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Abstract

Artificial intelligence (AI) and its impact on society have received a great deal of attention in the past five years since the first Stanford AI100 report. AI already globally impacts individuals in critical and personal ways, and many industries will continue to experience disruptions as the full algorithmic effects are understood. Higher education is one of the industries that will be greatly impacted; consequently, many institutions have begun accelerating its adoption across disciplines to address the fast-approaching market shift. Recent advances with the technology are especially promising for its potential to create and scale personalized learning for students, to optimize strategies for learning outcomes, and to increase access to a more diverse populations. In the US alone, colleges are predicted to witness a 48% growth in AI market between 2018-2022. Research has confirmed that the current use of AI in education (AIEd) leads to positive outcomes, including improved learning outcomes for students, along with increased access, increased retention, lower cost of education, and decreased time to completion. Future uses of AI will include the following: enabling engaging and interactive education anytime and anywhere; personalized AI mentors that will help students identify and reach their goals; and mass-personalization that will allow AI to be tailored to

each student's learning style, level, and needs. Yet with all the potential benefits that AI and machine learning (ML) may provide students, there remains a general reticence to adopt this technology because of misconceptions and perceptions that faculty will need to retool since their current teaching strategies will be outmoded. This study provides an overview for those in higher education of what AI is and is not, and how it may be used in various disciplines. Considerations of becoming an AI institution include the following: 1) curricular planning and oversight from academic affairs to identify appropriate use cases for AI in various disciplines, and 2) coordination with IT and technology infrastructure to develop ML to support student services in general.

Keywords

Artificial Intelligence, AI, Machine Learning, Higher Education, Emerging Technologies, Innovative Pedagogy, Digital Disruption

1. Introduction

The term Artificial Intelligence (AI) means different things to different people. It is a fast-growing, deep, and wide field of study, describing a class of technologies. Many people use AI to refer to an intelligent device, such as a robot, and call it "The AI." In this paper, we use the term in all these ways, depending on context. What remains constant is the impact AI will have on the future of work, education, and social life, as outlined in the AI100 study by Stanford University (Littman et al., 2021). AI is estimated to create a value of $13 trillion by 2030, and at the same time, an estimated 800 million jobs will be displaced due to AI and automation. With readily accessible and free tools and training on services such as Amazon Web Services (AWS) and the Google Cloud Platform, AI and machine learning (ML) is expanding beyond computer engineering and into use by the broader populations, including higher education. Image classification systems and software, such as Deep Lens and Natural Language Processing (NLP) are just a few of the areas that are in common use by academia. More commonly, faculty and students interact daily with AI. Even as we write this article, AI is providing suggestions on how to finish sentences and recommending changes. On a regular basis, we ask Siri, Alexa, and other virtual assistants for information on shopping, weather, factoids, and even to tell us jokes. Students use AI-based software, like Grammarly and web-based algorithms, to complete searches for research and writing term papers. In fact, one would be hard pressed to find a place in academic and the academic experience for contemporary students that are not supported by AI.

The examples cited above represent only one type of AI. In fact, AI encompasses a wide range functionality and is widely used in industry and education, most commonly to solve simple problems, whereas deep learning (neural networks), a subset of ML, is designed to solve more complex problems. Though

experts disagree on terminology, there are degrees of complexity with how AI can engage. For instance, so-called Narrow AI (NAI) is used to solve one given problem, such as with a chatbot, self-driving car, web search, or classification system. On the other hand, Artificial General Intelligence (AGI) can perform unsupervised tasks and, based upon the context, find patterns in data on its own. Finally, though some differentiate only between NAI and AGI as being simple tasks and everything a human can do, Super AI (SAI) will, theoretically, be comparable to the human mind. Given the emergence of Big Data and a larger neural net, combining performance with a significant amount of data, AI has seen exponential advances in the past decade. Yet despite the new capacities of ML, data scientists will still be necessary to help interpret and contextualize the data, extracting insights from what AI produces (Russell, Dewey, & Tegmark, 2015).

The expanding use, however, does not mean broad acceptance and adoption in all fields in higher education (Yu, 2020). With reports estimating that 400 - 800 million jobs will be displaced by 2030 due to AI and automation, every advance that is reported is met with a degree of reticence (Bughin et al., 2017; Smithies, 2017). In 2011, The Kress Foundation sponsored a study in conjunction with the Roy Rosenzweig Center for History and New Media at George Mason University on the use of digital art history in the community (Zorich, 2012). The findings showed an ambivalence or open hostility among those in the Humanities toward adoption of digital tools in their fields, which continues to hold marginal status in these disciplines despite promising learning outcomes. Others have questioned the viability of AI in traditional Humanities disciplines; Drimmer (2021), for instance, notes how the number of "mysteries solved" by AI in the field of art history were actually conclusions drawn from existing research that is now decades old. Even as the integration of digital tools and AI continues to expand beyond computer science departments, there remains no systematic reference or support structure for institutions, faculty, and students looking to adopt such strategies for the classroom. With the number of institutes, organizations, events, and conferences exponentially increasing each year to showcase these efforts—Association for Computers and Humanities (ACH), Immersive Learning Research Network (ILRN), Champions in Higher Education for XR (CHEX), The Future of Technology in Higher Education Summit, Technology and Future of Global Education—faculty are often working in isolation within their own departments and institutions, working on individual projects without the support of a broader campus network and infrastructure. For such reason, an onramp for faculty and students needs to be made available.

To fully realize the potential of AI, higher education will need to become familiar with what AI is and what AI is not. In fact, AI is still almost exclusively confined to NAI, and restricted to simple supervised tasks that a human could do within around a second, though AGI is expanding at an exponential rate. Some experts prefer to not use the term "Artificial Intelligence," but instead "Augmented Intelligence": humans working collaboratively with machines to

maximize our own potential (National Academies of Sciences, Engineering, and Medicine, 2018; Fourtané, 2021; Long & Magerko, 2020). Furthermore, should a wider range of academics, not confined to computer science, leverage this processing capacity and focus on what humans are able to do better, through complex reasoning, metacognition, and other abilities, advances in all fields could be made at a more rapid pace (Liao & Wu, 2020; Long & Magerko, 2020). For instance, ML works well when learning a "simple" concept and with adequate data available. On the other hand, ML works poorly when trying to learn complex problems with limited data, and if asked to perform the same task with new types of data without training (Nilsson, 2009; Müller & Bostrom, 2016). Referencing the anticipation of job loss due to AI by 2030, the same report also notes that 555 - 890 million new jobs will be created because of the same AI, and higher education needs to prepare students for those emerging jobs to work with, not against, AI and ML. Reviewing the projected areas of greatest impact, jobs that involve repetitive tasks, such as driving, construction, food preparation, and agricultural labor, will be the first to be lost; professions that require greater complex problem-solving and social skills, science and engineering, healthcare, upper-management, politics, and teaching, will remain viable (Nedelkoska & Quintini, 2018). Although the professions that will be retained currently require a college education, how these jobs, and emerging jobs, will be performed and how that will be impacted by AI needs to be considered and factored into pedagogy in higher education.

Research has already demonstrated the positive outcomes AI has for higher education. For instance, Klutka et al. (2018) reported improved learning outcomes for students, along with increased access, increased retention, lower cost of education, and decreased time to completion. AI technology and ML can increase the level of education bringing countless benefits to both students and faculty. One of the most important benefits of AI in higher education is personalized learning, tailored to each individual's needs and interests. Automated grading systems, conversational AI chatbots, and AI teaching assistants are just a few of the rising trends that we are witnessing in education. Additionally, with Augmented Intelligence adopted more broadly by faculty and researchers, greater amounts of data can be processed, and patterns recognized, allowing for more innovative and insightful scholarship from both student researchers and faculty. The benefits attached to the incorporation of AI into the academic curriculum, as well as in management and in administration, are going to place education on a strategic path toward a new kind of learning (Tang, Chang, & Hwang, 2021). Indeed, AI is crucial to the future of higher education. Specialized programs outside of academia, such as Inspirit Innovators, have begun demonstrating the viability of skills, such as data analysis in Python, statistics in R, and machine learn tools like Tensorflow and Keras, and how those can be applied to any university discipline. Through the intersection of AI and fields as varied as Art, Humanities, Psychology, and Healthcare, students are already being given the ability to

find intelligent solutions to real-world problems, such as detecting fake news online and delineating bias in the criminal justice system (Ozbay & Alatas, 2020; Raaijmakers, 2019). These strategies, tools, expertise, and training, need to be adopted more broadly in academia to prepare students with applicable portfolios, career planning, and skills to apply their discipline-specific knowledge and be even more impactful.

This study provides such an overview through a review of existing and future trends in various disciplines in higher education and provides a model to adopt AI across the fields of Education, Business, Humanities, and Sciences. Administrators and faculty need to consider three questions in redesigning curriculum to position themselves for the future of work:

1) Identify what AI can do better than humans in each field.

2) Identify what humans can do better than ML in each field.

3) Align curriculum with the skills identified for students to adapt and use technology.

While conferences and journals in higher education boast that students are being prepared for jobs that do not exist, there is a dearth of actual reachable solutions to substantiate these claims. Focus has shifted to job-specific training, especially in STEM fields. But the skills being trained are not necessarily transferable and are specific to existing occupations and sets of knowledge (Aoun, 2017). The following sets out to rectify this oversight by providing current and potential future examples of AI tools for each area of higher education, and suggests a pedagogical model that promotes adaptability, openness, and durable skills as outlined in NACE career competencies.

2. Literature Review

2.1. Overview of AI

AI impacts individuals globally in critical and personal ways. But at the same time, AI is little understood and often considered the "magic" of our times. Electricity held the same status through the turn of the last century. For example, The Lineman's Handbook of 1928 opens with this line: "What is electricity? —No one knows." The guide goes on to say that understanding the physics behind electricity was unimportant to benefit from it. Instead, the general population merely needed to know how electricity could be harnessed safely for heating, lighting, and powering their lives. By the same token, AI is often relegated to those few "experts" who understand how it works, while AI is becoming ubiquitous and increasingly accessible like electricity for the public. The term "Artificial Intelligence" itself is well-traveled, having been coined in 1956 with the promise of immediate impact across society, which soon led to disappointment in its limitations, and finally re-emerged more recently with greater optimism for its use (Crevier, 1993). As with electricity, breakthroughs in AI will require mass adoption and experimentation. And while many (if not most) early experiments will end up in failure, those that are successful, will have a substantial

impact on society as a whole (Thomas, 2019).

The first step to demystification of AI is to understand what it is, and what it is not (Queiroz et al., 2020). As a concept, AI has been part of public discourse for decades in the form of literature, film, and academic studies. Most often, AI has been depicted in the science fiction genre in film and in theoretical debates over whether machines will surpass humans in intelligence and take over the world, forcing humans into a subservient position. While the notion seems like hyperbole and a caricature of technology-gone-awry, AI has matured to such an extent that it does interact with us on a regular basis in our daily lives (Dwivedi et al., 2021). An ever-expanding variety of AI are being deployed to address a variety of areas, including facial recognition software, NLP, virtual assistants, and autonomous vehicles (Berente et al., 2021). Literature on AI has provided multiple definitions in an attempt at describing key functions and concepts for non-human intelligence that is programmed to perform specific tasks. For example, Russell & Norvig (2016) use the term to describe a system that imitates or mimics the cognitive functions commonly associated with humans, which includes speech, learning and problem-solving abilities. Another definition proposed Kaplan & Haenlein (2019) provides an even more refined analysis. Their study described AI within the context of the ability to independently interpret data and learn from external data in order to arrive at specific outcomes with flexible application. The increased capabilities and functionality are largely due to the emergence of big data, which has enabled AI algorithms to perform quite well with specific tasks, such as playing games, autonomous scheduling, robotic vehicles, and much more. The difference between the latest generation of AI and what was seen earlier is that there is much more pragmatic application. Furthermore, cognitive-focused algorithms that attempt to imitate the complexities of human feelings and thinking have yet to be successfully realized (Hays & Efros, 2007; Russell & Norvig, 2016). What arises when looking at all definitions of AI as it has evolved is the increase in capability for machines to perform tasks previously performed exclusively by humans in industry and society at large. In other words, AI can now augment what humans can do, especially simple, repetitive tasks, but still not replace human intelligence.

2.2. AI in Higher Education

As the abilities of AI, including computation, simulated intelligence, and even creativity, have evolved, new possibilities are emerging in how it may be leveraged in areas such as manufacturing, healthcare, finance, marketing, and education (Luckin & Cukurova, 2019). We are already witnessing the impact on productivity and performance. The debate on where, when, and to what extent AI will disrupt business continues to dominate the discussion on the technology. The field of education is already feeling the effects, challenging the standard quo in areas like student-support services, as well as teaching and learning methods (Barakina et al., 2021; Joshi, Rambola, & Churi, 2021; Owoc, Sawicka, & Weich-

broth, 2021). AI in education (AIEd) is one domain that has hitherto received little attention. The most established use of AIEd is in support of teaching and learning with student-support services (Baker, 2000; Roll & Wylie, 2016). Although the concept of AIEd may seem alienating for many academics outside Computer Science departments, the algorithms and models at the core of AIEd are grounded in the desire to connect and promote feedback loops and greater socialization. A recent poll (Brooks, 2021) confirmed the following:

- 36% of campuses use chatbots or other virtual assistants to support students
- 17% use AI to encourage admitted students to make deposits toward first semester tuition
- 22% use AI to identify at-risk students to intervene more quickly
- 16% to send early-warning notices (14% noted they were planning to implement such a system in the near future).

The use and awareness of AI for teaching and learning, however, is telling in the poll as anti-plagiarism software is used by 8% of institutions and 23% for tutoring. What is noticeably absent is the use of AI in actual instruction or equipping students with the tools to excel in their field. Regardless, AIEd has the potential to create more flexible, inclusive, personalized, and engaged learning, by empowering teachers and learners with the tools that allow quicker responses to what and how students are learning, but also how learners feel about the experience (Schiff, 2021; Taneri, 2020). In other words, AIEd is the engine behind much "smart" ed tech used by major publishers, such as McGraw Hill, Cengage, Pearson, and others, that track reading habits and times, test for understanding, and log analytics (Luckin et al., 2016; Pinkwart, 2016). With such widespread adoption, the full integration of AI into education seems to be in a mature phase, yet little research has been done on the benefits and challenges of fully integrating AI, considering the role in different fields and considerations of equity and ethics.

A comprehensive review of empirical studies conducted on the use of AI in education between 1993-2020 reveals the current state of AIEd research. Conducted by Zhang & Aslan (2021), the study notes that most AI research is only in STEM fields, while applications in education (AIEd) demands interdisciplinary approaches (Zawacki-Richter et al., 2019; Luttrell et al., 2020). The greatest number of AIEd research studies were ranked as follows, with engineering with the most followed by computer science, information technology (IT), followed by mathematics, foreign language, science, and, lastly, business. Overall, 25 of the 40 major research studies in AIEd were in STEM disciplines. Of the major topics of research, six major themes emerged:

- Chatbots
- Expert systems
- Intelligent tutors or agents
- Machine learning
- Personalized learning systems or environments (PLS/E)

- Visualizations

Chatbots represented only one study in education in an experiment lasting twelve-weeks where students were partnered either with chatbots or with human partners. In the study, 122 students participated in foreign language classes (Fryer et al., 2017). The study did not yield a positive correlation between the use of the chatbots and increased engagement. In fact, students were seen to lose interest after a week with the chatbot, whereas those with human partners had more positive results. Structural Equation Modelling used by the researchers indicated that task interest predicted future course interest in human partner conditions, while under chatbot partner conditions it did not.

AIEd research also suggests that encompassing expert systems are potentially helpful with pedagogical planning and can play a role in fully realizing the potential of learning management systems (LMS) (Dias et al., 2015). Dias and fellow researchers, for instance, investigated the quality of interactions in a blended learning environment with 1037 students and 75 instructors in an LMS environment over the course of an academic year in multiple courses. The resulting study demonstrated that an expert system, if appropriately structured and designed, can impact how users interact with the LMS (Dias et al., 2015). These systems can, therefore, assist in improving teaching and learning experiences with LMS.

Intelligent tutors or agents are also able to intervene, provide timely guidance, and customize appropriate materials to guide learners with feedback. Studies, however, have seen ambiguous results as relating to secondary education learning environments. One such series of studies looked at the effects of Teachable Agents (TA) in the classroom (Chin et al., 2010; Chin, Dohmen, & Schwartz, 2013; Matsuda, Weng, & Wall, 2020; Tärning et al., 2019). Results found that TA were able to improve learning in secondary education students, but not in every grade and not at all levels (Chin et al., 2010, 2013; Matsuda, Weng, & Wall, 2020). However, TA were able to assist students in learning unfamiliar science content, even when not actively engaging the AI (Chin et al., 2010). Researchers in Sweden performed another study (Gulz et al., 2020), looking at the understanding of a TA math game by preschoolers as reflected in the behaviors of their gazes. These participants seemed to believe the TA was an independent entity, thus pointing to the potential for metacognitive scaffolding in future uses.

In spite of the broad use of ML, there are surprisingly few studies that have been conducted regarding the use of AI in teaching and learning for education. One of the few studies that exists assessed the changing learning styles in ESL/EFL at different grade levels (Wei et al., 2018). Another study looked at ML algorithms and their use to predict the attitudes of undergraduate students toward educational applications of cloud-based mobile computing services through their information management behaviors with 74% accuracy (Arpaci, 2019).

Another application of AI to facilitate interactions has been identified with personalized learning systems or environments (PLS/E) (Xu & Wang, 2006).

PLS/E were also found to improve e-learning experiences (Cheung et al., 2003; Köse, 2018; Köse & Arslan, 2016; Xu & Wang, 2006). Researchers in Turkey (Köse & Arslan, 2016) also studied PLS with 110 undergraduates over the course of two semesters in computer programming degrees. Findings confirmed that the PLS both helped improve learning outcomes and student learning experiences. A related study by Köse (2018) in open computer education found that related personalized mobile learning applications, accessed via AI and augmented reality (AR), also improved learning outcomes and learning experiences.

Lastly, research has begun exploring the potential benefits of visualizations and virtual learning environments (VLE) for education alongside virtual reality (VR) technologies. The immersive nature of VLE led to greater engagement with learning and facilitated collaborations and learning better than other learning activities. Teachers also noted greater engagement with learning and the content in general (Griol, Molina, & Callejas, 2014). An Australian study also found that combining AI and VR was effective in improving engagement and learning in younger generations. The same outcomes were observed with undergraduate students, as well, who used AI and VR (Ijaz, Bogdanovych, & Trescak, 2017).

With all of these advances in AIEd, there remains a lack of research in how to apply AIEd outside of STEM fields and that of student-support services. Recent literature reviews have highlighted the need for greater perspectives from education in the field of AIEd research (Chen et al., 2020; Hinojo-Lucena et al., 2019; Zawacki-Richter et al., 2019). Additionally, the absence of educational theories and models has been noted by researchers when reviewing AI-enabled e-learning research over the last two decades (Tang, Chang, & Hwang, 2021). The result has been a noticeable gap existing between what AIEd technologies are capable of and how they are implemented in educational settings (Bates et al., 2020; Kabudi, Pappas, & Olsen, 2021).

In outlining the benefits and challenges of integrating AI into education, Owoc, Sawicka, & Weichbroth (2021) studied a number of public and private institutions of higher education in Poland. The researchers outlined ways in which AI is currently being used and could also be used in the future given use case scenarios. Some examples, like those above, focused on personalizing education for a better student learning experience. For instance, Querium, a start-up company from Austin, TX, works to deliver customizable STEM tutor programs that support mastery of critical STEM skills through PC and smartphones. Century, another start-up in London founded in 2013, uses cognitive neuroscience and data analytics in order to produce personalized learning plans for students, which reduces workload for educators. Aside from these companies, the researchers looked at regional institutions to see how AI could be used to streamline workflow. Uses were identified as follows:

1) Grouping, sorting and responding to emails.
2) Scheduling appointments.
3) Using Smart Agents (SAs) to automate certain administrative processes to

simplify tasks.

4) A customer service AI chatbot.

The examples provided can be grouped into two categories: teaching and learning and institutional and process support.

AIEd also supports the trend towards learning how to learn, as opposed to job-specific skills. Andriessen and Sandberg predicted the shift in 1999. Since then, there have been new educational and pedagogic paradigms being proposed and investigated that stress the importance of learning how to learn instead of learning job-specific skills (Detweiler, 2021). The shift can be seen in a movement away from procedural and skills in a specific domain or field and towards a conceptual understanding with graduates being able to think critically and creatively about said concepts and their relationships (Owoc, Sawicka, & Weichbroth, 2021). Since daily life requires the ability to access, categorize, and work with large amounts of information, one of the greatest assets of AI is the seemingly limitless potential to store, access, and create said information. Leveraging the technology in educational domains raises questions regarding: didactics and considering meaningful tasks, using databases to teach users how to interface with them; knowledge management and how to index, organize, and maintain information; and user strategies and how to access relevant information and evaluate what is found, or information literacy.

Foretelling current trends, Andriessen & Sandberg (1999) identified three specific scenarios for future consideration in education: transmission scenario, studio scenario, and negotiation scenario. The transmission scenario is designed to function in an educational environment with a closed domain and where the learning goal is fixed beforehand and remains stable over time. The studio scenario, on the other hand, is designed to operate in a setting that is either closed or open, and where learning is both fixed and stable but in such a way that attaining the goal can be achieved in different ways. The final example, the negotiation scenario, is designed to function in an educational domain that is open with an unfixed learning goal and may continually change through an iterative process. The first example is designed on models of expert reasoning and requires detailed monitoring of problem-solving steps, or model tracing, in order to diagnose user behaviors. The second example departs from modelling the cognitive states of individual learners to supporting the ongoing interactions between users, and the tools and tasks they use in their respective environments. The final example uses only open-ended scenarios and tasks, leading to the inability to reach detailed domain and user modelling. In this scenario, how information is exchanged between users and how activities are interpreted are of utmost importance (Guilherme, 2019). Those involved in this scenario must become highly skilled at negotiating knowledge and then disclosing important information. In order to be successful, flexible retrieval models need to be designed to make use of information and form knowledge, while interfaces need to provide easy access to the activities of other users. As such, rich databases that

are regularly updated are required for knowledge and information management that are able to provide students with answers.

The trend from understanding to application may also be understood by way of Bloom's revised taxonomy. The triadic system also reflects the development of AI systems and support in general, as well as expectations of students. New uses of technology accompany the shift away from discipline-specific knowledge to a more conceptual understanding of a given field, and studies over the past three decades bear this out. Detweiler (2021), for instance, recently argued in a longitudinal study that durable and transferable skills lead to lifelong learning and the ability to retool more quickly and easily. Students today will be expected to retool—learn new skills for jobs that do not yet exist (Raimi, 2021; Ebben & Drescher, 2022). Thus, arguably, the most valuable skills and outcomes of a college education are developing an open mindset along with promoting neural plasticity to readily adapt to new challenges, and AI is ideally suited to assist through personalized and adaptive learning strategies and support.

Few studies have been conducted on how AI or AIEd is used outside of Computer Science, IT, and the student-service models identified above. AI has been developed to support and augment work in all areas of academia, yet professors and students are not always made aware of the potential benefits. In fact, standard Ed Tech continues to be the industry standard across postsecondary disciplines, primarily in the form of the Microsoft Office suite (Ritzhaupt & Kumar, 2015; Mirrlees & Alvi, 2019). The promise of AI has intrigued academics from various fields for decades. Higher education institutions boast that students are being prepared for jobs that do not exist; however, there is a dearth of actual reachable solutions to substantiate the claim (Aoun, 2017). The following sets out to rectify this oversight by providing an overview by field on how AI is currently being used. Furthermore, this study will provide strategies for integration and look to future developments and use of AI and ML across higher education.

2.3. AI in Teaching and Learning across Disciplines

While AI is well-represented across campuses for institutional and student-support services, such as chatbots, plagiarism detection, and tutoring, there is little understanding of how the technology may be applied to actual classroom instruction methods and pedagogy (Vlasova et al., 2019; Brooks, 2021; Wang, 2021). The groundwork has already been laid through infrastructure and support, as well as through smart textbooks and the general use of AI and virtual assistants on a daily basis by faculty, staff, and students. AIEd has the potential to offer more personalized, inclusive, flexible, and engaging learning through providing access to tools for teachers and learners that allow quicker responses to what and how students are learning, but also how learners feel about the experience (Schiff, 2021; Taneri, 2020). Yet, as educators, we need to move beyond this understanding of the use of AI and begin equipping our students with the actual algorithms, software, and tools for future use, such as Natural Language

Processing (NLP), computer vision, pattern recognition, ML, neural networks, and deep learning. While these seem far removed from non-STEM disciplines, such as Education or the Humanities, there are applicable AI that can be readily adopted in all areas of higher education (Tchudi, 1993; Venturini, 2021).

But how do educators find the appropriate AI for their disciplines? There are a number of free or inexpensive certificates and tutorials on a wide range of platforms, including LinkedIn Learning, Coursera, Udemy, edX, Sololearn, and more, that provide easy access to introductory to advanced training in AI. These, however, do not include how such skills may be applied to non-quantitative disciplines. The confusion is understandable. Zawacki-Richter et al. (2019) found in their research that educators were unsure, despite the technology being around for three decades, how to use it in their given areas. As this paper attempts to address, there are, in fact, a number of resources for educators in all areas (Lin et al., 2021). Aside from individual applications, several support systems have been developed to assist with the integration of AI into all areas of education—"from artists to engineers." Companies such as Inspirit Innovators (https://inspiritinnovators.com/), supported through a number of tech industry notables and ivy league colleges, provides learning tracks for all areas to support the integration of Python, SQL, and ML fundamentals to apply to discipline-specific research questions. Content Technologies (http://contenttechnologiesinc.com/) Inc. also provides AI resources in the form of customized textbooks that summarize key points of lessons for students. Other training specific resources are readily available to educators to upskill in the area of AI, such as AI for Teachers (https://aiforteachers.catalog.instructure.com/). Aside from full courses to support the learning of AI fundamentals and skills to apply to disciplines are a number of ad hoc options, including app stores dedicated specifically to AI. For instance, The Educational App Store includes a full list of the "Best AI Apps," (https://www.educationalappstore.com/best-apps/best-ai-apps). While dedicated to secondary education, such resources are a useful starting place for any educator interested in AI. While many of the "Best AI Apps for Education" lists include generically applicable resources such as Socratic, SmartEd, Brainly, Front Row, Mika, and DataBot, these, along with more specific applications, may be used to augment learning in the classroom while simultaneously preparing students with the tools they will need to succeed, and problem solve in a variety of industries. The following review of use cases is in no way meant to be exhaustive but should provide an example of how these tools may be used in a variety of areas.

2.4. Education and Human Services

The adoption of AI for use in Education has paralleled that with Health Care, using simulators for counseling and teacher preparation—AI provide the feedback to students through online platform or through physical platform. In Edu-

cation and Human Services, Virtual Reality (VR) experiences are implemented through simulation tools such as TLE TeachLivE, which uses classroom simulators and interactive student avatars to help students become better educators (Ade-Ojo et al., 2022). Fraser et al. (2020) noted the positive impact that TLE TeachLivE had with training teachers that work with students diagnosed with autism spectrum disorder (ASD). Similarly, Mursion is a technology for virtual simulations used in teacher preparation programs to support preservice special education teachers in developing classroom management skills (Hudson, Voytecki, & Owens, 2019). According to Zolfaghari et al. (2020), using virtual headsets with the 360-video format supported more teacher observance toward student actions through simulations in teacher training programs. In the interest of VR, Second Life® has been used for teaching, counseling, and social work preparation (Hartley, Ludlow, & Duff, 2015). Within social work courses, VR and computer simulation are being used as viable teaching methods with interactive, immersive learning experiences mirroring previous examples from nursing and health programs (Dodds, Haslop, & Meredith, 2018).

Additional Resources

1) Virtual Reality and Computer Simulation in Social Work Education.

2) A Cutting-Edge Classroom Stimulator.

3) Using Virtual Worlds in Education: Second Life.

4) Preservice Teacher Experiences Implementing Classroom Management Practices through Mixed-Reality Simulations.

5) Using a Virtual Reality Environment to Train Special Educators Working with Students with Autism Spectrum Disorder to Implement Discrete Trial Teaching.

6) Preservice Teachers' Professional Noticing When Viewing Standard and 360 Video.

2.5. Humanities and Language Arts

In the Digital Humanities (DH), quantum computing is used to leverage the models and techniques from computer science in order to conduct research in the humanities (Dobson, 2015; McCarty, 2016; Hai-Jew, 2017; Gaffield, 2018; Barzen & Leymann, 2020; Phillips, Schiefelbein-Guerrero, & Kurlberg, 2019; Nowakowski & Bernard, 2019; Bassett et al., 2017; Hyvönen, 2020; Cao et al., 2020; Menon & Shanmugapriya, 2020; Messemer et al., 2020). However, the most impact in the classroom has been seen in the area of modern languages. In a survey of the role of AI in the language classroom, Ćalušić (2021) finds many practical applications already in experimental use, including computer-aided pronunciation training that can help students master spoken language, and intelligent language tutoring systems that can adjust the difficulty of student learning to match individual students' progress. While Ćalušić (2021) views the eventual widespread adoption of these technologies in the language classroom as inevitable, he cautions against the view that artificial tools alone can teach lan-

guage; rather, these tools must be designed to "assist teachers, not to replace them" (p. 39). Other surveys of the usage of such tools have made similar observations, both about the value of these tools and about the continued need for a human instructor, whose role may become more like that of a facilitator, stepping in as needed as students train with software (De Smedt, 2002; Ceolin et al., 2016; Xu & Margevica-Grinberga, 2021; Mukherjee, 2020). Most of the tools designed thus far are for English language training (with China in particular planning to spend billions on AI-assisted English-language instruction), but tools to teach other languages are also being developed (Pokrivčáková, 2019; Xiao & Hu, 2019; Ćalušić, 2021; Orlandi, 2021; Xu & Margevica-Grinberga, 2021; Haristiani, 2019).

While students in literature and history courses remain unlikely to work directly with AI, they do benefit from it when they search archives or take "big data"-focused digital humanities courses. Over the past several decades, humanities researchers have built massive textual corpora, and transforming these corpora of "big data" into "smart data" (that is, data that is usable) often requires ML (Zeng, 2017). Moreover, these transformations can be particularly tricky with data in the humanities. The domains of humanities research are highly specialized, so ML algorithms likewise require specialized training data or adaptations to work effectively in them (Suissa et al., 2022). Yet the benefits of doing so are considerable. As observed by Gefen et al. (2021), the ML performed on these corpora has opened the doors to textual analyses that take place on a grand scale, making it possible to achieve more definitive (or at least quantifiable) answers to questions of literary, linguistic, and historical interest than ever before. In digital humanities courses, students often perform such analyses, and in many cases, are unaware that AI was used to prepare the data they work with (Qian, Xing, & Shi, 2021).

The use of computer technology by poets, novelists, and mixed-media writers has mirrored the development of AI and the theorizing about these tools. In The Deep Learning Revolution, Sejnowski (2018) points out that medical diagnosis partnerships between physicians and AI technologies perform better than either human doctors or AIs on their own. However, Sejnowski also tells the familiar story of AlphaGo and AlphaGo Zero trouncing the best human Go players. In the world of creative writing, writers and writing communities that use databases and archives to enhance the work of authorship are developing human-computer partnerships, while writers like coder-and-poet Allison Parrish push forward with building bots that will generate poems increasingly independent of the traditional human writing process.

Since the earliest experiments with hypertext fiction in the 1990's, a parallel effort has been the development of archives and databases that would allow readers to access these texts. This is no trivial task, given the constant changes in computer hardware and computer languages. For example, many writers experimented with Flash technologies to build multi-media poetry and fiction, only

to see their work become obsolete when HTML, CSS, and Javascript transformed web development (Hoy, 2006; Tanasescu, Kesarwani, & Inkpen, 2018). The Electronic Literature Organization (ELO) (2016) and the ELMCIP Knowledge Base have conceived of machine intelligence as a hybrid of human creativity and databases that allow readers to access both the words and ideas created by authors and the technological environment for particular renderings of those words. Flores (2017), at a more individual scale, has pioneered a mix of blog and archive in his I ❤ E-Poetry website. Flores argues that even independently machine-written poetry requires the cooperation of human organizing and cataloging in order for that poetry to be perceived as poetry and remembered.

Other creative writers use more standard AI techniques to generate poetry-writing bots. Montfort (2021) advocates for blurring the line between code and text and works to develop what he calls a "computational poetics." A similar fusion of AI-generated text and community archive was the Flarf movement in experimental poetry. These poets used Google searches to randomly generate seed-language for poetry, an early form of bot-generated literature. They also used message boards and forums to archive the poetry and blogs to circulate the conversation. Though Flarf is now 15 years old, it was an early example of what much AI in creative writing is likely to be, human stochastic processes augmented by search and other algorithmic procedures. Finally, Parrish (2016) uses mainstream AI techniques such as word2vec to compose poetry. She uses gists on Github to give readers from the humanities the background they will need to venture out into computer science topics. She publishes poetry in print and online formats, and she presents at both computer technology venues such as Strange Loop in St. Louis as well as more conventional academic conferences.

2.6. Art and Design

An artist creates art rather than the computer they may utilize in the process, but with AI enhancements being applied to graphic and video applications, many processes that normally would have fallen to a graphic designer have been streamlined or replaced by AI technology (Gabriele et al., 2017; Liu, Siu, & Chan, 2021). According to a survey by Pfeiffer (2018) Consulting, 74% graphic designers stated that of their time spent, half was on non-creative tasks. Through the use of Generative Adversarial Networks (GAN), industry leaders in the arts such as Adobe have infused applications with AI an effort to help designers gain back some of that lost time. Adobe's AI engine Sensei (https://www.adobe.com/sensei.html) has enabled the industry leader to add neural filters and content-aware functionality to its flagship application, Photoshop. Through Sensei, image driven searches allow designers to find stock images from collections in a matter of seconds which otherwise could have taken hours. Removal of unwanted elements in a photograph or video can be done quickly with the pixels being replaced with unseen imagery derived from AI extrapolations. The sky in a photo can be swapped out and all associated lighting, color,

and reflections adjusted through the use of AI. Portraits can be quickly adjusted to reveal smoother skin, change the subject's expression from a frown to a smile, increase or reduce hair-growth, change the subjects age, adjust lighting on the subject, change eye gaze, or even transfer make-up from one person to another. Transferring the style of one work of art to another or even to a photograph becomes possible through a few checkboxes, sliders, and clicks. Changing the season of a landscape from summer to winter or colorizing a black and white photograph now all become possible through the integration of AI. Such functionality and more are now available to designers and have direct impact on the arts. AI's impact extends beyond merely enhancing work; GANs are used at sites such as "thispersondoesnotexist.com" to generate portraits based on analysis of thousands of faces, enabling the generation of completely fictitious photo-realistic images. This same level of AI has the potential to further enhance VR experiences to the point where countless new faces may be encountered in games and simulations. Pattern recognition has proven integral to the use of AI and the arts, and such use cases will only continue to expand (Cornia et al., 2020). AI enhanced applications provide artist and designers with an improved set of tools to which to practice their craft. Features such as those mentioned above are only the beginning of what we can expect to see from the use of AI in the arts and art education (Leonard, 2020; Ng & Ng, 2021).

2.7. STEM

Not surprisingly, the use of AI, originating in Computer Science and Mathematics departments have seen the highest percentage of use cases for teaching and learning in STEM fields (Gong et al., 2018; Ostherr, 2020). Zhang & Aslan (2021) noted that most uses of AI in education research were carried out in STEM disciplines. Not surprisingly, the primary text used in Computer Science to teach AI is nicknamed "The AI Bible" (Chollet, 2021). The results followed other studies, such as by Zawacki-Richter et al. (2019). The greatest number of AIEd research studies were ranked as follows with engineering with the most followed by computer science, IT, followed by mathematics, foreign language, science, and, lastly, business. In standard practice, most theory and application are taught in Computer Science using standard interactive platforms, such as WebAssign, XYZ Homework, MyLabMath, MyLabStats, Hawkes Learning Online HW Platform, Knewton Alta, Aleks, Wolfram Alpha, Desmos and standard interactive assessments, such as Polleverywhere and Kahoot. The interactive learning and homework platforms provide additional teaching and review that depend upon interaction with the student. They also usually auto grade for the teacher and provide feedback for the student. The level of AI varies in each platform. The benefits and limitations of these types of programs in teaching mathematics were reviewed by Voskoglou & Salem (2020). The authors reviewed commonly used learning theories and teaching methods of mathematics as well as the use of computers and AI in mathematics education. They include many

benefits, such as additional methods for student learning, and point out limitations, such as these programs falling short of "replicating" teachers.

Aside from standard platforms to teach AI, federal agencies and organizations also provide ready-made resources for instructors for both secondary and post-secondary use. The National Aeronautics and Space Administration (NASA) provides examples of student projects and ideas focused on AI and ML, such as Design a Robotic Insect (https://www.jpl.nasa.gov/edu/learn/project/design-a-robotic-insect/) available through the NASA Jet Propulsion Lab (JPL) (https://www.jpl.nasa.gov/edu/O). A simple search of "artificial intelligence" reveals many projects, examples, and materials useful to educators interested in utilizing AI in their teaching practices. NASA also provides data sets educators may utilize through their website EarthData (https://earthdata.nasa.gov/). Specifically, NASA's Earth Science Data Systems (ESDS) (https://earthdata.nasa.gov/) program, provides Artificial Intelligence and Machine Learning resources (https://earthdata.nasa.gov/esds/ai-ml) focused on utilizing AI to study the Earth, including programs, research projects, studies, and challenges. NASA STEM Engagement (https://www.nasa.gov/stem) is another resource useful to educators as it focuses on STEM education experiences for students of all ages.

3. Recommendations

3.1. Ethical Considerations and Algorithmic Bias

Recent polls have demonstrated serious concerns over the ethical use of AI. For instance, 68% of higher educational professionals raised concerns about ethics in AI, while 67% had concerns about algorithmic bias (Brooks, 2021). In a recent study of different AI ethics instructional patterns in higher education, the authors note "if AI education is in the infancy stage of development, then AI ethics education is barely an embryo" (Garrett, Beard, & Fiesler, 2020: p. 272). This qualitative analysis surveyed syllabi from the field to catalog current approaches to ethical formation across higher education programs. Among key observations, such as highlighting bias and privacy as the two most common ethical issues addressed, the study raises the important question of how a university system may address the ethical formation of future AI, ML, and data scientists (Greer & Wolf, 2020). Syllabi surveyed are indicative of two general approaches, standalone ethics courses and ethical topics embedded in technical courses (Garrett, Beard, & Fiesler, 2020: p. 274). Ayling & Chapman (2021) make the complementary observation that as "bias, unfairness and lack of transparency and accountability" remain fundamental issues in the AI space, known gaps in AI ethics may be addressed by expanding the range of stakeholders engaged in developing AI ethics tools (Ayling & Chapman, 2021: p. 1). The recent Responsible Artificial Intelligence (2021) report outlining the University of California's system framework for AI exemplifies higher education as a key resource for addressing these broad social concerns, even if the instructional design of these

experiences in the classroom environment requires ongoing exploration. Crawford's (2021) claim that AI and ML pose questions about the "structures of power" present in the implementation of technical developments underscores this connection between industry and university (p. 9). In addition to industry AI ethics codes, process enhancements for decision-making, and emerging technology ethics roles, ELSI-based (ethics, legal, and social issues) approaches may connect industry efforts with a similar scale of past impact on Human Genome Project ethical reflection provided by university-based scholars in that field (cf. Hartwig et al., 2022; Calo, 2017). While some have argued that academic approaches "do not speak to the highly particular, concrete uses of data and AI," higher education should embrace conceptual and vocational training as a space for embedded experiences of technical decision-making based on the complex and unique nature of potential harms posed by these technologies (Blackman, 2020). By making AI and ML ethics an interdisciplinary question populating higher education programs, traditional industry solutions will be supplemented by humanistic inquiry and experiential learning in the earliest vocational experiences of this technical workforce. It will take a diversity of professional perspectives and social locations to decipher ethically how we may continue to engage "organizing the data universe" (Beaton et al., 2017: p. 137). From this perspective, the ethical framework for AI health research by Nebeker et al. (2019), forged in substantial university collectives, charts the course for grounding specific technological advances in formative, interdisciplinary scholarship with groundbreaking pedagogical application in higher education. The abiding process question then becomes an opportunity to ask, in the context of higher education, "what, if any, baseline ethical commitment binds disparately situated researchers, analysts, and (of course) professional data scientists?" (Stark & Hoffman, 2019: p. 2).

3.2. Curricular Integration

The recommendations align with considerations of moving an educational institution to becoming an AI institution. These recommendations include curricular planning and oversight from academic affairs to identify appropriate use cases for AI in various disciplines, and coordination with IT and technology infrastructure to develop ML to support student services in general. In order to support the dissemination and ease of discovery of specific AI tools by discipline, Pan (2018) recommends an interdisciplinary resource library for AI be created and housed within an institution's library services. The resources to include within such a repository should be identified by representatives from across an institution, representing a range of disciplines. The AI early adopters should be provided with the resources to upskill, if necessary, and gain the necessary background and abilities to begin creating and using simple AI and ML in their fields. Use cases should then be created by the representatives and included as learning resources for instructors and workshops held on how these

might be applied and are applicable to each school, college, and discipline. Simple tutorials should be created or identified to lower barriers to entry and ensure ease of learning for both instructors and students.

4. Conclusion

AI has the potential to radically transform the delivery of educational materials. In an age of social and cultural evolution, technology is no longer a novel addition to an academic tradition now over two centuries old of the sage on the stage. Yet, the introduction of new technologies to support course delivery and learning outcomes, and the resistance against them, is not new. The introduction of the chalkboard into classes after 1801 was met with widespread revolt from students who had been trained to memorize instead of writing out their lessons (Betcher & Lee, 2009); the adoption of the magic lantern in universities in the nineteenth century, replacing engraved illustrations, was slow due to its perceived use primarily as a device for entertainment (Eisenhauer, 2006). Education is now at a turning point, along with the rest of industry with the changes wrought by AI and automation. However, educators will not be replaced, nor will other non-repetitive task-oriented professions. Instead, AI will "augment" rather than replace what teachers do in the classroom and it is imperative that, as educators, we equip our students with the tools necessary to succeed in an unknown future-both cognitive and technological.

Research into existing AI tools by discipline are presented and provide non-specialist faculty with educational materials necessary to begin integrating into their classes to expose students before entering the workforce. Where no tools can be identified, a standing AI group, made up of representatives from all colleges, staff and administration, should identify small projects to begin meeting the needs of those areas. Information technology (IT) should be involved in all stages of the process in order to assure student, faculty and staff support services utilize appropriate AI in order to streamline communications, provide access to information, and maximize performance. AI is not going to replace educators. However, it is changing the way educators work with their students. AI mentors are also challenging educators to become better, which is always a positive thing. AI mentors might soon be replacing teaching assistants. In a not-so-distant future, every student will count with a personalized and advanced AI mentor that will reinforce difficult concepts at the student's pace, especially those in mathematics and the physical sciences.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Ade-Ojo, G. O., Markowski, M., Essex, R., Stiell, M., & Jameson, J. (2022). A Systematic

Scoping Review and Textual Narrative Synthesis of Physical and Mixed-Reality Simulation in Pre-Service Teacher Training. *Journal of Computer Assisted Learning*. https://doi.org/10.1111/jcal.12653

Andriessen, J., & Sandberg, J. (1999). Where Is Education Heading and How about AI? *International Journal of Artificial Intelligence in Education, 10,* 130-150.

Aoun, J. E. (2017). *Robot-Proof: Higher Education in the Age of Artificial Intelligence*. MIT Press. https://doi.org/10.7551/mitpress/11456.001.0001

Arpaci, I. (2019). A Hybrid Modeling Approach for Predicting the Educational Use of Mobile Cloud Computing Services in Higher Education. *Computers in Human Behavior, 90,* 181-187. https://doi.org/10.1016/j.chb.2018.09.005

Ayling, J., & Chapman, A. (2021). Putting AI Ethics to Work: Are the Tools Fit for Purpose? *AI Ethics, 2,* 405-429. https://doi.org/10.1007/s43681-021-00084-x

Baker, M. J. (2000). The Roles of Models in Artificial Intelligence and Education Research: A Prospective View. *Journal of Artificial Intelligence and Education, 11,* 122-143.

Barakina, E. Y., Popova, A. V., Gorokhova, S. S., & Voskovskaya, A. S. (2021). Digital Technologies and Artificial Intelligence Technologies in Education. *European Journal of Contemporary Education, 10,* 285-296. https://doi.org/10.13187/ejced.2021.2.285

Barzen, J., &Leymann, F. (2020). Quantum Humanities: A Vision for Quantum Computing in Digital Humanities. *SICS Software-Intensive Cyber-Physical Systems, 35,* 153-158. https://doi.org/10.1007/s00450-019-00419-4

Bassett, C., Berry, D. M., Fazi, B., Pay, J., & Roberts, B. (2017). Critical Digital Humanities and Machine-Learning. In *ADHO 2017-Montréal*.

Bates, T., Cobo, C., Mariño, O., & Wheeler, S. (2020). Can Artificial Intelligence Transform Higher Education? *International Journal of Educational Technology in Higher Education, 17,* 1-12. https://doi.org/10.1186/s41239-020-00218-x

Beaton, B., Acker, A., Di Monte, L., Shivrang, S., Sutherland, T., & Tracy, S. (2017). Debating Data Science. *Radical History Review, 127,* 133-148. https://doi.org/10.1215/01636545-3690918

Berente, N., Gu, B., Recker, J., & Santhanam, R. (2021). Managing Artificial Intelligence. *MIS Quarterly, 45,* 1433-1450.

Betcher, C., & Lee, M. (2009). *The Interactive Whiteboard Revolution: Teaching with IWBs*. Australian Council for Educational Research.

Blackman, R. (2020, October 15). A Practical Guide to Building Ethical AI. *Harvard Business Review.* https://hbr.org/2020/10/a-practical-guide-to-building-ethical-ai

Brooks, C. (2021). *EDUCAUSE QuickPoll Results: Artificial Intelligence Use in Higher Education*. EDUCAUSE Research Notes. https://er.educause.edu/articles/2021/6/educause-quickpoll-results-artificial-intelligence-use-in-higher-education

Bughin, J., Hazan, E., Ramaswamy, S., Chui, M., Allas, T., Dahlstrom, P., & Trench, M. (2017). *Artificial Intelligence: The Next Digital Frontier?* McKinsey Global Institute. https://www.mckinsey.com/~/media/mckinsey/industries/advanced%20electronics/our%20insights/how%20artificial%20intelligence%20can%20deliver%20real%20value%20to%20companies/mgi-artificial-intelligence-discussion-paper.ashx

Calo, R. (2017). Artificial Intelligence Policy: A Primer and Roadmap. *UC Davis Law Review, 51,* 399. https://doi.org/10.2139/ssrn.3015350

Ćalušić, M. (2021). *Artificial Intelligence and Language Acquisition*. Master's Thesis, University of Split. Digitalni Akademski Arhivii Repozitoriji.

Cao, M.-Y., Li, D., & Wang, J. (2020). A Study of College English Culture Intelligence-

Aided Teaching System and Teaching Pattern. *English Language Teaching, 13,* 77-83. https://doi.org/10.5539/elt.v13n3p77

Ceolin, D., Noordegraaf, J., Aroyo, L., & van Son, C. (2016). Towards Web Documents Quality Assessment for Digital Humanities Scholars. In *Proceedings of the 8th ACM Conference on Web Science* (pp. 315-317). ACM. https://doi.org/10.1145/2908131.2908198

Chen, X., Xie, H., Zou, D., & Hwang, G. J. (2020). Application and Theory Gaps during the Rise of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence, 1,* Article ID: 100002. https://doi.org/10.1016/j.caeai.2020.100002

Cheung, B., Hui, L., Zhang, J., & Yiu, S. M. (2003). SmartTutor: An Intelligent Tutoring System in Web-Based Adult Education. *Journal of Systems and Software, 68,* 11-25. https://doi.org/10.1016/S0164-1212(02)00133-4

Chin, D. B., Dohmen, I. M., & Schwartz, D. L. (2013). Young Children Can Learn Scientific Reasoning with Teachable Agents. *IEEE Transactions on Learning Technologies, 6,* 248-257. https://doi.org/10.1109/TLT.2013.24

Chin, D. B., Dohmen, I. M., Cheng, B. H., Oppezzo, M. A., Chase, C. C., & Schwartz, D. L. (2010). Preparing Students for Future Learning with Teachable Agents. *Educational Technology Research and Development, 58,* 649-669. https://doi.org/10.1007/s11423-010-9154-5

Chollet, F. (2021). *Deep Learning with Python*. Simon and Schuster.

Cornia, M., Stefanini, M., Baraldi, L., Corsini, M., & Cucchiara, R. (2020). Explaining Digital Humanities by Aligning Images and Textual Descriptions. *Pattern Recognition Letters, 129,* 166-172. https://doi.org/10.1016/j.patrec.2019.11.018

Crawford, K. (2021). *Atlas of AI*. Yale University Press. https://doi.org/10.12987/9780300252392

Crevier, D. (1993). *AI: The Tumultuous Search for Artificial Intelligence*. Basic Books.

De Smedt, K. (2002). Some Reflections on Studies in Humanities Computing. *Literary and Linguistic Computing, 17,* 89-101. https://doi.org/10.1093/llc/17.1.89

Detweiler, R. A. (2021). *The Evidence Liberal Arts Needs: Lives of Consequence, Inquiry, and Accomplishment*. MIT Press. https://doi.org/10.7551/mitpress/13954.001.0001

Dias, S. B., Hadjileontiadou, S. J., Hadjileontiadis, L. J., & Diniz, J. A. (2015). Fuzzy Cognitive Mapping of LMS Users' Quality of Interaction within Higher Education Blended-Learning Environment. *Expert Systems with Applications, 42,* 7399-7423. https://doi.org/10.1016/j.eswa.2015.05.048

Dobson, J. E. (2015). Can an Algorithm Be Disturbed? Machine Learning, Intrinsic Criticism, and the Digital Humanities. *College Literature, 42,* 543-564. https://doi.org/10.1353/lit.2015.0037

Dodds, C., Heslop, P., & Meredith, C. (2018). Using Simulation-Based Education to Help Social Work Students Prepare for Practice. *Social Work Education, 37,* 597-602. https://doi.org/10.1080/02615479.2018.1433158

Drimmer, S. (2021). How AI Is Hijacking Art History. *Discover.* https://www.discovermagazine.com/technology/how-ai-is-hijacking-art-history

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., & Williams, M. D. (2021). Artificial Intelligence (AI): Multidisciplinary Perspectives on Emerging Challenges, Opportunities, and Agenda for Research, Practice and Policy. *International Journal of Information Management, 57,* Article ID: 101994. https://doi.org/10.1016/j.ijinfomgt.2019.08.002

Ebben, M., & Drescher, K. (2022). Retooling the Self for the Post-Pandemic Economy:

Identity, Work, and Well-Being. In *Career Re-Invention in the Post-Pandemic Era* (pp. 1-26). IGI Global.

Eisenhauer, J. F. (2006). Next Slide Please: The Magical, Scientific, and Corporate Discourses of Visual Projection Technologies. *Studies in Art Education, 47,* 198-214. https://doi.org/10.1080/00393541.2006.11650082

Electronic Literature Organization (2016). *The Electronic Literature Collection, Volume 3*. https://collection.eliterature.org/3/index.html

Flores, L. (2017). *I Love E-Poetry*. http://iloveepoetry.org

Fourtané, S. (2021). *Artificial Intelligence to Play Instrumental Role in Future of Higher Education*. Fierce Education. https://www.fierceeducation.com/administration/artificial-intelligence-to-play-instrumental-role-future-higher-education

Fraser, D. W., Marder, T. J., deBettencourt, L. U., Myers, L. A., Kalymon, K. M., & Harrell, R. M. (2020). Using a Mixed-Reality Environment to Train Special Educators Working with Students with Autism Spectrum Disorder to Implement Discrete Trial Teaching. *Focus on Autism and Other Developmental Disabilities, 35,* 3-14. https://doi.org/10.1177/1088357619844696

Fryer, L. K., Ainley, M., Thompson, A., Gibson, A., & Sherlock, Z. (2017). Stimulating and Sustaining Interest in a Language Course: An Experimental Comparison of Chatbot and Human Task Partners. *Computers in Human Behavior, 75,* 461-468. https://doi.org/10.1016/j.chb.2017.05.045

Gabriele, L., Marocco, D., Bertacchini, F., Pantano, P., & Bilotta, E. (2017). An Educational Robotics Lab to Investigate Cognitive Strategies and to Foster Learning in an Arts and Humanities Course Degree. *International Journal of Online Engineering, 13,* 7-19. https://doi.org/10.3991/ijoe.v13i04.6962

Gaffield, C. (2018). Words, Words, Words: How the Digital Humanities Are Integrating Diverse Research Fields to Study People. *Annual Review of Statistics and Its Application, 5,* 119-139. https://doi.org/10.1146/annurev-statistics-031017-100547

Garrett, N., Beard, N., & Fiesler, C. (2020). More than "If Time Allows": The Role of Ethics in AI Education. In *Proceedings of the AAAI/ACM Conference on AI, Ethics, and Society* (pp. 272-278). Association for Computing Machinery. https://doi.org/10.1145/3375627.3375868

Gefen, A., Saint-Raymond, L., & Venturini, T. (2021). AI for Digital Humanities and Computational Social Sciences. In *Reflections on Artificial Intelligence for Humanity* (pp. 191-202). Springer. https://doi.org/10.1007/978-3-030-69128-8_12

Gong, X., Wu, Y., Ye, Z., & Liu, X. (2018). Artificial Intelligence Course Design: iSTREAM-Based Visual Cognitive Smart Vehicles. In *2018 IEEE Intelligent Vehicles Symposium (IV)* (pp. 1731-1735). IEEE. https://doi.org/10.1109/IVS.2018.8500457

Greer, C., & Wolf, M. J. (2020). Overcoming Barriers to Including Ethics and Social Responsibility in Computing Courses. In *Societal Challenges in the Smart Society* (pp. 131-144). Universidad de La Rioja.

Griol, D., Molina, J. M., & Callejas, Z. (2014). An Approach to Develop Intelligent Learning Environments by Means of Immersive Virtual Worlds. *Journal of Ambient Intelligence and Smart Environments, 6,* 237-255. https://doi.org/10.3233/AIS-140255

Guilherme, A. (2019). AI and Education: The Importance of Teacher and Student Relations. *AI & Society, 34,* 47-54.

Gulz, A., Londos, L., & Haake, M. (2020). Preschoolers' Understanding of a Teachable Agent-Based Game in Early Mathematics as Reflected in Their Gaze Behaviors—An Experimental Study. *International Journal of Artificial Intelligence in Education, 30,*

38-73. https://doi.org/10.1007/s40593-020-00193-4

Hai-Jew, S. (2017). *Data Analytics in Digital Humanities*. Springer. https://doi.org/10.1007/978-3-319-54499-1

Haristiani, N. (2019). Artificial Intelligence (AI) Chatbot as Language Learning Medium: An Inquiry. *Journal of Physics: Conference Series, 1387,* 1-6. https://doi.org/10.1088/1742-6596/1387/1/012020

Hartley, M. D., Ludlow, B. L., & Duff, M. C. (2015). Second Life®: A 3D Virtual Immersive Environment for Teacher Preparation Courses in a Distance Education Program. *Rural Special Education Quarterly, 34,* 21-25. https://doi.org/10.1177/875687051503400305

Hartwig, T., Ikkatai, Y., Takanashi, N., & Yokoyama, H. (2022, January 22). Artificial Intelligence ELSI Score for Science and Technology: A Comparison between Japan and the US. *AI and Society,* 1-18. https://doi.org/10.1007/s00146-021-01323-9

Hays, J., & Efros, A. A. (2007). Scene Completion Using Millions of Photographs. *ACM Transactions on Graphics (TOG), 26,* 4. https://doi.org/10.1145/1276377.1276382

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. https://doi.org/10.3390/educsci9010051

Hoy, D. (2006). The Virtual Dependency of the Post-Avant and the Problematics of Flarf: What Happens When Poets Spend Too Much Time Fucking around on the Internet. *Jacket2.* http://jacketmagazine.com/29/hoy-flarf.html

Hudson, M. E., Voytecki, K. S., Owens, T. L., & Zhang, G. (2019). Preservice Teacher Experiences Implementing Classroom Management Practices through Mixed-Reality Simulations. *Rural Special Education Quarterly, 38,* 79-94. https://doi.org/10.1177/8756870519841421

Hyvönen, E. (2020). Using the Semantic Web in Digital Humanities: Shift from Data Publishing to Data-Analysis and Serendipitous Knowledge Discovery. *Semantic Web, 11,* 187-193. https://doi.org/10.3233/SW-190386

Ijaz, K., Bogdanovych, A., & Trescak, T. (2017). Virtual Worlds vs Books and Videos in History Education. *Interactive Learning Environments, 25,* 904-929. https://doi.org/10.1080/10494820.2016.1225099

Joshi, S. S., Rambola, K. R., & Churi, P. (2021). Evaluating Artificial Intelligence in Education. *Journal of Physics: Conference Series, 1714,* Article ID: 012039. https://doi.org/10.1088/1742-6596/1714/1/012039

Kabudi, T., Pappas, I., & Olsen, D. H. (2021). AI-Enabled Adaptive Learning Systems: A Systematic Mapping of the Literature. *Computers and Education: Artificial Intelligence, 2,* Article ID: 100017. https://doi.org/10.1016/j.caeai.2021.100017

Kaplan, A., & Haenlein, M. (2019). Siri, Siri, in My Hand: Who's the Fairest in the Land? On the Interpretations, Illustrations, and Implications of Artificial Intelligence. *Business Horizons, 62,* 15-25. https://doi.org/10.1016/j.bushor.2018.08.004

Klutka, J., Ackerly, N., & Magda, A. J. (2018). *Artificial Intelligence in Higher Education: Current Uses and Future Applications*. Learning House.

Köse, U. (2018). An Augmented-Reality-Based Intelligent Mobile Application for Open Computer Education. In *Virtual and Augmented Reality: Concepts, Methodologies, Tools, and Applications* (pp. 324-344). IGI Global. https://doi.org/10.4018/978-1-5225-5469-1.ch016

Köse, U., & Arslan, A. (2016). Intelligent e-Learning System for Improving Students' Academic Achievements in Computer Programming Courses. *The International Jour-*

nal of Engineering Education, 32, 185-198.

Leonard, N. (2020). Entanglement Art Education: Factoring Artificial Intelligence and Nonhumans into Future Art Curricula. *Art Education, 73,* 22-28. https://doi.org/10.1080/00043125.2020.1746163

Liao, S. P. S. H. T., & Wu, X. (2020*). The Role of Big Data and Artificial Intelligence in Education and Education Research: A Literature Mapping.* In *6th International Conference on and Social Science Research (ICHSSR 2020)* (pp. 241-245).

Lin, C. H., Yu, C. C., Shih, P. K., & Wu, L. Y. (2021). STEM Based Artificial Intelligence Learning in General Education for Non-Engineering Undergraduate Students. *Educational Technology & Society, 24,* 224-237.

Littman, M., Ajunwa, I., Berger, G., Boutilier, C., Currie, M., Doshi-Velez, F., Hadfield, G., Horowitz, M., Isbell, C., Kitano, H., Levy, K., Lyons, T., Mitchell, M., Shah, J., Sloman, S., Vallor, S., & Walsh, T. (2021). *Gathering Strength, Gathering Storms: The One Hundred Year Study on Artificial Intelligence (AI100) 2021 Study Panel Report.* The Stanford University. http://ai100.stanford.edu/2021-report

Liu, Z.-S., Siu, W.-C., & Chan, Y.-L. (2021). Photo-Realistic Image Super-Resolution via Variational Autoencoders. *IEEE Transactions on Circuits and Systems for Video Technology, 31,* 1351-1365. https://doi.org/10.1109/TCSVT.2020.3003832

Long, D., & Magerko, B. (2020). What Is AI Literacy? Competencies and Design Considerations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1-16). Association for Computing Machinery. https://doi.org/10.1145/3313831.3376727

Luckin, R., & Cukurova, M. (2019). Designing Educational Technologies in the Age of AI: A Learning Sciences-Driven Approach. *British Journal of Educational Technology, 50,* 2824-2838. https://doi.org/10.1111/bjet.12861

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An Argument for AI in Education.* Pearson. https://static.googleusercontent.com/media/edu.google.com/en//pdfs/Intelligence-Unleashed-Publication.pdf

Luttrell, R., Wallace, A., McCollough, C., & Lee, J. (2020). The Digital Divide: Addressing Artificial Intelligence in Communication Education. *Journalism & Mass Communication Educator, 75,* 470-482. https://doi.org/10.1177/1077695820925286

Matsuda, N., Weng, W., & Wall, N. (2020). The Effect of Metacognitive Scaffolding for Learning by Teaching a Teachable Agent. *International Journal of Artificial Intelligence in Education, 30,* 1-37. https://doi.org/10.1007/s40593-019-00190-2

McCarty, W. (2016). *Collaborative Research in the Digital Humanities* (pp. 13-22). Routledge. https://doi.org/10.4324/9781315572659

Menon, N., & Shanmugapriya, T. (2020). Pedagogy, Publishing and Practices. In M. Dodd, & N. Kalra (Eds.), *Exploring Digital Humanities in India: Pedagogies, Practices, and Institutional Possibilities* (p. 93). Routledge. https://doi.org/10.4324/9781003052302-10

Messemer, H., Perera, W. L., Heinz, M., Niebling, F., & Maiwald, F. (2020). Supporting Learning in Art History-Artificial Intelligence in Digital Humanities Education. In *Workshop Gemeinschaften in Neuen Medien (GeNeMe) 2020* (pp. 28-35). TUDpress.

Mirrlees, T., & Alvi, S. (2019). *EdTech Inc.: Selling, Automating and Globalizing Higher Education in the Digital Age.* Routledge. https://doi.org/10.4324/9780429343940

Montfort, N. (2021). A Platform Poetics/Computational Art, Material and Formal Specificities, and 101 Basic Poems. *The Digital Review, No. 1.*

Mukherjee, R. (2020). The Introduction of Artificial Intelligence in ESL Teaching: Possi-

bilities and Limitations. In *Changing Trends in Human Thoughts and Perspectives: Science, Humanities and Culture Part I* (pp. 89-93). Jogamaya Devi College.

Müller, V. C., & Bostrom, N. (2016). Future Progress in Artificial Intelligence: A Survey of Expert Opinion. In V. C. Müller (Ed.), *Fundamental Issues of Artificial Intelligence* (pp. 555-572). Springer. https://doi.org/10.1007/978-3-319-26485-1_33

National Academies of Sciences, Engineering, and Medicine (2018). *The Integration of the Humanities and Arts with Sciences, Engineering, and Medicine in Higher Education: Branches from the Same Tree.* https://www.nationalacademies.org/our-work/the-integration-of-the-humanities-and-arts-with-sciences-engineering-and-medicine-in-higher-education#:~:text=In%20its%202%02018%20report%20The%20Integration%20of%20the,active%20and%20informed%20members%20of%20a%20modern%20democracy

Nebeker, C., Torous, J., & Bartlett Ellis, R. (2019). Building the Case for Actionable Ethics in Digital Health Research Supported by Artificial Intelligence. *BMC Medicine, 17,* 137. https://doi.org/10.1186/s12916-019-1377-7

Nedelkoska, L., & Quintini, G. (2018). *Automation, Skills Use and Training.* OECD Social, Employment, and Migration Working Papers No. 202.

Ng, S. F. E., & Ng, C. H. (2021). Reports from the Field: Secondary School in Hong Kong Integrating the Spirit of Humanities into STEAM Education. *Journal of Learning for Development, 8,* 456-464. https://doi.org/10.56059/jl4d.v8i2.500 https://jl4d.org/index.php/ejl4d/article/view/500

Nilsson, N. (2009). *The Quest for Artificial Intelligence: A History of Ideas and Achievements.* Cambridge University Press.

Nowakowski, S., & Bernard, G. (2019). From Digital Humanities to a Renewed Approach to Digital Learning and Teaching. *Journal of Siberian Federal University. Humanities & Social Sciences, 12,* 1682-1693. https://doi.org/10.17516/1997-1370-0486

Orlandi, T. (2021). Reflections on the Development of Digital Humanities. *Digital Scholarship in the Humanities, 36,* ii222-ii229. https://doi.org/10.1093/llc/fqaa048

Ostherr, K. (2020). Artificial Intelligence and Medical Humanities. *Journal of Medical Humanities, 43,* 211-232.

Owoc, M. L., Sawicka, A., & Weichbroth, P. (2021). Artificial Intelligence Technologies in Education: Benefits, Challenges and Strategies of Implementation. In M. L. Owoc, & M. Pondel (Eds.), *Artificial Intelligence for Knowledge Management* (pp. 37-58). Springer. https://doi.org/10.1007/978-3-030-85001-2_4

Ozbay, F. A., & Alatas, B. (2020). Fake News Detection within Online Social Media Using Supervised Artificial Intelligence Algorithms. *Physica A: Statistical Mechanics and its Applications, 540,* Article ID: 123174. https://doi.org/10.1016/j.physa.2019.123174

Pan, X. (2018). Construction of Interdiscipline Curriculum Resource Library Based on Artificial Intelligence. *DEStech Transactions on Social Science, Education and Human Science,* 151-156. https://doi.org/10.12783/dtssehs/ichae2018/25641

Parrish, A. (2016). *Project Gutenberg Poetry Corpus.*

Pfeiffer, A. (2018). *Creativity and Technology in the Age of AI.*

Phillips, P., Schiefelbein-Guerrero, K., & Kurlberg, J. (2019). Defining Digital Theology: Digital Humanities, Digital Religion and the Particular Work of the Codec Research Centre and Network. *Open Theology, 5,* 29-43. https://doi.org/10.1515/opth-2019-0003

Pinkwart, N. (2016). Another 25 Years of AIED? Challenges and Opportunities for Intelligent Educational Technologies of the Future. *International Journal of Artificial Intelligence in Education, 26,* 771-783. https://doi.org/10.1007/s40593-016-0099-7

Pokrivčáková, S. (2019). Preparing Teachers for the Application of AI-Powered Technologies in Foreign Language Education. *Journal of Language and Cultural Education, 7,* 135-153. https://doi.org/10.2478/jolace-2019-0025

Qian, Y., Xing, Z., & Shi, X. (2021). From Collection Resources to Intelligent Data: Construction of Intelligent Digital Humanities Platform for Local Historical Documents of Shanghai Jiao Tong University. *Digital Scholarship in the Humanities, 36,* 439-448. https://doi.org/10.1093/llc/fqaa027

Queiroz, R. L., Sampaio, F. F., Lima, C., & Lima, P. M. V. (2020). *AI from Concrete to Abstract: Demystifying Artificial Intelligence to the General Public.*

Raaijmakers, S. (2019). Artificial Intelligence for Law Enforcement: Challenges and Opportunities. *IEEE Security & Privacy, 17,* 74-77. https://doi.org/10.1109/MSEC.2019.2925649

Raimi, L. (2021). Human Capital Development through Reinventing, Retooling and Reskilling Strategies. In *Conference towards ASEAN Chairmanship 2023 (TAC 23 2021)* (pp. 22-29). Atlantis Press.

Ritzhaupt, A. D., & Kumar, S. (2015). Knowledge and Skills Needed by Instructional Designers in Higher Education. *Performance Improvement Quarterly, 28,* 51-69. https://doi.org/10.1002/piq.21196

Roll, I., & Wylie, R. (2016). Evolution and Revolution in Artificial Intelligence in Education. *International Journal of Artificial Intelligence in Education, 26,* 582-599. https://doi.org/10.1007/s40593-016-0110-3

Russell, S. J., & Norvig, P. (2016). *Artificial Intelligence: A Modern Approach.* Pearson Education Limited.

Russell, S., Dewey, D., & Tegmark, M. (2015). Research Priorities for Robust and Beneficial Artificial Intelligence. *AI Magazine, 36,* 105-114. https://doi.org/10.1609/aimag.v36i4.2577

Schiff, D. (2021). Out of the Laboratory and into the Classroom: The Future of Artificial Intelligence in Education. *AI & Society, 36,* 331-348. https://doi.org/10.1007/s00146-020-01033-8

Sejnowski, T. J. (2018). *The Deep Learning Revolution.* The MIT Press. https://doi.org/10.7551/mitpress/11474.001.0001

Smithies, J. (2017). Artificial Intelligence, Digital Humanities, and the Automation of Labour. In *The Digital Humanities and the Digital Modern* (pp. 79-111). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-49944-8_4

Stark, L., & Hoffmann, A. (2019). Data Is the New What? Popular Metaphors & Professional Ethics in Emerging Data Culture. *Journal of Cultural Analytics, 4,* 1-22. https://doi.org/10.22148/16.036

Suissa, O., Elmalech, A., & Zhitomirsky-Geffet, M. (2022). Text Analysis Using Deep Neural Networks in Digital Humanities and Information Science. *Journal of the Association for Information Science and Technology, 73,* 268-287. https://doi.org/10.1002/asi.24544

Tanasescu, C., Kesarwani, V., & Inkpen, D. (2018). Metaphor Detection by Deep Learning and the Place of Poetic Metaphor in Digital Humanities. In *The Thirty-First International Flairs Conference* (pp. 122-128). Palo Alto: The AAAI Press.

Taneri, G. U. (2020). *Artificial Intelligence & Higher Education: Towards Customized Teaching and Learning, and Skills for an AI World of Work.* Research & Occasional Paper Series: CSHE. 6.2020. Center for Studies in Higher Education.

Tang, K. Y., Chang, C. Y., & Hwang, G. J. (2021). Trends in Artificial Intelligence-Sup-

ported e-Learning: A Systematic Review and Co-Citation Network Analysis (1998-2019). *Interactive Learning Environments,* 1-19.
https://doi.org/10.1080/10494820.2021.1875001

Tärning, B., Silvervarg, A., Gulz, A., & Haake, M. (2019). Instructing a Teachable Agent with Low or High Self-Efficacy—Does Similarity Attract? *International Journal of Artificial Intelligence in Education, 29,* 89-121.
https://doi.org/10.1007/s40593-018-0167-2

Tchudi, S. (1993). *The Astonishing Curriculum: Integrating Science and Humanities through Language*. National Council of Teachers of English.

Thomas, R. (2019). *AI Is Not Magic: It's Time to Demystify and Apply*. IBM Think Blog.
https://www.ibm.com/blogs/think/2019/03/ai-is-not-magic

Venturini, T. (2021). AI for Digital Humanities and Computational Social Sciences. In B. Braunschweig, & M. Ghallab (Eds.), *Reflections on Artificial Intelligence for Humanity* (pp. 191-202). Springer. https://doi.org/10.1007/978-3-030-69128-8_12

Vlasova, E. Z., Avksentieva, E. Y., Goncharova, S. V., & Aksyutin, P. A. (2019). Artificial Intelligence—The Space for the New Possibilities to Train Teachers. *Espacios, 40,* 17.

Voskoglou, M. G., & Salem, A. B. M. (2020). Benefits and Limitations of the Artificial with Respect to the Traditional Learning of Mathematics. *Mathematics, 8,* 611.
https://doi.org/10.3390/math8040611

Wang, X. (2021). College English Teaching Innovation under Artificial Intelligence. In *The Sixth International Conference on Information Management and Technology* (pp. 1-4). The Association for Computing Machinery.
https://doi.org/10.1145/3465631.3465844

Wei, Y., Yang, Q., Chen, J., & Hu, J. (2018). The Exploration of a Machine Learning Approach for the Assessment of Learning Styles Changes. *Mechatronic Systems and Control, 46,* 121-126. https://doi.org/10.2316/Journal.201.2018.3.201-2979

Xiao, Y., & Hu, J. (2019). Assessment of Optimal Pedagogical Factors for Canadian ESL Learners' Reading Literacy through Artificial Intelligence Algorithms. *International Journal of English Linguistics, 9,* 1-14. https://doi.org/10.5539/ijel.v9n4p1

Xu, B., & Margevica-Grinberga, I. (2021). A Discourse on Innovation of English Teaching in China from the Perspective of Artificial Intelligence. *Cypriot Journal of Educational Sciences, 16,* 2313-2323. https://doi.org/10.18844/cjes.v16i5.6347

Xu, D., & Wang, H. (2006). Intelligent Agent Supported Personalization for Virtual Learning Environments. *Decision Support Systems, 42,* 825-843.
https://doi.org/10.1016/j.dss.2005.05.033

Yu, Z. (2020). Visualizing Artificial Intelligence Used in Education over Two Decades. *Journal of Information Technology Research (JITR), 13,* 32-46.
https://doi.org/10.4018/JITR.2020100103

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic Review of Research on Artificial Intelligence Applications in Higher Education—Where Are the Educators? *International Journal of Educational Technology in Higher Education, 16,* Article No. 39. https://doi.org/10.1186/s41239-019-0171-0

Zeng, M. L. (2017). Smart Data for Digital Humanities. *Journal of Data and Information Science, 2,* 1-12. https://doi.org/10.1515/jdis-2017-0001

Zhang, K., & Aslan, A. B. (2021). AI Technologies for Education: Recent Research & Future Directions. *Computers and Education: Artificial Intelligence, 2,* Article ID: 100025.
https://doi.org/10.1016/j.caeai.2021.100025

Zolfaghari, M., Austin, C. K., Kosko, K. W., & Ferdig, R. E. (2020). Creating Asynchron-

ous Virtual Field Experiences with 360 Video. *Journal of Technology and Teacher Education, 28,* 315-320.

Zorich, D. (2012). *Transitioning to a Digital World: Art History, Its Research Centers, and Digital Scholarship.*