledge and a control mechanism to resolve a specific problem in a systematic fashion are required" (Tanwar, Prasad & Datta, 2014, p. 56). Requiring the combination of human learning and machine reasoning, the process aims to comprehend user-given verbal or written commands that require automatic response, text translation and speech generation.

As an interaction medium, language is a composite tool that allows the transmission of existing messages through words. According to Cambria and White (2014), NLP is a theory-motivated range of computational techniques for the automatic analysis and representation of human language via virtual entities. As discussed by Kumar et al. (2016), question answering is a complex natural language processing task which requires an understanding of the meaning of a text and the ability to reason over relevant facts. Regarding the interaction between humans and non-human entities, question answering can be a complex process for virtual beings. As highlighted by Nilsson (2014), it can be very hard for a computer system to become capable of generating and understanding fragments of a natural language, such as English, because of encoding and decoding obstacles. The same writer mentions that many researchers have focused on creating computer programs that are capable of understanding expressions in English, such as ELIZA by Weizenbaum, SIR by Raphael, BASEBALL by Newell, Shaw and Simon, SAD SAM by Lindsay, SYNTHEX by Simmons, and STUDENT by Bobrow (Nilsson, 2010).

According to LeCun, Bengio, and Hinton (2015), natural language understanding is an area that should be observed within the context of DL, as DL and simple reasoning have been used for speech and handwriting recognition for quite some time. The central idea of "DL is that if we can train a model with several representational levels to optimize a final objective, such as translation quality, then the model can itself learn intermediate representations that are useful for the task at hand" (Hirschberg & Manning, 2015, p. 261). However, the logic behind DL should be clarified, as "new paradigms are needed to replace rule-based manipulation of symbolic expressions by operations on large vectors" (LeCun, Bengio, & Hinton, 2015, p. 9).

Voice recognition, voice analysis, and language processing can be regarded as the common features of Intelligent Personal Assistants (IPAs). Therefore, we can visit this concept to see just how capable AI can be in understanding and communicating with human beings.

Intelligent Personal Assistants (IPAs)

The advances that have been made in technology have allowed life to be more entertaining for users. In the light of these advances, daily life routines can be fulfilled in an easier way with IPAs. As emphasized by Eric Enge (2017), the personal assistant feature has been available on smartphones since Siri's launch in October 2011, Google Now's appearance in 2012 and Cortana's introduction in 2013.

Developed within the scope of artificial intelligence, IPAs and the services they offer have started to be used in daily life, business, health, and education. This big internet revolution brought a new paradigm, where people and machines can communicate among themselves (Santos, Rodrigues, Casal, Saleem & Denisov, 2018). This form of speech-based interaction allows users to feel like they are communicating with a real individual. With the recent boost in Artificial Intelligence and Speech Recognition technologies, the Voice Assistant, also known as the Intelligent Personal Assistant, has become increasingly popular as a human-computer interaction mechanism (Zhang, et al., 2018).

When we look at the progress made so far, it becomes clear that AI has long existed in the field of education (Bozkurt & Göksel, 2018). As stated by Johnson, Rickel & Lester (2000), pedagogical agents like STEVE (Soar Training Expert for Virtual Environments) and ADELE (Agent for Distance Learning: Light Edition) are "beginning to perform a variety of tasks in surprisingly lifelike ways", and these small prototype systems have quickly become practical (p. 31). Recently, educational approaches have focused on the use of technologies in classrooms. Smartphones, for instance, offer many IPA applications on different platforms, such as Siri on IOS, Cortana on Windows, Google Now, My Assistant, Google Allo, Robin, Databot, Indigo (Lyra), and Smart Voice Assistant on Android, all of which could also be used for improving English language to foster speaking skills (Charisma et al., 2018). Current IPAs differ in "their interface designs, hardware requirements, and the types of tasks they are designed for" (Lopatovska et al., 2018, p.3). Therefore, each device should be examined separately to see how the tasks can serve to foster English learning. Voice-activated devices, such as Alexa, may fill existing gaps in users' information, entertainment, educational, social and other needs; however, its positioning and unique value compared to alternative IPAs (such as Apple's Siri and Google Assistant/Now apps) require further examination (Lopatovska et al., 2018).

There have been similar studies conducted to analyze how IPAs that employ voice commands, physical touch gestures, and other interaction signals can be more effective, in terms of facilitating a more practical way to communicate, by using search dialogue. As underlined by Kiseleva et al. (2016) this method of interaction is a more natural way for people to communicate and is often faster and more convenient (e.g., while driving) than typing. The IPAs can be a particularly convenient tool to help people who are in an eyes-busy, hands-busy situation that retain them to access to a keyboard and/or a monitor (Nielsen, 2003). In such cases, it is more practical to use IPAs that have a voice recognition feature, as this would provide users with a realistic person-to-person interaction and human-like entity.

METHODOLOGY

Purpose of the Research

The main purpose of this research is to identify areas of AI within the educational context. In line with this purpose, this chapter seeks to answer the following research question

- What are the key concepts in AI in educational papers?
- What promise does AI hold for the future of education?

Method and Research Design

To achieve the purposes of this study, data mining and analysis are performed, and a social network analysis (SNA) is conducted to better understand the research findings. SNA can be used to study, track, and compare the dynamics of communities and the influence of individual contributions. SNA provides powerful ways to map, summarize and visualize networks and to identify key vertices "that occupy strategic locations and positions within the matrix of links" (Hansen, Shneiderman and Smith, 2010, p. 5).

Sampling

The sample for this study included a total of 393 papers published between 1970 and 2018. In terms of the type of papers included, 210 were conference proceedings, 173 were journal articles, and 10 were book chapters. Publications that were written in English, indexed in Scopus, and had "artificial intelligence" in their title and "education" in their title, abstract, or keywords were included in the research.

Social Network Analysis (SNA)

The keywords of the articles constituting the research corpus were analyzed according to their co-occurrence. In this regard, a total of 597 keywords were analyzed through SNA. To gain a concentrated view, the first 79 keywords, at a minimum degree of 10, were displayed on a sociogram (Figure 2). The graph's vertices were grouped by cluster using the Clauset-Newman-Moore cluster algorithm (Clauset, Newman and Moore, 2004) and laid out using the Harel-Koren Fast Multiscale layout algorithm (Harel & Koren, 2001).

The research findings indicated that AI- and Education-related keywords are related as presented in Figure 3. Following the SNA, the identified related keywords were grouped under three broad themes to better understand the outlook for AI in education.

FINDINGS

This section presents the three themes identified (adaptive learning, personalization and learning styles; expert systems and intelligent tutoring systems, and; AI as a future component of educational processes) and explains how they refer to education.

Figure 2. SNA of the keywords of the sample publications

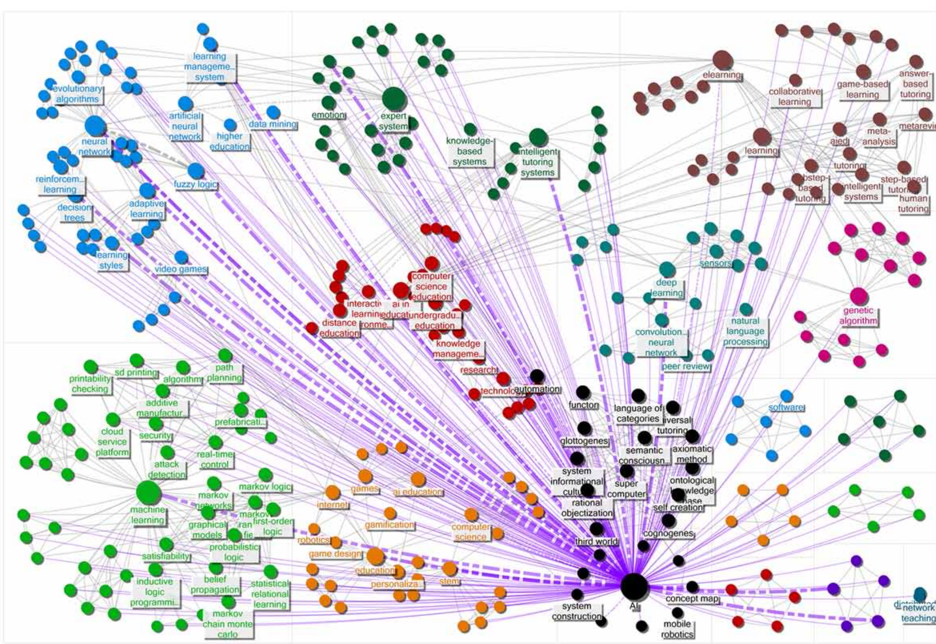


Figure 3. AI- and education-related keywords in terms of degree centrality and betweenness centrality

Keyword	Degree Centrality	Betweenness Centrality
AI	429	163690.241
Expert system	56	5743.120
E-learning	33	8831.566
Intelligent tutoring systems	28	3259.991
Education	26	3604.140
Learning	25	8676.371
Adaptive learning	18	860.647
AI education	15	3126.966
Game-based learning	14	2142.492
Personalization	13	2531.434
Reinforcement-learning	13	2146.245
Undergraduate education	13	1451.276
Distance education	12	1515.142
Learning management system	12	74.786
Learning styles	11	8.381
Interactive learning environment	10	380.011
Answer-based tutoring	10	0.000
Human tutoring	10	0.000
Tutoring	10	0.000

Adaptive Learning, Personalization and Learning Styles

For the first theme, the research findings revealed that the keywords *adaptive learning* (DC:18; BC: 860.647), *personalization* (DC:13; BC;2531), and *learning styles* (DC: 11; BC: 8.38) are key nodes in the AI network. As illustrated in the graph, adaptive learning is one of the key concepts related to AI.

Adaptive learning (Aroyo et al., 2006; Paramythis and Loidl-Reisinger, 2003) through personalization (Chen, 2008; Pane, Steiner, Baird, and Hamilton, 2015) and consideration of learning styles (Brown, Cristea, Stewart, and Brailsford, 2005; Kolb and Kolb, 2005) emerge as the focal point of AI research in the educational context. This theme indicates that AI implementations in education intend to provide learning spaces that meet the learners needs and provide learning opportunities according to the learning preferences of the learners. That is, rather than adopting a "one size fits all" approach, the use of AI in education allows for tailored learning by positioning the learners at the center of the learning environments.

Expert Systems and Intelligent Tutoring Systems

For the second theme, the research findings revealed that the keywords *expert systems* (Degree Centrality: 56; Betweenness Centrality:5743), *intelligent tutoring systems* (DC: 28; BC: 3259.991), *answer-based tutoring* (DC:10 ; BC: 0.00), *human tutoring* (DC:10 ; BC: 0.00), and *tutoring* (DC:10; BC: 0.00) are key nodes in the AI network.

An expert system (ES) can be defined as a program designed to emulate and mimic human intelligence, skills or behavior, while an intelligent tutoring system (ITS) can be defined as a program that aims to provide immediate and customized instruction or feedback to learners. ES (Collins, 2018) and

ITS (Wenger, 2014) are terms that are at the forefront of the developments in AI research (Burns & Parlett, 2014). ES has started using advanced algorithms, while ITS has been able to provide human-like interaction with conversation style dialogues. The potentials of ES and ITS emerge from the idea that they can be used 24/7 to support, enhance, enrich and amend learning processes.

AI as a Future Component of Educational Processes

For the third theme, the research findings revealed that the keywords *eLearning* (DC:33; BC: 8831.566), *education* (DC: 26; BC: 3604.140) *learning* (DC: 25; BC: 8676.371), *AI education* (DC: 15; BC:3126.966), *undergraduate education* (DC: 13; BC: 1451.276), and *distance education* (DC: 12; BC: 1515.142) are key nodes in the AI network.

The use of AI in education has resulted in significant progress in theory and practice in the new millennium (Roll & Wylie, 2016). There are alternative routes and scenarios for integrating AI to educational processes (Devedžić, 2004), with a special focus being online learning and distance education (Kose, 2015). For example, Lin, Wooders, Wang and Yuan (2018) suggest that AI can be used as a solution to increase efficiency in online learning and to "engage and connect students with each other and their instructors in asynchronous online environments that break through spatiotemporal barriers to learning" (p. 27). However, it is also noted that the integration of AI in educational processes requires policy development, if the researchers wish to avoid confining their efforts to statistically significant results (McArthur, Lewis & Bishary, 2005).

CONCLUSION AND SUGGESTIONS

In this study, current insights and futuristic perspectives of AI have been explored from an educational perspective. The study also looked at IPA features in relation to AI in a broad sense. When "AI and Education" related keywords are evaluated, it is observed that the key themes in AI research are (1) adaptive learning, personalization and learning styles, (2) expert systems and intelligent tutoring systems, and (3) AI as a future component of educational processes.

It is quite clear that AI and other AI featured technologies are here to ease human lives and contribute to the advancement of human progress. However, we should not settle with the idea that the adaptation of technology is good by default; instead, we need to develop a critical stance before fully integrating AI into educational processes. As part of this critical stance, first, there is a need to develop an ethical policy and to clearly define the ethical boundaries of how AI would use human generated data. Secondly, we should test, and retest AI featured educational processes to avert automated processes and mechanical learning.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence: The theory governing the development of computer systems that are able to perform tasks which normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Deep Learning: A part of a broader family of machine learning methods based on learning data representations

Intelligent Learning Environments: A form of computer software which employs artificial intelligence-based programs for (online) learning activities.

Intelligent Personal Assistant: Software that has been designed to assist people with basic tasks, typically providing information using natural language.

Intelligent Tutoring System: Artificial intelligence-based computer software that provides immediate and customized feedback to students/learners.

Machine Learning: A field of artificial intelligence that uses statistical techniques to give computer systems the ability to learn.

Natural Language Processing: A subfield of computer science, information engineering, and artificial intelligence concerned with the interactions between computers and human (natural) language.