Chapter 3

AI and the Existence of Everything

Erna Oliver
Department of Christian Spirituality, Church History and Missiology
University of South Africa
Pretoria, South Africa

Artificial intelligence is one of the most significant developments in the age of digitalization. Perhaps it can be described as the third major evolutionary step following the invention of computers and their interconnection (the Internet), ushering in comprehensive everyday support based on machine learning, which we considered impossible just a few years ago
(Ebner, Schön, & Jahic 2023).

The Digital Transformation of Education[1]

Two outstanding truths that the educator of the 21st century is confronted with, are first, that we have entered the 4IR (fourth industrial revolution), also called the age of 'big data' (Anyoha 2017) and second, the acknowledgment that every student studies in a different/unique way. It is imperative for IHEs (institutions of higher education) to take note of the fact that there is no one-size-fits-all package for education (cf. Gous 2022:215), while the 4IR with all its disruptive elements is currently presenting itself in almost every aspect of our life.[2] One of the best examples in which the 4IR presents itself

1 The title of this section compares much to the chapter written by Thoring, Rudolph, and Vogl in 2018.
2 The 4IR can be described as (part of) a fragmented, liquid, and uncertain revolution. This 4IR world is already expanding into the 5IR (fifth industrial revolution), called the cognitive age (cf. Ziatdinov,

is AI (artificial intelligence),[3] although the latter has preceded the former with quite a couple of years. For many people AI has become part of their everyday existence and life. This also rings true for educators and administration personnel in IHEs. Holmes *et al*. (2019:202) put it this way: 'AI has become an often hidden but integral, pervasive, and inescapable part of our daily lives. In fact, paradoxically, the more it is integrated into our lives, the less we tend to think of it as AI.' Due to larger amounts of big data, new computational approaches, and faster computer processors the development of AI 'has been both groundbreaking…and transformative' (Holmes *et al*. 2019:202). A focal part of AI for education is that it is student-centred (Owan, Abang, Idika, Etta, & Bassey 2023:2 of 15).

However, all these developments do not mean that there will soon be robot educators in class (Holmes *et al*. 2019:80). Many people associate AI with (humanoid) robots. Fact is that robotics is key to AI research, although AI can be applied within many different contexts and ways (cf. Holmes *et al*. 2019:84).

Definitions of AI

There is no common definition for AI (cf. Chen, Xie, Zou, & Hwang 2020b:4 of 20). According to Coppin (2004:4), AI can be described as the ability given to a machine (sometimes a computer) to act humanlike by dealing with emerging situations, handling the user's problem/s and answering their questions.

Atteraya, & Nabiyev 2024), into the 6IR (sixth industrial revolution) presenting us with AI (cf. Di Nardo & Yu 2021), and even the 7IR (seventh industrial revolution) with NOAI (natural organic artificial intelligence) systems (cf. Ruiz Estrada 2024). Added to these are, *inter alia*, the fourth communications revolution (cf. Katsh 1984), the fourth education revolution (Seldon 2018), as well as the fourth revolution of human self-understanding (Floridi 2014). The conflation of these eras present the educator of today with challenging new encounters and suggestions on how educators should support their students.

3 Holmes, Bialik, and Fadel (2019:195-196) have a strong argument that AI should rather be called 'augmented intelligence' which is, according to them, more accurate and useful, thereby referring to the human brain as the source of intelligence instead of the computer because a computer cannot really act intelligently equal to the level of a human. Computer programmes can therefore act as a sophisticated tool to augment the human brain.

In more advanced AI programmes, the user may ask the AI bot to devise a plan or perform other intelligent functions. Chen, Chen, and Lin (2020a:75265) define AI as follows: '[A]rtificial intelligence is the culmination of computers, computer-related technologies, machines, and information communication technology innovations and developments, giving [these machines] the ability to perform near or human-like functions.' Devedžic (2004:29) elaborates that WI (web intelligence) must be added, as it creates a balance between web technology and AI, thereby producing a better learning environment for the student. Chassignol, Khoroshavin, Klimova, and Bilyatdinova (2018:17) argue that AI is a theoretical framework that acts as a guide in developing computer systems which have the capability to act humanlike, with the ability of advanced intelligence, being able to perform human tasks like having visual perception, the ability to recognise speech, decision-making, and being able to translate languages. Haenlein and Kaplan (2019:5) conclude that AI is a 'system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation.' Baker, Smith, and Anissa (2019:10) shortly refer to AI as 'computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem-solving.' Pokrivcakova (2019:138) points out that the implementation of AI, incorporating its design, *inter alia* involves a myriad of professionals, 'including system designers, data scientists, product designers, statisticians, linguists, cognitive scientists, psychologists, [and] education experts.' Lastly, a comprehensive definition or explanation of AI is given by Butterfield, Ngondi, and Kerr (2016:26), stating that AI is a 'discipline concerned with the building of computer programs that perform tasks requiring intelligence when done by humans. Examples of tasks tackled within AI are: game playing, automated reasoning, machine learning, natural-language understanding, planning, speech understanding, and theorem proving.'

AI can therefore be considered as a 'broad field with many subsets, such as [ML] machine learning, [DL] deep learning, expert systems, machine vision, etc.,' already being utilised in HE (higher education) (Jahic, Ebner, & Schön 2023:1463). It is

also fully interdisciplinary, covering disciplines like 'information science, [cognitive] psychology, linguistics, neuroscience, philosophy, mathematics, and many others' (Chen *et al.* 2020b:4 of 20). With all these definitions in mind, AI can be categorised into analytical, human-inspired, or humanised AI, differing from each other on the level of intelligence that each exhibits, be it cognitive, emotional, or social intelligence, or when taking the evolutionary stage of AI into account, into artificial narrow, general, and super intelligence (Haenlein & Kaplan 2019:6).

All the above definitions and descriptions make one wonders what can really be classified as AI, as opposed to 'normal' programmes. If one looks deeply into all the programmes pointed out in this chapter, one could make a case for many of them to not meet or satisfy a good description of AI. However, as we are still trying to settle into this developing environment, many a programme may 'slip through' as AI, while it may not really be AI. From its inception in the 1950s, scholars were continuously predicting and guessing about AI, while often warning that AI will soon reach the level of AGI (artificial general intelligence), where its behaviour will indistinguishably be humanlike on the levels of cognitive, emotional, and social intelligence (Haenlein & Kaplan 2019:6).

History of AI

Precursors of AI can be traced back to as far as 1763 when the mathematician Thomas Bayes has developed the *Bayesian Inference*, which was a decision-making method, being adopted by teaching machines and people on how to make 'decisions using pattern recognition and predictions based on probability' (Meacham 2021). In 1837 Charles Babbage has created an analytical machine made for mathematical calculations. Ada Lovelace has created the programme for his machine. Babbage's machine is referred to as the first computer, while Lovelace is considered to be the first programmer (Meacham 2021).

Two more prominent precursors were Sydney Pressey and BF Skinner – both being psychologists. In the 1920s Pressey was an educator at Ohio State University. He devised a machine

that aimed to give immediate feedback to student assessments, as well as being some sort of a mechanical typewriter (Holmes *et al.* 2019:95). His aim was to make life easier for educators so that they could give more attention to their students (not their research!) (Pressey 1926:374). Skinner, an educator at Harvard University between 1948 and 1974, followed in Pressey's footsteps and is well-known as the father of behaviourism (Holmes *et al.* 2019:94). He created a teaching machine as a personal tutor for students, thereby 'foreshadowing AIED's [artificial intelligence in education's] [ITSs] intelligent tutoring systems' (Holmes *et al.* 2019:96), although it was not adaptive. 1939 was the year in which Westinghouse created the first robot, called *Elektro*. This bot could already respond to a limited number of questions, while he could also walk, smoke a cigarette, and blow up a balloon (Meacham 2021). His robot dog's name was Sparko.

The 'real beginnings' of AI can be traced back to 1942, where Isaac Asimov (an American Science fiction writer) drafted a novel called *Runaround.* In this story, the robot, which was the creation of two engineers, Gregory Powell and Mike Donovan, had to adhere to the so-called Three Laws of Robotics, entailing that a robot had to protect and obey a human, as well as its own existence (Haenlein & Kaplan 2019:6). Asimov followed this up with *I, Robot*, published in 1950.

However, the 'official history' of AI (where AI 'that either completely replaces humans in performing some tasks or helps perform human tasks' – Jahic *et al.* 2023:1462) goes back to 1950[4] when the English mathematician, Alan Turing[5] invented the most basic AI chatbot called the *Imagination Game* (later renamed to *Turing Test*[6]). With this 'game' he attempted to test the intelligent behaviour (humanlike responses) of a machine (Oppy & Dowe

4 The good reason why AI's history only started here, is because before 1950, computers could only execute commands and not store it (Anyoha 2017).

5 He was the 'father' of the fourth revolution of human self-understanding (cf. Floridi 2014:231–232).

6 In his ground-breaking article called 'Computing machinery and intelligence,' published in 1950, Turing published his so-called 'Turing Test,' with which he gave an indication of how one must test the intelligence of a machine. Up to this day, the Turing Test still acts as a benchmark for the identification of intelligent machines.

2021). He also created *The Bombe*, which was a code breaking machine, specifically used by the English government to decipher the Enigma Code of the German army being used in World War 2 – something no human was able to do during that time (Haenlein & Kaplan 2019:6). This one tonner was considered to be the 'first working electro-mechanical computer' (Haenlein & Kaplan 2019:6).

In the 1950s, Norman Crowder developed the forerunner of the adaptive teaching machine, where a student gets some information about a subject and is then presented with multiple questions. When a student answers one question correctly, the programme moves on to the following question. Should the student's answer be wrong, a page appears where the student is given more information. State Holmes *et al.* (2019:97): 'Crowder's system adapted the pathway through the teaching materials according to the individual student's developing knowledge, such that each student might see quite different sets of pages.'

In 1956 the British polymath, Gordon Pask developed the 'real' adaptive teaching machine (Watters 2015), calling it *SAKI* (self-adaptive keyboard instructor). This machine was invented for 'trainee keyboard operators learning how to use a device that punched holes in cards for data processing' (Holmes *et al.* 2019:97; cf. Pask 1982). What distinguishes this machine from its predecessor, is that it adapted tasks to every individual's performance by building a probabilistic model for that specific person.

Also in 1956[7] the DSRPAI (Dartmouth summer research project on artificial intelligence) presented a workshop at Dartmouth College,[8] which was a US (United States) Ivy League research university. At this workshop, the small group of scientists discussed the first AI programme called *Logic Theorist*. John

7 According to Meacham (2021), it was 1955.

8 According to Meacham (2021), this conference was the first to be held where scholars in computer science discussed the possibility to programme computers with human language; to mimic human thought-processing in computers by making use of neural nets ML, which would be a 'truly intelligent machine that will carry out activities which may best be described as selfimprovement;' to programme a computer to be able to 'think orderly,' and be creative.

McCarthy is regarded as the person who coined the term 'artificial intelligence' there, defining it as 'the science and engineering of making intelligent machines' (Jahic *et al.* 2023:1462). Other scientists who would become leading AI researchers, and who attended the workshop, are Marvin Minsky, Allen Newell, and Herbert Simon (Holmes *et al.* 2019:196).

1957 saw the creation of the *General Problem Solver* programme by Herbert Simon (who won a Nobel prize) and two Rand[9] Corporation scientists, Cliff Shaw and Allen Newell. In line with its name, it could solve simple problems. In 1964 the computer scientist Joseph Weizenbaum wrote a computer programme called *Eliza*,[10] which was a natural language processor that could simulate a conversation with its user (Haenlein & Kaplan 2019:7; HistoryofInformation 2023; cf. Guan, Mou, & Jiang 2020:135). Haenlein and Kaplan (2019:8) refer to these two programmes as 'Expert Systems, that is, collections of rules which assume that human intelligence can be formalized and reconstructed in a top-down approach as a series of "if-then" statements,' which are 'technically speaking' not AI.

During the 1960s and 1970s many CAIs (computer-aided instruction systems) were drafted, of which *PLATO* (programmed logic for automatic teaching operations) is a prime example. Being developed at the University of Illinois, *PLATO* was a mainframe computer system for students to access their study material and it could accommodate up to 1,000 students at a time (Holmes *et al.* 2019:98). What makes this system outstanding, is the fact that it introduced many features or forums that are currently still in use, like the use of instant messaging, e-mail, remote screen-sharing, and multiplayer games (Holmes *et al.* 2019:98-99). Two other CAIs which were used with limited success during these days, are 1) a system made available to a few elementary schools by Stanford University and IBM (International Business Machines), and 2) *TICCIT* (time-shared interactive computer-controlled

9 Rand = research and development.

10 An advanced *Eliza* (now called 'the chatbot therapist') is still in working order (cf. web.njit n.d.). What is a bit annoying of *Doctor* is that she is programmed to mostly ask open-ended questions – a good therapist?

information television), being launched by Brigham Young, focusing on courses like chemistry, various language courses like English, freshman-level mathematics, and physics (Holmes *et al.* 2019:99).

Come 1966 Ellis Page developed *PEG* (Project Essay Grade), which was a marking programme, at Duke University. The programme was based on already marked assessment documents, but was not very successful as it only marked surface features like the number of sentences and grammar (Holmes *et al.* 2019:130).[11] This can be regarded as the beginnings of AWE (automated writing evaluation).

In 1970 the computer scientist Jaime Carbonell created *Scholar* which was a communicating AI system 'capable of reviewing the knowledge of a student in a given context' (Carbonell 1970:190), with emphasis on the geography of South America. *Scholar* was the initial example of an ITS,[12] something we still have with us today. What makes this programme unique, is that it does not only present instructional material as well as learning activities to a student, but it also converses with the student about the contents of the subject, giving rise to a better form of ITS, called DBTS (dialogue-based tutoring systems).[13]

11 Shermis (2014) reports that PEG was later upgraded to a 'State-of-the-art automated essay' marker.

12 ITSs are used for subjects like mathematics and science, providing elaborated tutorials which are individualised for each student, leading them step-by-step to successfully complete the subject's learning material and all the activities (Holmes *et al.* 2019:102). ITSs make use of three models: 1) The *domain model* covering the contents of and knowledge about the subject; 2) the *pedagogy model* contains effective approaches for the educator on how to teach the subject; and 3) the *learner model* constitutes personalised knowledge about the student's way of learning (Luckin, Holmes, Griffiths, & Forcier 2016:18). Other ITSs include *Mathia* (Carnegie Learning 2023), *Assistments* (Assistment n.d.), *Knewton Alta* (Wiley 2023), Area9 Lyceum's *Rhapsode* (Area9 2023), *Dreambox* (Dreambox.ai 2023), *Toppr* (n.d.), *Yixue* (Squirrel AI Learning 2023), *Aleks* (Aleks Hammo 2023), *Byju* (Byjus 2022), *Century* (2023), *CogBooks* (2021), *iReady* (Curriculum Associates 2023), *RealizeIt* (2023), *Smart Sparrow* (n.d.), and *Summit Learning* (n.d.).

13 Fine examples of DBTS are *Circsim* by the Illinois Institute of Technology (CIRCSIM-Tutor Project 2015), *AutoTutor* by the University of Memphis (2019), and *Watson Tutor* by IBM (IBM Watson n.d.).

Come 1972 psychiatrist Kenneth Colbe created an AI computer programme, called *Parry* (also called '*Eliza* with attitude'), to replicate the 'thinking patterns of a paranoid schizophrenic' person (Malm 2016). Shortly afterwards, in 1977 Edward Shortliffe designed *Mycin*, which was a knowledge-based computer programme, serving as a 'clinical consultant on the subject of therapy selection for patients' with infectious diseases (Shortliffe 1977:67).

In the 1980s Edward Feigenbaum (with Herbert Simon as his *Doktorvater*), arrived at Stanford University and initiated the development of expert systems (Anyoha 2017). The first system was called *Dendral* and was intended to help chemists to determine organic molecules' structures (Dennis n.d.).

In 1984 the personal computer was launched, which would completely change the scenario of technology, learning, and communication. This year also saw the creation of *Racter* – similar to *Eliza* – by William Chamberlain and Thomas Etter, with the difference that *Racter* did not always act sane. In the same year *Racter* became the first AI programme to author a book, called *The policeman's beard is half-constructed* (Chatbots.org 2023a). In 1995 *ALICE* (Artificial Linguistic Internet Computer Entity), also called *Alicebot*, was incepted by Richard Wallace. She is a 'natural language processing (NLP) chatbot designed to engage in a conversation by reacting to human input and responding as naturally as possible' (Debecker 2017), being inspired by the *Eliza* programme. ALICE is extraordinary, having received three Loebner prizes for AI[14] (2000, 2001, and 2004) for being a top accomplished humanoid and talking robot (Debecker 2017). In both 2005 and 2006 *Jabberwacky* took the Loebner prize (Shah & Warwick 2009:325). This chatbot does not only chat, but it also learns by modelling the way in which humans learn language (Chatbots.org 2023b). It further records every conversation it has with humans. Whereas chatbots are mostly rule-bound and finite, *Jabberwacky* has no hard-coded rules (Chatbots.org 2023b).

14 Hugh Loebner instigated the Loebner Prize in 1990 in order to find the most humanlike chatbot. He awarded a Grand Prize of $100,000 to the person whose chatbot was able to pass the Turing Test which involved visual, textual, and auditory components (Berkeley n.d.).

1997 saw the second example of an AWE, when the Pearson Knowledge Technologies (formerly Knowledge Analysis Technologies) invented a programme called *IEA* (the intelligent essay assessor) that uses LSA (latent semantic analysis) to mark papers. The programme can recognise the meaning of words within their context (Dikli 2006:3; Foltz, Streeter, Lochbaum, & Landauer 2013:68). This year also saw the implementation by Dragon Systems of speech recognition on Windows (Anyoha 2017). Another interesting robot that originated in 1997, is *Kismet*, which is a 'sociable machine [that] can interact with humans in a human-like way via myriad facial expressions, head positions, and tones of voice,' built by Cynthia Breaseal at MIT (Massachusetts Institute of Technology) (MIT 2001).

AI games worth mentioning are IBM's *Deep Blue* chess game that has beaten the chess champion Gary Casparov in 1997 (cf. Haenlein & Kaplan 2019:8), and Google's *AlphaGo* that has beaten the Go champion Ke Jie in 2017 (Meacham 2021). *AlphaGo* was able to achieve this success by utilising a particular kind of ANN (artificial neural network), which is called DL (deep learning). These ANNs are still currently in use, acting as basis for most programmes being labelled as AI (Haenlein & Kaplan 2019:8; Luckin *et al*. 2016). In 2011 *IBM Watson* has beaten the champions in the TV games show Jeopardy (Meacham 2021). This programme can understand human speech and respond to it, thereby 'paving the way for many uses of natural language processing in future applications' (Meacham 2021).

In 2014 a chatbot called *Eugene Goostman* was the first AI to achieve success with the Turing Test. However, having reassessed the answers given, the judges discovered that the AI avoided to answer some of the questions, thereby invalidating the test (Meacham 2021).

From the start of the 21st century, especially the second decade, chatbots increased exponentially, with the recent LLM (Large Language Model) chatbot called *ChatGPT* (Chat Generative Pre-Trained Transformer) taking most of the limelight. Others are *Slack bot* (created in 2014), an assistant that helps the user with specific requests (Pot 2022), *Messenger bots* – specifically created

for Facebook, from 2015 (Rosenberg 2016), *Skilla bot*, which is a bot-based talent search platform, founded in 2016 (Tracxn 2023), and *Wordtune*, an AI writer and text generator (Wordtune 2023).

2016 saw the development of *Jill Watson* at Georgia Tech University, which is an ITS or a 'teacher bot' – an exceptionally good example of AIED, using ML to adapt to students' individual learning needs (Hardman 2023). While interacting with the bot, the system gathers data on the student's performance, and with that information the system trains a reinforcement learning algorithm, which can predict the strong points of that specific student with regards to tasks and assignments. In the meantime *Jill Watson* has split into two bots: The one does academic support, while the other one provides social and emotional support to students and helps them to connect to each other (Hardman 2023; cf. Wang, Jing, Camacho, Joyner, & Goel 2020).

In 2019 CMU (Carnegie Mellon University) launched the *OpenSimon* toolkit for educators 'to fuel new advances in student success and learning science. The toolkit is an integrated set of techniques and tools used to drive deliberate, iterative improvements in education. This approach, called Learning Engineering, supports educators as citizen scientists' (CMU 2023). According to CMU (2023), Learning Engineering consists of four phases: Design, develop, deliver, and discover.

There are numerous websites that teach people how to construct a personal chatbot (cf. e.g., a website teaching one how to modify *ChatGPT* for one's personal needs – Chatbase n.d.). As from the end of 2022, the 'new' subset of AI on the market is called Gen-AI (generative artificial intelligence), being capable to autonomously create music, 'audio, videos, images, and even texts' (Ebner *et al*. 2023; cf. Bozkurt & Sharma 2023; Boskurt 2023; cf. Jahic *et al*. 2023:1463). Examples of Gen-AI that are already available, are *ChatGPT* (n.d.), which is an advanced Gen-AI model (Jahic *et al*. 2023:1463),[15] *Bing* (Microsoft Bing n.d.), *Midjourney*

15 According to Ebner *et al*. (2023), *ChatGPT* can currently be used to
- help a student with research;
- generate assessments for a specific subject;
- create curricula and plan courses for students;
- assist students with assessments;

(n.d.), *Jasper Art* (Jasper n.d.), and *Musenet* (OpenAI n.d.). Owan *et al.* (2023:1 of 15) specifically refer to *Bing* and *ChatGPT*, claiming: 'Bing and ChatGPT have been referred to as objects individuals can think with, especially in the teaching-learning situation for learners to enhance their ability to think critically and reflectively, foster creativity, acquire problem-solving skills, and grasp concepts effectively.'

Many of the AI bots being discussed above are chatbots. Chatbots can be divided into two broad categories, namely ruled-based chatbots and AI chatbots (cf. Zendesk 2023). Ruled-based chatbots[16] are the most rudimentary types of bots that communicate through pre-set rules. These bots often supply the user with more than one choice from which they can choose the answer applicable for them – similar to programmed phone menus. AI chatbots (also called visual or contextual chatbots) deliver customer services by using either ML or NLP, both to converse with a user. These bots are learning from their conversations and with time deliver more helpful answers (Zendesk 2023). Examples of these bots are *Dom*, the Domino's ordering assistant bot, preparing pizzas (Adyen 2023), HelloFresh's *Freddy*, preparing food (Chatfuel 2023), and *Ask Benji*, Arixona's FAFSA[17] assistant, helping Arizona students to navigate their financial aid process at FAFSA (AskBenji n.d.).

There is also another category (subset) of AI bots called conversational AI (Zendesk 2023). Whereas the chatbots discussed above only simulate human conversations, while others make use of AI and NLP (deciphering questions and then sending

- boost critical thinking;
- summarise documents;
- provide a personalised learning experience;
- be a great writing assistant;
- assist in language learning;
- generate and translate codes.

The negative side of *ChatGPT* in education is

- plagiarism concerns;
- a bias based on its restriction to only a limited number of sources;
- 'AI hallucinations;' and
- certain privacy concerns.

16 These bots are also referred to as 'decision-tree, menu-based, script-based, button-based, or basic chatbots' (Zendesk 2023).

17 FAFSA = Free Application for Federal Student Aid.

responses which were previously automated, based on keywords), the conversational AI bots act more as virtual assistants, like *Siri* and *Amazon Alexa* (Zendesk 2023). These bots use 'data, machine learning…and NLP to recognize vocal and text inputs, mimic human interactions, and facilitate conversational flow,' either through text messages or as a voice assistant on a (mobile) phone (Zendesk 2023). They are therefore able to interact with their user in a more humanlike way, improving their user's satisfaction. More examples of conversational AI are *Erica*, the financial assistant of the Bank of America (Bank of America 2023), *Edward*, the virtual host of the Edwardian Hotels in London (Oram 2019), and *Julie*, Amtrak's virtual travel assistant (Amtrak 2023).

Scientists are also applying AI, together with ML, on mobile devices, with the purpose to 'enhance computation quality and create possibilities for new applications, such as face unlock, speech recognition, natural language translation, and virtual reality' (Chen *et al*. 2020a:75267). A good example is the Android NNAPI (neural networks application programming interface – cf. Ignatov, Timofte, Chou, Wang, Wu, Hartley, & Van Gool 2018; Android for Developers n.d.). Architectures (DL models – Löw 2018) like *SqueezeNet*, *MobileNet*, and *Shufflenet* have already been developed for mobile phones (Chen *et al*. 2020a:75267). This technical development of AI helps students to achieve interactive and personalised learning and assess their levels of understanding (Chen *et al*. 2020a:75267).

Looking at all these innovative inventions, the question is not anymore if we should implement them, but rather how (much) and where we should utilise it. The logical question is therefore what the effect of AI will be on the HE environment in the (near) future: Will the educator together with IHEs become redundant in the end (which we do not hope for)? Will our education system become obsolete (which is maybe necessary)? Will an improved form of HE develop (which is imperative)? However, these questions also arose with the dawn of the internet and smartphones – and these two commodities have in the meantime become irreplaceable for most of their users (cf. Ebner *et al*. 2023).

AI and HE[18, 19]

Computers became part of the classroom and presentation of lectures during the later part of the previous century. This 'novelty' developed further with the introduction of the internet, networking, e-learning systems, and the availability of software programmes that made life easier for both educators and students. In most cases the computer has already become indispensable in HE.

The next big step in the process of evolution was the installation and utilisation of AI, Gen-AI, and LLMs. The introduction, proliferation, and advancement of AI presented educators with opportunities to revolutionise various aspects of education, facilitating their work in HE and fostering better effectiveness and efficiency on the level of education, especially during the 21st century (Chen *et al.* 2020a:75264). Timms (2016:702) elaborates that those educators who have already utilised AI, have discovered that it assists them in both global and personalised learning, and the creation of smarter content – with a relatively big contingent of AI not limited to being part of computers anymore. Currently AI is not dependent on computers only, but is also found in machines and robots, also called cobots (colleague robots) or simply bots (cf. Chassignol *et al.* 2018).

As education is for at least the past 30 years very susceptible to AI, it paved the way to refer to it as AIED. AIED[20] can be defined as the development of 'computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem-solving' (Baker *et al.* 2019:10). AI is currently utilised on at least four levels in education: Administration, teaching (instruction), learning, and assessment (Chen *et al.* 2020a:75265). These systems simplify the work of the educator

18 For a bibliometric study on the impact of AI on HE covering the period 2007-2017, cf. Hinojo-Lucena, Aznar-Díaz, Cáceres-Reche, & Romero-Rodríguez (2019).

19 It is for obvious reasons impossible to name 'all' the AI programmes, specifically with relation to education.

20 According to Luckin *et al.* (2016), AIED has already been researched for the past 30 years.

and administrative personnel and assist students in their learning process.

AI in Educational Administration

Admin (administration) in general is time consuming. This also applies to admin for education: The enrolment of students and the processing of marks serve as examples. Here AI already assists by means of AIWBE (adaptive and intelligent web-based educational system) programmes with the enrolment at IHEs as well as the reviewing and grading of portfolio work, and to provide the necessary feedback. Take for instance the student who wants to enrol at an IHE: The AI uses the student's study data that are available, and then facilitates a career path and learning system for the student to improve their personal learning capabilities in specific subjects. After the student has enrolled, AI analyses their thinking capacity and capability, thereby assessing their learning abilities (Chen *et al.* 2020a:75268). This enables the educator to create tailor-made educational strategies for the student. Added to these, are three 'intelligent education technologies[, namely] machine learning, [LA] learning analytics, and [EDM educational] data mining' (Chen *et al.* 2020a:75268).

ML is focused on knowledge discovery, assisting the student to choose a university or to select their educational classes, all based on the student's capabilities and aspirations. Arthur Samuel has coined this term in 1959 (Samuel 1959). Mitchell (1997:2) defines ML, stating that 'a computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E.' This implies that ML, although requiring a huge amount of programming, does not fully rely on algorithms to be programmed what to do, but that it has the ability to learn what to do (Holmes *et al.* 2019:89). For students, ML suggests specific methods which will enable them to learn from data and to make predictions (Chen *et al.* 2020b:4 of 20; Holmes *et al.* 2019:89). ML, being a subset of AIED, is therefore a specific way in which students are trained to complete certain tasks while using much data. Holmes *et al.* (2019:89) describe ML as follows: '[M]achine learning may be considered a three-step

process (analyze data, build a model, undertake an action) that is continuously iterated (the outcomes of the action generate new data, which in turn amends the model, which in turn causes a new action).' Applications or programmes that made use of ML include 'natural language processing, self-driving cars, and the Google DeepMind AlphaGo program' (Holmes *et al.* 2019:89). ML can be sub-divided into 1) supervised learning (the most common one) where the AI is provided with large amounts of data that have already been labelled; 2) unsupervised learning, provided with more, but unlabelled data; and 3) reinforcement learning, which is the most powerful. Over against the previous two where a student derives a fixed model, the model in reinforcement learning continuously changes because of the feedback being received (cf. Holmes *et al.* 2019:90-91).

ANNs are AI algorithms that are based on the brains of humans (called biological neural networks), although it is not on the level of the human brain, having only thousands (sometimes millions) of neurons compared to the human brain's billions of neurons. These neurons are not capable of reproducing intelligent data but are rendering statistical phenomena which are merely mathematical incarnations. The algorithms can be applied in all three the subdivisions of ML. An ANN comprises of the following layers: 1) The input layer that uses stimuli called data points or pixels from images, from its surroundings; 2) one or more hidden intermediary layers (being the power of the ANN) doing the processing of the data; and 3) the output layer which presents the result/s. The processing takes place in the form of reinforcement learning (Holmes *et al.* 2019:92).

Added to ML is DL. DL appeared on the scene much later than ML – in 1986, when Rina Dechter introduced it to the ML community (Dechter 1986). Chen *et al.* (2020b:5 of 20) define DL as follows: 'As part of ML algorithms…DL focuses on extracting higher-level features from the inputted data by adopting multiple layers.' Whereas ML is a subset of AI, DL forms a subset of ML (Chen *et al.* 2020b:5 of 20).

LA generates critical data from a student, thereby indicating and predicting the 'critical competencies' that they can pursue,

which gives the IHE a good indication on how to act proactively on behalf of the student (Chen *et al.* 2020a:75269). Romero and Ventura (2013:12) define LA as 'the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs.' LA is also instrumental in determining the possibility if the student would be failing or succeeding.

EDM supplies the student with systematic and automated responses to their personal needs. It also improves the 'learning process and knowledge mastery' of the student (Chen *et al.* 2020a:75269), being able to assist them to study in their own time and at their own pace, therefore creating a personalised learning environment for the student. With EDM, an educator analyses various forms of educational data using ML, DM (data mining), and statistical algorithms. By doing this, the educator focuses on educational data, which indicates how a student learns and where they get their data from to understand their educational material better (Chen *et al.* 2020b:5 of 20).

Although there are many similarities between LA and EDM, they differ in the following aspects:

- EDM is more involved with 'clustering, classification, Bayesian modeling, relationship mining, as well as discovery with models' (Chen *et al.* 2020b:6 of 20).
- Whereas LA is more concerned with data and results, EDM would rather describe and compare the DM technologies.

These come to show that AI supersedes our conventional perception of all the different technologies which are implemented to establish it, including 'web-based elements online, distance, and computer-assisted instruction courses and learning' (cf. Chen *et al.* 2020a:75270; Sharma, Kawachi, & Bozkurt 2019).

AI in Teaching (Instruction)

In the past, the development of curricula and assessment took the bulk of an educator's time. With the implementation of AI, this has become a much easier task, making use of VR (virtual reality),

AR (augmented reality), web-based platforms, as well as 3-D (three-dimensional) technology, audiovisual presentations, and other forms of robotics, providing the student with up-to-date experiential learning. VR and AR are immersive technologies that can practically demonstrate different materials to students in an interactive way, assisting them with their experiential learning (cf. Owan *et al.* 2023:4 of 15). AIWBEs[21] make the utilisation of the internet much easier. The IALS (individual adaptive learning system) supports individual learning, while the ATS (aided teaching system) assists in the management of the classroom environment, and the IAS (institute administration system) is of assistance in student enrolment (Guan *et al.* 2020:134).

The educator also has access to LMSs (learning management systems), where they are able to 'create, deliver, and manage learning materials, assignments, assessments, and evaluations for students' (Owan *et al.* 2023:4 of 15). On these platforms the educator oversees both online assessments and the progress of their students, while providing feedback on the performance of the students. Examples of LMSs are *Blackboard* (2023), *Canvas* (Canva 2023), and *Moodle* (2023).

IWBE (intelligent web-based education) is a powerful pedagogical tool used for WBE (web-based education). Through implementing AI, communication between the educator and student improve significantly (Chassignol *et al.* 2018:19). Chassignol *et al.* (2018:19) point out that AI is already applied on different platforms, including ILEs (interactive learning environments), acting as a conversation tool between the educator and student, and intelligent student-centred tutoring programmes, including *Mathia* (Carnegie Learning 2023), *ActiveMath* (Melis & Siekmann 2004), *Why2Atlas* (VanLehn, Jordan, Rosé, Bhembe, Böttner, Gaydos, Makatchev, Pappuswamy, Ringenberg, Roque, Siler, & Srivastava 2002), *Comet* (2023), *Viper* (2023), *DeepTutor* (n.d.), and *AutoTutor* (University of Memphis 2019).

21 AIWBEs can be defined as 'the integration of AI principles and technology into web-based learning platforms, which improves the learners' experiences' (Chen *et al.* 2020a:75271).

Robots play a decisive role as educator assistants and cobots, undertaking specific teaching tasks (basic or advanced) (Chen *et al*. 2020a:75272; cf. Timms 2016). Added to these are chatbots ('online computer-based robots with conversational and dialogue abilities to answer routine student queries' – Chen *et al*. 2020a:75272). These bots (ITSs) are equipped with cognitive as well as decision-making abilities, being able to converse with the user in an instructional and pedagogical way. This also includes bots with CALL (computer-assisted language learning) abilities.

A further example of this wide range of ITSs is a programme called *Knewton* that provides a 'platform for feedback to students premised on the interaction on the platforms' (Chen *et al*. 2020a:75271). This is complemented by programmes such as *Turnitin* (on similarity), *Grammarly*, *PaperRater*, and *WhiteSmoke* (all three are assisting with proofreading), *Ecree* (an on-demand writing tutor), and *WriteToLearn* (building writing skills) also assisting the educator and the student). These AI programmes assist educators to focus on their core performance area of teaching, learning, and assessment of students towards graduation.

AI in (Personalised) Learning

Nowadays, intelligent learning systems have many adaptive capabilities (cf. Sharma *et al*. 2019; Pokrivcakova 2019), producing learning plans per student, which are 'based on their learning progress, strengths, and weaknesses' (Owan et al. 2023:3 of 15). Presenting (personalised) material to a student on the internet makes the knowledge available for them wherever they are and whenever they want to utilise it (cf. Gardner, O'Leary, & Yuan 2021:1207) – called 'smart education' by Bajaj and Sharma (2018:840). Smart education is an educational system where a student is provided with personalised learning material and up-to-date technology, wherever they are and at any time (Bajaj & Sharma 2018:840; Demir 2021:3 of 36). To make this possible, an AI system or programme is needed to determine the student's learning style and capabilities, also taking their

learning environment into consideration. Based on these data, the programme will determine a specific learning model/s or style/s.[22]

Web-based learning platforms facilitate the process for the student. Should the student be unable to recognise the language, language translation tools are available. In this way AI eliminates many barriers that students used to struggle with. Another ability of AI is to customise and personalise curricula to be in line with the needs, abilities, and capabilities of each learner (Chen *et al.* 2020a:75273; cf. Della Ventura 2017:6 of 9). This includes students with learning or physical disabilities (Chen *et al.* 2020b:2 of 20). Additionally, ITSs are fostering DL, pushing students to explain themselves, and improving their retention of information (Chen *et al.* 2020a:75274-75275).

ELEs (Exploratory Learning Environments)

ELEs act as an alternative type of AIED for ITSs and DBTSs. Whereas ITSs and DBTSs guide a student to become knowledgeable of a specific subject, ELEs are following a constructive approach (within an unstructured environment), encouraging a student to 'actively construct their own knowledge by exploring and manipulating elements of the learning environment' (Holmes *et al.* 2019:120). Examples of ELEs are *Fractions Lab*, facilitating students to experiment with fractions (European Commission n.d.; cf. Mavrikis, Holmes, Zhang, & Ma 2018), *Betty's Brain* by Vanderbilt University, making use of a teachable agent to assist the student (Vanderbilt School of Engineering 2023), and *Crystal Island*, involving and implementing a game in the learning process (Data.ai 2023).

Automatic Writing Evaluation

These programmes assist students in the writing of documents by giving them feedback on both grammatical and semantic

22 Learning theory models/styles include *Felder & Silverman* (The Peak Performance Center 2023), *Kolb's learning theory/style model* (Main 2022), *Honey and Mumford* (G 2020), and *VARK* learning style model (Cherry 2023). Specific AI methods are *Fuzzy Logic systems* (Tutorialspoint n.d.), *Genetic Algorithms* (Turing 2023b), *Bayesian Networks* (Turing 2023a), and *Hidden Markov Model* (Dharaneishvc n.d.).

levels on the documents that they have submitted. There are two overlapping approaches, called formative and summative. The former assists the student before they submit their work, while the later provides the student with automatic scoring (Holmes *et al.* 2019:129). Examples of AWEs are *e-Rater*, *Revision Assistant*, *OpenEssayist*, and *AI Grading*. *e-Rater* is developed by ETS (the educational testing service) (ETS 2023a), using ML to analyse a myriad of linguistic features in a submitted document. *Turnitin* created *Revision Assistant* and *Gradescope*, programmes which are able to supply formative feedback on submitted documents (Turnitin 2023; Gradescope 2023). These programmes use both supervised (utilising similar essays being scored by at least two educators) and unsupervised (using unscored essays) ML. *OpenEssayist*, being developed by both the Open University and Oxford University in England, focuses more on its feedback to the student (Holmes *et al.* 2019:134). *AI Grading* marks essays for students on *edX Mooc* (Electronic Data Exchange massive open online course) (EdX 2023). During the past few years Pearson has incorporated IEA in their product called *WriteToLearn* (cf. Pearson 2023), providing formative feedback to the student, including a summative scoring. By using a supervised ML approach, containing at least 300 matching documents, the programme assesses submitted documents by students.

AI in Assessment

Assessment is some kind of an admin task, but with at least two added instructional features, called feedback and final marks (results). AWE programmes, as discussed above, are very helpful in the evaluation process of students. These programmes are also used to assist with the assessment process. Assessment – in fact evaluation – starts when a student begins with their enrolment process, as their learning abilities are assessed/evaluated to help them choose the right direction with their studies (Chen *et al.* 2020a:75268).

Assessment by AI programmes is done with great accuracy, efficacy, and validity, and with less (educator) bias (Owan *et al.* 2023:1 of 15). According to Gardner *et al.* (2021:1207),

the essence of AI related to both formative[23] and summative assessment, 'is the concept of machine "learning" – where the computer is "taught" how to interpret patterns in data and "trained" to undertake predetermined actions according to those interpretations.' Using ML, the computer programme is taught to know both the contents of and quality criteria applicable to each question in a variety of ways, so as to assess the knowledge produced by the student as well as the quality of the work, thereby instilling better outcomes for students (Owan *et al.* 2923:1 of 15).

The two common types of questions asked in assessment papers are essays or short questions, including multiple choice questions, in whichever form. For the first, AES (automated essay scoring) will do the job (cf. Gardner *et al.* 2021:1208), also called automated grading (Owan *et al.* 2923:3 of 15), while for the second type of questioning, CATs (computerised adaptive tests) are applicable. Two successful programmes used for CAT are *GMAT* (the graduate management admission test) (MBA.com 2023) and *GRE* (the graduate record examination) by ETS (ETS 2023b). When it comes to formative and summative assessment, programmes like *Revision Assistant* and *Gradescope* (Turnitin 2023) are well equipped. These programmes supply the student with almost immediate feedback on tasks or assessments, while the educator takes longer to respond.

However, when it comes to assessment, the educator should thoroughly take note of the following: 'The distinction between having knowledge and being able to understand and apply it will not be lost on educators, as it is along this continuum that the capabilities of human judges and machine assessments ultimately part company' (Gardner *et al.* 2021:1208).

CCR (The Center for Curriculum Redesign)

CCR is an international body that creates and overlooks the development of curricula from Grade 1 up to HE. CCR is an international research centre that is redesigning education standards for the 21st century, taking the 4IR and AI into account.

23 Examples of formative assessment tools are *Mentimeter* (n.d.), *Nearpod* (n.d.), and *Socrative* (2023).

In order to reach this goal, this organisation has invited groups with different points of view to partake, like 'non-governmental organizations, jurisdictions, academic institutions, corporations, and non-profit organizations including foundations' (CCR n.d.), 'actively engaging with policymakers, standard setters, curriculum and assessment developers, school administrators, heads of schools, department heads, key [educators], EdTech [educational technology] experts and other thought leaders and influencers to develop a thorough understanding of the needs and challenges of all education stakeholders' (Holmes *et al.* 2019:225). Their aim is to launch meaningful curricula to establish 'sustainability, balance, and wellbeing,' therefore creating a sustainable humanity (Holmes *et al.* 2019:224). They are taking into consideration that information and technology are changing at a phenomenal rate, affecting people's societal and personal needs. By focusing on innovation and synthesis, CCR teaches that students need to be 'adaptive, versatile and wise' (Holmes *et al.* 2019:224).

Conclusion

The use of AI has become imperative for HE. However, HE should not become an education drenched with AI, but rather an adaptive kind of education where AI is utilised where and when needed (cf. Bajaj & Sharma 2018).[24] As Oliver (2019; 2024) has already indicated about serious games,[25] the time has come for the educator to realise their real mission being an educator, i.e., the education of students within a student-centred environment.

However, one may ask: Once AI has been 'fully implemented,' what then? Who will control everything? Haenlein and Kaplan (2019:12) 'naively' ask whether AI 'will allow us' to do certain things. This implies that 'we' will not be in control anymore. Elon Musk once predicted that 'AI could lead' to a next World War (Browne 2017). No more human control? Maybe we

24 Various AI techniques have already been used in adaptive educational systems, like Fuzzy Logic and Decision Trees, as well as Bayesian Networks, Neural Networks, Hidden Markov Models, and Genetic Algorithms (cf. Colchester, Hagras, Alghazzawi, & Aldabbagh 2017).

25 Cf. Oliver 2024.

should stop with all the conspiracy theories and focus on working more intelligently and responsibly with the creation of AI. Then we would not have to worry about what AI will do to us, but how we can develop AI to work with us in a reasonable and innovative way.

References

Adyen. 2023. Domino's voice-activated ordering assistant tops half-million orders. Available at: https://bit.ly/3IwTv6T. (Accessed on 27 August 2023).

Aleks Hammo. 2023. Aleks Hammo. Available at: https://www.aleks.co. (Accessed on 9 September 2023).

Amtrak. 2023. Meet Julie: Your virtual assistant. Available at: https://www.amtrak.com/about-julie-amtrak-virtual-travel-assistant. (Accessed on 27 August 2023).

Android for Developers. n.d. Neural Networks API. *NDK*. Available at: https://developer.android.com/ndk/guides/neuralnetworks. (Accessed on 28 August 2023).

Anyoha, R. 2017. Can machines think? *Science in the News*. 28 August 2017. Available at: https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/. (Accessed on 12 September 2023).

Area9. 2023. Higher education. Available at: https://area9learning.com. (Accessed on 9 September 2023).

AskBenji. n.d. Questions about FAFSA? Ask Benji, has the answers! Available at: https://bit.ly/3GLa6mT. (Accessed on 27 August 2023).

Assistment. n.d. Supercharging data-driven math instruction. Available at: https://www.assistments.org. (Accessed on 9 September 2023).

Bajaj, R. & Sharma, V. 2018. Smart education with artificial intelligence based determination of learning styles. *Procedia Computer Science* 132:834-842. https://doi.org/10.1016/j.procs.2018.05.095

Baker, T., Smith, L., & Anissa, N. 2019. Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges. Available at: https://media.nesta.org.uk/documents/Future_of_AI_and_education_v5_WEB.pdf. (Accessed on 2 September 2023).

Bank of America. 2023. Personalized. Proactive. Predictive. See what Erica® can do. Available at: https://promotions.bankofamerica.com/digitalbanking/mobilebanking/erica. (Accessed on 27 August 2023).

Berkeley. n.d. The Loebner prize. Available at: https://www.ocf.berkeley.edu/~arihuang/academic/research/loebner.html. (Accessed on 26 August 2023).

Blackboard. 2023. Blackboard: Now part of anthology. Available at: https://www.blackboard.com/services/student-success-services/blackboard-chatbot/how-chatbot-works. (Accessed on 25 September 2023).

Bozkurt, A. 2023. Generative AI, synthetic contents, open educational resources (OER), and open educational practices (OEP): A new front in the openness landscape. *Open Praxis* 15(3):178-184. https://doi.org/10.55982/openpraxis.15.3.579

Bozkurt, A. & Sharma, RC. 2023. Generative AI and prompt engineering: The art of whispering to let the genie out of the algorithmic world. *Asian Journal of Distance Education* 16(2):i-vi. https://doi.org/10.5281/zenodo.8174941

Browne, R. 2017. Elon Musk says global race for A.I. will be the most likely cause of World War III. *CNBC*. 4 September 2017. Available at: https://www.cnbc.com/2017/09/04/elon-musk-says-global-race-for-ai-will-be-most-likely-cause-of-ww3.html. (Accessed on 2 September 2023).

Butterfield, A. Ngondi, GE. & Kerr, A. 2016. *Artificial intelligence: A dictionary of Computer Science*. 7th ed. Oxford: Oxford University Press. https://doi.org/10.1093/acref/9780199688975.001.0001

Byjus. 2022. Enhance your potential. Available at: https://byjus.com. (Accessed on 9 September 2023).

Canva. 2023. Free online AI image generator. Available at: https://www.canva.com/ai-image-generator/. (Accessed on 25 September 2023).

Carbonell, JR. 1970. AI in CAI: An artificial-intelligence approach to computer-assisted instruction. Available at: https://stacks.stanford.edu/file/druid:xr633ts6369/xr633ts6369.pdf. (Accessed on 25 August 2023).

Carnegie Learning. 2023. MATHia: The 1-to-1 math coach that makes your life easier. Available at: https://www.carnegielearning.com/products/software-platform/mathia-learning-software. (Accessed on 9 September 2023).

CCR (Center for Curriculum Redesign). n.d. Making education ore relevant. Available at: https://curriculumredesign.org/. (Accessed on 6 September 2023).

Century. 2023. 10x national average grade improvement. Available at: https://www.century.tech. (Accessed on 9 September 2023).

Chassignol, M., Khoroshavin, A., Klimova, A., & Bilyatdinova, A. 2018. Artificial intelligence trends in education: A narrative overview. *Procedia Computer Science* 136:16-24. https://doi.org/10.1016/j.procs.2018.08.233

Chatbase. n.d. Custom ChatGPT for your data. Available at: https://bit.ly/456xmoA. (Accessed on 26 August 2023).

Chatbots.org. 2023a. Racter. Available at: https://www.chatbots.org/chatbot/racter/. (Accessed on 25 Augustus 2023).

Chatbots.org. 2023b. Jabberwacky. Available at: https://www.chatbots.org/chatterbot/jabberwacky/. (Accessed on 26 Augustus 2023).

Chatfuel. 2023. HelloFresh creates customer service chatbot with Chatfuel. Available at: https://chatfuel.com/blog/hellofresh-reduces-support-wait-times-with-chatfuel-messenger-bot. (Accessed on 27 August 2023).

ChatGPT. n.d. Website. Available at: https://chat.openai.com/. (Accessed on 1 September 2023).

Chen, L., Chen, P., & Lin, Z. 2020a. Artificial intelligence in education: A review. *IEEE (Institute of Electrical and Electronics Engineers) Access 8:75264-75278.* https://doi.org/10.1109/ACCESS.2020.2988510

Chen, X., Xie, H,. Zou, D., & Hwang, G-J. 2020b. Application and theory gaps during the rise of artificial intelligence in education. *Computers and Education: Artificial Intelligence* 1. 100002. 20 pages. https://doi.org/10.1016/j.caeai.2020.100002

Cherry, K. 2023. Overview of VARK learning styles. *Verywellmind*. 28 February 2023. Available at: https://www.verywellmind.com/vark-learning-styles-2795156. (Accessed on 6 September 2023).

CIRCSIM-Tutor Project. 2015. CIRCSIM-Tutor Project. Available at: http://www.cs.iit.edu/~circsim/. (Accessed on 10 September 2023).

CMU (Carnegie Mellon University). 2023. The Somin Initiative: About OpenSimon. Available at: https://www.cmu.edu/simon/open-simon/about/index.html. (Accessed on 12 September 2023).

CogBooks. 2021. We make blended/hybrid/online/remote learning work. Available at: https://www.cogbooks.com. (Accessed on 9 September 2023).

Colchester, K., Hagras, H., Alghazzawi, D., & Aldabbagh, G. 2017. A survey of artificial intelligence techniques employed for adaptive educational systems within e-learning platforms. *Journal of Artificial Intelligence and Soft Computing Research* 7(1):47-64. https://doi.org/10.1515/jaiscr-2017-0004

Comet. 2023. Less friction, more ML. Available at: https://www.comet.com/site/. (Accessed on 12 September 2023).

Coppin, B. 2004. *Artificial intelligence illuminated*. Boston: Jones & Bartlett.

Curriculum Associates. 2023. I-Ready: Personalize learning. Accelerate growth. Available at: https://www.curriculumassociates.com/Products/i-Ready. (Accessed on 9 September 2023).

Data.ai. 2023. Performance of Crystal Island. Available at: https://www.data.ai/en/apps/google-play/app/com.qublix.crystalisland/. (Accessed on 10 September 2023).

Debecker, A. 2017. A closer look at chatbot ALICE. *Ubisend*. 4 May 2017. Available at: https://blog.ubisend.com/discover-chatbots/chatbot-alice. (Accessed on 26 August 2023).

Dechter, R. 1986. Learning while searching in constraint-satisfaction-problems. *Association for the Advancement of Artificial Intelligence (AAAI) Conference Proceedings* 86, 178-183.

DeepTutor. n.d. A teacher in every pocket: Deep Tutor. Available at: https://deeptutor.ai/. (Accessed on 12 September 2023).

Della Ventura, M. 2017. Creating inspiring learning environments by means of digital technologies: A case study of the effectiveness of WhatsApp in music education. *EAI Endorsed Transactions on e-Learning* 4(14). 9 pages. https://doi.org/10.4108/eai.26-7-2017.152906

Demir, KA. 2021. Smart education framework. *Smart Learning Environments* 8(29). 36 pages. https://doi.org/10.1186/s40561-021-00170-x

Dennis, MA. n.d. Edward Albert Feigenbaum: American computer scientist. *Brittanica*. Available at: https://www.britannica.com/biography/Edward-Albert-Feigenbaum. (Accessed on 12 September 2023).

Devedžic, V. 2004. Web intelligence and artificial intelligence in education. *Educational Technology and Society* 7(4):29-39.

Dharaneishvc. n.d. Hidden Markov model in machine learning. *Geeksforgeeks*. Available at: https://www.geeksforgeeks.org/hidden-markov-model-in-machine-learning/. (Accessed on 6 September 2023).

Dikli, S. 2006. An overview of automated scoring of essays. *The Journal of Technology, Learning and Assessment* 5(1):3-35.

Di Nardo, M. & Yu, H. 2021. Special issue: Industry 5.0: The prelude to the sixth industrial revolution. *Applied System Innovation* 4. 45. 3 pages. https://doi.org/10.3390/asi4030045

Dreambox.ai. 2023. Turn your AI designs into physical products. Available at: https://www.dreambox.ai/. (Accessed on 9 September 2023).

Ebner, M., Schön, S., & Jahic, I. 2023. The good and the bad of AI in education. *Technical Report*. Available at: https://www.researchgate.net/profile/Martin-Ebner-3/research. (Accessed on 31 August 2023).

EdX (Electronic Data Exchange). 2023. Fuel your ambition. Available at: https://www.edx.org. (Accessed on 11 September 2023).

ETS (The Educational Testing Service). 2023a. e-Rater scoring engine. Available at: https://www.ets.org/erater.html. (Accessed on 11 September 2023).

ETS (The Educational Testing Service). 2023b. The GRE® Test is the world's most widely used admissions test for graduate & professional school. Available at: https://www.ets.org/gre)by. (Accessed on 21 September 2023).

European Commission. n.d. Fractions Lab: Exploratory learning environment that enables students to experiment with fractions. Available at: https://innovation-radar.ec.europa.eu/innovation/398. (Accessed on 10 September 2023).

Floridi, L. 2014. *The 4th revolution: How the infosphere is reshaping human reality*. Oxford: Oxford University Press.

Foltz, PW., Streeter, LA., Lochbaum, KE., & Landauer, TK. 2013. Implementation and applications of the intelligent essay assessor. In Shermis, MD. & Burstein, J. (Eds.): *Handbook of automated essay evaluation: Current applications and new directions,* 68-88. London: Routledge.

G, D. 2020. Honey and Mumford learning styles. October 2020. Available at: https://expertprogrammanagement.com/2020/10/honey-and-mumford/. (Accessed on 6 September 2023).

Gardner, J., O'Leary, M., & Yuan, L. 2021. Artificial intelligence in educational assessment: 'Breakthrough? Or buncombe and ballyhoo?' *Journal of Computer Assisted Learning* 37:1207-1216. https://doi.org/10.1111/jcal.12577

Gous, IGP. 2022. You're on your own now! Cultivating curiosity to support self-directed learning by means of a three dimensional questioning strategy. In Oliver, E. (Ed.): *Global initiatives and higher education in the fourth industrial revolution*, 213-236. Johannesburg: UJ Press. https://doi.org/10.36615/9781776405619-09

Gradescope. 2023. Deliver and grade your assessments anywhere. Available at: https://www.gradescope.com/. (Accessed on 12 September 2023).

Guan, C., Mou, J., & Jiang, Z. 2020. Artificial intelligence innovation in education: A twenty-year data-driven historical analysis. *International Journal of Innovation Studies* 4:134-147. https://doi.org/10.1016/j.ijis.2020.09.001

Haenlein, M. & Kaplan, A. 2019. A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California Management Review* 61(4):5-14. https://doi.org/10.1177/0008125619864925

Hardman, P. 2023. A brief history of AI in education. *DOMS: The Learning Science Newsletter*. 23 March 2023. Available at: https://drphilippahardman.substack.com/p/a-brief-history-of-ai-in-education. (Accessed on 12 September 2023).

Hinojo-Lucena, F-J., Aznar-Díaz, I., Cáceres-Reche, M-P., & Romero-Rodríguez, J-M. 2019. Artificial intelligence in higher education: A bibliometric study on its impact in the scientific literature. *Education Sciences* 9(51). 9 pages. https://doi.org/10.3390/educsci9010051

HistoryofInformation. 2023. Joseph Weizenbaum writes ELIZA: A pioneering experiment in artificial intelligence programming. *HistoryofInformation.com*. Available at: https://www.historyofinformation.com/detail.php?id=4137. (Accessed on 25 Augustus 2023).

Holmes, W., Bialik, M., & Fadel, C. 2019. *Artificial intelligence in education: Promise and implications for teaching and learning*. Boston: The Center for Curriculum Redesign.

IBM Watson. n.d. Introducing watsonx. Available at: https://www.ibm.com/watson. (Accessed on 10 September 2023).

Ignatov, A., Timofte, R., Chou, W., Wang, K., Wu, M., Hartley, T., & Van Gool, L. 2018. AI benchmark: Running deep neural networks on Android smartphones. *Proceedings of the European Conference on Computer Vision Workshops*, 288-314. https://doi.org/10.1007/978-3-030-11021-5_19

Jahic, I., Ebner, M., & Schön, S. 2023. Harnessing the power of artificial intelligence and ChatGPT in education – a first rapid literature review. In Bastiaens, T. (Ed.): *Proceedings of EdMedia + Innovate Learning*, 1462-1470. Vienna: AACE (Association for the Advancement of Computing in Education).

Jasper. n.d. Meet Jasper. On-brand AI content wherever you create. *Jasper Art*. Available at: https://www.jasper.ai. (Accessed on 1 September 2023).

Katsh, ME. 1984. Communications revolutions and legal revolutions: The new media and the future of law. *Nova Law Review* 8(3):631-669. 8.

Löw, S. 2018. SqueezeNet and MobileNet: Deep learning models for mobile phones. *AI in practice*. 10 May 2018. Available at: https://aiinpractice.com/squeezenet-mobilenet/. (Accessed on 29 August 2023).

Luckin, R., Holmes, W., Griffiths, M., & Forcier, LB. 2016. Intelligence unleashed: An argument for AI in education. Available at: https://bit.ly/4nNADkd. (Accessed on 3 September 2023).

Main, P. 2022. Classroom practice: Kolb's learning cycle. *Structural Learning*. 9 September 2022. Available at: https://www.structural-learning.com/post/kolbs-learning-cycle. (Accessed on 6 September 2023).

Malm, P. 2016. PARRY: The AI chatbot from 1972. *Phrasee*. 2 March 2016. Available at: https://phrasee.co/news/parry-the-a-i-chatterbot-from-1972/. (Accessed on 25 Augustus 2023).

Mavrikis, M., Holmes, W., Zhang, J., & Ma, N. 2018. Fractions Lab goes east: Learning and interaction with an exploratory learning environment in China. In Penstein Rosé, C., Martínez-Maldonado, R., Hoppe, HU., Luckin, R., Mavrikis, M., Porayska-Pomsta, K., McLaren, B., & Du Boulay, B. (Eds.): *Artificial Intelligence in Education*, 209-214. **AIED: International Conference on Artificial Intelligence in Education**. Cham: Springer Nature.

MBA.com 2023. The #1 exam for business school. Available at: www.mba.com/exams/gmat. (Accessed on 21 September 2023).

Meacham, M. 2021. A brief history of AI and education. *Global Science Research Journals*. 19 August 2021. Available at: https://www.globalscienceresearchjournals.org/articles/a-brief-history-of-ai-and-education-75546.html. (Accessed on 12 September 2023).

Melis, E. & Siekmann, J. 2004. ACTIVEMATH: An intelligent tutoring system for Mathematics. In Rutkowski, L., Siekmann, JH., Tadeusiewicz, R., & Zadeh, LA. (Eds): *Artificial intelligence and soft computing*, 91-101. ICAISC 2004. Lecture Notes in Computer Science 3070. Berlin: Springer. https://doi.org/10.1007/978-3-540-24844-6_12

Mentimeter. n.d. Make your teaching/time/meetings count. Available at: https://www.mentimeter.com/. (Accessed on 25 September 2023).

Microsoft Bing. n.d. Create images from words with AI. Available at: https://www.bing.com/images/create?FORM=GENILP. (Accessed on 5 September 2024).

Midjourney. n.d. Website. Available at: https://www.midjourney.com/. (Accessed on 1 September 2023). https://doi.org/10.1007/979-8-8688-0336-9_1

MIT (Massachusetts Institute of Technology). 2001. MIT team building social robot. 14 February 2001. Available at: https://news.mit.edu/2001/kismet. (Accessed on 12 September 2023).

Mitchell, TM. 1997. *Machine learning*. New York: McGraw Hill.

Moodle. 2023. The potential of AI and Moodle. Available at: https://moodle.com/news/the-potential-of-ai-and-moodle/. (Accessed on 25 September 2023).

Nearpod. n.d. What is Nearpod? Available at: https://nearpod.com/blog/chatgpt-ai-artificial-intelligence/. (Accessed on 25 September 2023).

Oliver, WH. 2019. Serious games in theology. *HTS Teologiese Studies/Theological Studies* 75(4), a5465. 8 pages. https://doi.org/10.4102/hts.v75i4.5465

Oliver, WH. 2024. Serious games in service of Theology. *Verbum et Ecclesia* 44(1), a2883. 8 pages. https://doi.org/10.4102/ve.v44i1.2883

OpenAI. n.d. MuseNet. Available at: https://openai.com/research/musenet. (Accessed on 1 September 2023).

Oppy, G. & Dowe, D. 2021. The Turing Test. *Stanford Encyclopedia of Philosophy*. Available at: https://plato.stanford.edu/entries/turing-test/. (Accessed on 25 August 2023).

Oram, R. 2019. Meeting Edward: Chatbots and the changing face of the hotel guest experience. *Oracle Hospitality Check-In*. 26 September 2019. Available at: https://blogs.oracle.com/hospitality/post/meeting-edward-chatbots-and-the-changing-face-of-the-hotel-guest-experience. (Accessed on 27 August 2023).

Owan, VJ., Abang, KB., Idika, DO., Etta, EO., & Bassey, BA. 2023. Exploring the potential of artificial intelligence tools in educational measurement and assessment. *Eurasia Journal of Mathematics, Science and Technology Education* 19(8). em2307. 15 pages. https://doi.org/10.29333/ejmste/13428

Pask, G. 1982. SAKI: Twenty-five years of adaptive training into the microprocessor era. *International Journal of Man-Machine Studies* 17(1):69-74. https://doi.org/10.1016/S0020-7373(82)80009-6

Pearson. 2023. Improving results. Available at: https://mlm.pearson.com/global/. (Accessed on 11 September 2023).

Pokrivcakova, S. 2019. Preparing teachers for the application of AI-powered technologies in foreign language education. *Journal of Language and Cultural Education* 7(3):135-153. https://doi.org/10.2478/jolace-2019-0025

Pot, J. 2022. How to build your own Slack bot. *Zapier*. 24 October 2022. Available at: https://bit.ly/46MN6OS. (Accessed on 12 September 2023).

Pressey, SL. 1926. A simple apparatus which gives tests and scores – and teaches. *School and Society* 23(586):373-376.

RealizeIt. 2023. Modern learning is adaptive. Available at: http://realizeitlearning.com. (Accessed on 9 September 2023).

Romero, C. & Ventura, S. 2013. Data mining in education. *Wiley Interdisciplinary Reviews* 3(1):12-27. https://doi.org/10.1002/widm.1075

Rosenberg, S. 2016. How to build bots for Messenger. *Meta*. 12 April 2016. Available at: https://developers.facebook.com/blog/post/2016/04/12/bots-for-messenger/. (Accessed on 12 September 2023).

Ruiz Estrada, MA. 2024. The seventh industrial revolution (IR 7.0). *Econographication Laboratory*. Available at: https://bit.ly/4nSHp8e. (Accessed on 29 October 2024).

Samuel, A. 1959. Some studies in machine learning using the game of checkers. *IBM Journal of Research and Development* 3(3):210-229. https://doi.org/10.1147/rd.33.0210

Seldon, A. 2018. *The fourth education revolution: Will artificial intelligence liberate or infantilise humanity*. London: Legend Press.

Shah, H. & Warwick, K. 2009. Emotion in the Turing Test: A downward trend for machines in recent Loebner prizes. In Vallverdú, J. & Casacuberta, D. (Eds.): *Handbook of research on synthetic emotions and sociable robotics: New applications in affective computing and artificial intelligence*, 325-349. Hershey: Information Sciences Reference. https://doi.org/10.4018/978-1-60566-354-8.ch017

Sharma, RC., Kawachi, P., & Bozkurt, A. 2019. The landscape of artificial intelligence in open, online and distance education: Promises and concerns. *Asian Journal of Distance Education* 14(2):1-2.

Shermis, MD. 2014. State-of-the-art automated essay scoring: Competition, results, and future directions from a United States demonstration. *Assessing Writing* 20(April):53-76. https://doi.org/10.1016/j.asw.2013.04.001

Shortliffe, EH. 1977. A knowledge-based computer program applied to infectious diseases. *Proceedings of the Annual Symposium on Computer Applications in Medical Care*, 66-69.

Smart Sparrow. n.d. Inspiring the next wave in digital learning. Available at: https://www.smartsparrow.com. (Accessed on 9 September 2023).

Socrative. 2023. Meet Socrative. Available at: https://www.socrative.com/. (Accessed on 25 September 2023).

Squirrel AI Learning. 2023. Website. Available at: https://www.crunchbase.com/organization/yixue-squirrel-ai. (Accessed on 9 September 2023).

Summit Learning. n.d. Learners for life. Available at: https://www.summitlearning.org. (Accessed on 9 September 2023).

The Peak Performance Center. 2023. The pursuit of performance excellence: Felder-Silverman. Available at: https://thepeakperformancecenter.com/educational-learning/learning/preferences/learning-styles/felder-silverman/. (Accessed on 6 September 2023).

Thoring, A., Rudolph, D., & Vogl, R. 2018. The digital transformation of teaching in higher education from an academic's point of view: An explorative study. *International Conference on Learning and Collaboration Technologies*, 294-309. Cham: Springer. https://doi.org/10.1007/978-3-319-91743-6_23

Timms, MJ. 2016. Letting artificial intelligence in education out of the box: Educational cobots and smart classrooms. *International Journal of Artificial Intelligence in Education* 26(2):701-712.

Toppr. n.d. Artificial intelligence essay for students and children. Available at: https://www.toppr.com/guides/essays/artificial-intelligence-essay/. (Accessed on 9 September 2023).

Tracxn. 2023. Skilla. 27 July 2023. Available at: https://tracxn.com/d/companies/skilla/___aY-xohA1lcYzE2TRyTmUt-Ng6GrkJLwBS-fIf2mLXHs. (Accessed on 12 September 2023).

Turing. 2023a. An overview of Bayesian networks in AI. Available at: https://www.turing.com/kb/an-overview-of-bayesian-networks-in-ai. (Accessed on 6 September 2023).

Turing. 2023b. Applications of genetic algorithms in machine learning. Available at: https://www.turing.com/kb/genetic-algorithm-applications-in-ml. (Accessed on 6 September 2023).

Turnitin. 2023. Empower students to do their best, original work. Available at: https://www.turnitin.com/. (Accessed on 12 September 2023).

Tutorialspoint. n.d. Artificial intelligence – Fuzzy Logic systems. Available at: https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_fuzzy_logic_systems.htm. (Accessed on 6 September 2023).

University of Memphis. 2019. AutoTutor. *Institute for Intelligent Services*. Available at: https://www.memphis.edu/iis/projects/autotutor.php. (Accessed on 10 September 2023).

Vanderbilt School of Engineering. 2023. Betty's Brain. Available at: https://wp0.vanderbilt.edu/oele/bettys-brain/. (Accessed on 10 September 2023).

VanLehn, K., Jordan, PW., Rosé, CP., Bhembe, D., Böttner, M., Gaydos, A., Makatchev, M., Pappuswamy, U., Ringenberg, M., Roque, A., Siler, S., & Srivastava, R. 2002. The architecture of Why2-Atlas: A coach for qualitative physics essay writing. In: Cerri, SA., Gouardères, G., & Paraguaçu, F. (Eds.): *Intelligent tutoring systems: Lecture notes in Computer Science* 2363:158-167. Berlin: Springer. https://doi.org/10.1007/3-540-47987-2_20

Viper. 2023. Online plagiarism checker by Viper. Available at: https://www.scanmyessay.com/. (Accessed on 12 September 2023).

Wang, Q., Jing, S., Camacho, I., Joyner, D., & Goel, A. 2020. Jill Watson SA: Design and evaluation of a virtual agent to build communities among online learners. Conference paper: CHI EA '20: Extended abstracts of the 2020 CHI Conference on Human Factors in Computing Systems. 8 pages. https://dl.acm.org/doi/abs/10.1145/3334480.3382878

Watters, A. 2015. Gordon Pask's Adaptive Teaching Machines. *Hackeducation*. 28 March 2015. Available at: https://hackeducation.com/2015/03/28/pask. (Accessed on 9 September 2023).

Web.nijt. n.d. ELIZA: A very basic Rogerian psychotherapist chatbot. Available at: https://web.njit.edu/~ronkowit/eliza.html. (Accessed on 25 August 2023).

Wiley. 2023. Achievement within reach. Available at: https://www.knewtonalta.com. (Accessed on 9 September 2023).

Wordtune. 2023. Reach your professional potential. Available at: https://bit.ly/3GrgBeA. (Accessed on 12 September 2023).

Zendesk. 2023. Chatbots vs. conversational AI: What's the difference? *Blog*. Available at: https://www.zendesk.com/blog/chatbot-vs-conversational-ai/. (Accessed on 27 August 2023).

Ziatdinov, R., Atteraya, MS., & Nabiyev, R. 2024. The fifth industrial revolution as a transformative step towards Society 5.0. *Societies* 2024. 14. 15 pages. https://doi.org/10.3390/soc14020019