The use of Artificial Intelligence as a Teaching Tool in Academia

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Abstract

This study investigates the use of artificial intelligence as a teaching aid in academia. Using data on the application of existing AI tools and findings on effective one-on-one teaching, this research paper evaluates the effectiveness of existing AI technologies in facilitating knowledge acquisition in colleges. The review of studies indicates that a number of AI tools are already in use in colleges. These tools are *FreeStyler, Digalo, ARGUNAUT, Mika,* and *MATHia.* The research findings suggest that each of these tools has weaknesses that are undermining their effectiveness. In fact, none of these tools is effective in replicating the one-on-one learning experience needed to support learners' knowledge acquisition and improve students' educational attainment prospects. To achieve the required levels of effectiveness and replicate teachers' arm's length involvement, developers must deliver the AI through bionic people rather than computers and tablets.

Introduction and Statement of the Problem

For the last 29 years, the scientific community has been focusing on the development of artificial intelligence (AI) based technologies that higher learning institutions can use as teaching tools within colleges (Roll & Wylie, 2016). The process began 29 years ago with research into socially assertive robots could help human beings with everyday living activities like bathing, shopping, cooking, and washing (Timms, 2016). As technology experts' knowledge improved, they began to develop robots that could undertake more specialized tasks like injury rehabilitation, bomb detection, bomb disposal, and traffic control. Today, advances in AI have led to the emergence of autonomous systems that can complete complex and specialized daily living activities like driving, flying, natural language processing, knowledge reasoning, machine learning, planning, automated customer support, personalized shopping, workflow assistance, travel and navigation, creative arts, security, surveillance, and teaching.

As highlighted in the list of fields targeted by AI technologies, education is among the industries and professions that stand to benefit from advances in AI and robotics. In the teaching profession, AI applications have been particularly effective in giving learners the types of engagement opportunities that are often missing in the typical lecture hall, e-textbooks, and outdated hardcover books (Roll & Wylie, 2016). In this field, AI has offered smart content, virtual learning environments, virtual facilitators, and intelligent tutoring systems. AI-based smart content technologies assist the student community by condensing peer-reviewed journals, textbooks, reports, and other scholarly publications into useful content for examinations (Faggella, 2019). In a matter of seconds, the smart content technologies can analyze and summarize complex peer-reviewed journal into a series of true or false questions that seek to improve the students' knowledge of key concepts in the text. The AI-based virtual learning

environment and virtual facilitator technologies lower the deleterious consequences associated with teacher shortages by developing virtual instructors and teaching assistants. AI-based intelligent tutoring systems enhance students' learning experiences and improve learning outcomes by developing tutoring that is customized to individual learners' learning preferences, styles, and needs.

These intelligent tutoring systems have been particularly effective in delivering responsive teaching and personalized learning systems. Based on the mastery learning theory propounded by Benjamin Bloom (an educational psychologist) in the 1970s, the intelligent tutoring systems improve academic performance through individualized instruction in classrooms and lecture halls. They organize the curriculum based on each student's academic progress, offer constructive and timely feedback, and generate instantaneous opportunities for correcting errors. This AI-based teaching technology is the closest researchers have come to the development of a one-on-one tutoring system that can replace the human instructor and perform many of the tasks they undertake to improve learners' academic progress.

The reviewed AI trends related to the field of education suggest that scientists are edging closer and closer to the achievement of their overall objective of developing AIs that are more effective than human instructors. As colleges begin to adopt these technologies, human tutors will move to the periphery of college education. By delivering the AI-based learning systems through computers and other computer-mediated mediums, colleges will transform human tutors into black boxes with no meaningful role to play in the delivery of education or operationalization of the education systems. The prospect of complete automation of college education raises serious questions about the effectiveness of AI in replicating the ideal learning experiences needed to improve students' attitude towards education, enhance their academic

performance, and improve their academic achievement prospects. Some (Chaudhri, Gunning, Lane, & Roschelle, 2013) have argued that it is impossible to develop AI technologies that will address the contemporary education challenges that are undermining students' in-class performances and weakening their educational attainment prospects. Chaudhri, Gunning, Lane, and Roschelle (2013) assert that AI is yet to attain or replicate the holy grail of individualized tutoring. Others state that AI technologies have already reached that apex and can now deliver high-quality customized learning experiences.

Using the existing AI technologies and theories on effective one-on-one tutoring, this study will assess the effectiveness of AI as a teaching aid in college education. The research paper will evaluate whether existing AI technologies can replicate or better the personalized human tutoring experience that studies have claimed is critical to the achievement of positive learning outcomes. Findings gleaned from this analysis will determine whether human tutors are significant to the success of AIs. They will also state whether there is a need for scientists to focus more on the development of AIs that can complement the efforts of human tutors rather than the current technologies that seek to replace them without offering many of the benefits that competent tutors provide to students.

Limitations of the Study

This research paper will focus on one aspect of the education profession where researchers and technology companies planning to use AI to facilitate and augment knowledge acquisition. More specifically, the study focuses on the application of AI tools to college education and their effectiveness in supporting and improving learning. Researchers and AI firms have developed AI technologies that they claim can replicate and surpass the one-on-one learning experience that is crucial to academic achievement. They argue that their AIs can

develop customizable curriculum that progress with each learner's progress, thereby avoiding many of the in-class adversities that frustrate learners and force many of them to drop out. However, the researcher will not delve into an assessment of AI application in childhood education or other stages of learning development. Further, the research will not investigate future AI advancement. The study will only focus on existing AIs and their application to college.

Methodology

This is a qualitative research study in which the researcher uses desk-based research as the primary means of data collection. Desk-based research is a secondary research technique in which the researcher collects data from existing books, peer-reviewed journals, blogs, reports, and other published sources. In the context of the present study, the researcher collected data from peer-reviewed journals, online articles, and textbooks. Two factors prompted the researcher to opt for desk research. The first of these influences was the ready availability of studies that have analyzed the application of AI tools in colleges. The widespread availability of these studies and the extent of their reliability meant that there was no need to use interviews and other primary data collection methodologies that would have generated similar results. The second influence related to the topic under investigation. The limited use of AI tools in colleges meant that it would have been extremely difficult to recruit research participants with extensive knowledge on the effectiveness of the technologies. Therefore, the best option was to collect data publications and use it as the basis for an assessment into the effectiveness of AI tools in facilitating knowledge acquisition in colleges.

Literature Review

Researchers have undertaken extensive studies to document the application of AI tools to college. The general insight that springs from these treatises are that AI-based technologies are already in use in colleges across the US and other developed nations. The studies (Tsovaltzi, et al., 2010; McLaren, Scheuer, & Miksatko, 2010) indicate that experts have developed many AI applications to support learning in colleges. A 2010 survey of colleges in the Netherlands, Israel, the UK, and the US revealed that many higher learning institutions are using these computer-mediated AI tools to support and strengthen students' collaborative learning activities (McLaren, Scheuer, & Miksatko, 2010). The AI tools permit students using separate computers to synchronize their communication and engage in real-time arm's length communication, thereby contributing to lively and engaging discussions. An assessment of 15 classrooms in Israel, the UK, and the Netherlands showed that *FreeStyler* and *Digalo* are the AI tools that are in use in those institutions (McLaren, et al., 2010). *FreeStyler* uses graphical models and concept maps to facilitate collaborative learning. With the aid of *FreeStyler*, learners can chat and visually present arguments and debates (Tsovaltzi, et al., 2010). Like *FreeStyler*, the *Digalo* AI tool uses the same model. *Digalo* and *FreeStyler* use a shared user interface that has a drag-and-drop widget that permits users of different PCs to put forward their arguments, queries, assertions, or ideas in a vivid format (McLaren, et al., 2010). Students wishing to participate in a discussion can drag and drop widgets with varying semantics ("argument", "assertion", or "question"), fill them with the text that expresses their opinion on an issue (for example, I support Steve's assertion, because …"), and connect their opinion to the rest of the discussion by filing it under the claims that "support" (McLaren, et al., 2010). The scholars' analysis of the AI tools confirms that they have not given instructors a prominent role. The technologies have created a platform that is solely for students to work together and acquire knowledge in the absence of teachers.

Beyond *FreeStyler* and *Digalo,* scholars and other experts have developed ARGUNAUT technology, which gives teachers an important role in the knowledge acquisition process. ARGUNAUT makes it easier for teachers to improve the quality of debates and discussions by giving them a moderator interface (Wegerif, et al., 2013). ARGUNAUT is a machine learning technology that gives teachers the capabilities they need to guide students on the types of tasks they would execute in order to enhance the value of the debate and foster learning and knowledge acquisition (Wegerif, et al., 2013). The technology gives teachers the power to tutor the collaborating students and offer timely feedback that moderates their deliberations (Wegerif, et al., 2013). Through the AI, teachers would identify the students that are online, make real-time reviews of students' claims, questions, opinions, and arguments to determine whether they are accurate, reasoned, and on topic (Wegerif, et al., 2013). Thereafter, teachers guide the direction of the discussion by highlighting the meaningful contributions (Wegerif, et al., 2013). Through the ARGUNAUT, the instructor becomes an e-moderator who provides timely feedback that highlight issues that require the students' immediate attention (Wegerif, et al., 2013). ARGUNAUT developers acknowledged from the outset that it would be challenging for individuals teachers to moderate e-discussions in which students make multiple, simultaneous arguments and claims (Tchounikine, Rummel, & McLaren, 2010). Therefore, they incorporated a machine learning feature that hastens the teacher moderation process by summarizing the arguments and providing timely alerts that highlight important events in the e-discussion (Tchounikine, et al., 2010). Whereas the new AI-based tool has corrected weaknesses identified in the early AI tools by giving teachers superior functions, the authors reviewing the studies have not investigated the effectiveness of this improvement on students' collaborative learning. In particular, they have not investigated whether the advanced functionality enhances collaborative

learning and knowledge acquisition by replicating the one-on-one environment that exists in the classroom.

In recent years, AI advances have led to the design of tools that have taken over the role of teachers. These AI tools can boost learning by simulating the one-on-one experience that is present in the classroom environment. A review of existing studies suggests that Mika and MATHia are among the leading AI-based intelligence tutoring learning technologies available for use in colleges (Fancsali, Yudelson, Berman, & Ritter, 2018). Developed by Carnegie Learning, Mika and MATHia utilize AI analytics and cognitive science to deliver customized tutoring solutions and instantaneous feedback to students at the post-secondary education level (Singh, 2018). The technology has been particularly useful in the provision of remedial courses to new college freshmen who are experiencing challenges in adjusting to demands at the post-secondary level (Faggella, 2019). According to Carnegie Learning, the technology has been effective in reducing the astronomical costs that colleges incur in the provision of remedial courses (Faggella, 2019). Carnegie Learning asserts that colleges spend more than $6.5 billion every year in remedial classes, but statistics indicate that remedial math courses have a 33% success rate (Faggella, 2019). Therefore, the technology company states that AI can improve students' academic performance and increase the remedial success rate by giving them access to highly flexible and customized modules (Faggella, 2019). The modules develop in accordance with each learners' academic progress.

Analysis

The reviewed studies suggest that many of the early AI tools were not effective in facilitative knowledge acquisition and cognitive growth. Many of the early computer-mediated AI tools did not give instructors a prominent role. They merely provided a computer-mediated

platform through which students using networked computers could acquire knowledge through collaborative learning (Tsovaltzi, et al., 2010). Even though psychology education scholars suggested that teacher participation was central to success in collaborative learning, technology firms and experts continued to develop AI tools that relegated instructors to the periphery. While *FreeStyler, Digalo,* and many of the early AI tools provided learners using networked computers with an opportunity to collaborate on projects and undertake group work, the computer-mediated technologies did little to help students to promote students' engagement in meaningful discussions and collaborations. Their failure to give teachers a prominent role undermined their effectiveness as tools that facilitate collaborative learning. Indeed, evidence from educational psychology studies suggests that collaboration does not occur in a vacuum (McLaren, et al., 2010). Educational psychologists stress that teacher engagement is central to successful collaborative learning (Ku, Tseng, & Akarasriworn, 2013). Certainly, Vygotsky's socio-cultural theory posits that learners cannot attain a complete appreciation of a new concept or ideas without feedback from teachers and peers (Ku, et al., 2013). In Vygotsky's perspective, teachers' repeated interaction with their students is a critical component of collaborative learning (Ku, et al., 2013). Teacher feedback can facilitate peer collaboration, knowledge acquisition, and cognitive development (Ku, et al., 2013). These assertions suggest that teachers are pertinent to collaborative learning. They suggest that the effectiveness of the collaborative learning AI tools rests on their ability to give teachers a prominent role in the collaboration activities.

Prominence implies that the teachers' inclusion in AI application must be meaningful. A meaningful involvement implies that the teacher ought to embed themselves into the discussions, engage directly with the students, and give them feedback in the same way that they would do in the real world. ARGUNAUT and other AIs created avenues for teacher support, but none of the

opportunities were meaningful. In light of the criticism surrounding the absence of instructor presence, researchers and technology companies developed AI tools that give instructors a prominent role. They created software that enhances teachers' ability to guide discussion (Wegerif, et al., 2013). ARGUNAUT is one of the technologies that have sought to improve the quality of AI-based collaborative learning by giving teachers an e-moderator status (Wegerif, et al., 2013). An analysis of its efficacy suggests that the technology has increased teachers' ability to join in by giving them an e-moderator status. This status increases their active participation, but it does little to give it meaning. The technology intervenes to limit the extent to which instructors can participate in the technology. It restricts their involvement by limiting their feedback to summaries and pre-determined responses. The teachers cannot offer organic feedback or engage with students in ways that are outside the set modes of response. Even though tutors participate in discussions and debates, their role is not significant. It is just a perfunctory engagement that would not generate the type of real-life experience needed to improve the students' knowledge acquisition.

Even with the recent advancements in AI, experts are yet to develop effective AI applications that can replicate the one-on-one experience that instructors provide to college students. Carnegie Learning's Mika and MATHia technologies have dispensed with teacher inclusion by attempting to replicate the one-on-one learning setting that is present in real-world learning environments. The AI tools map the steps within each problem (Fancsali, et al., 2018). Thereafter, it utilizes the Bayesian Knowledge Tracing AI to categorize each of the steps into pre-determined knowledge components or skills (Fancsali, et al., 2018). Thereafter, it combines Bayesian Knowledge Tracing with mastery learning to generate accurate estimates on college students' mastery of each of the knowledge components as they attempt to resolve the problem

(Fancsali, et al., 2018). Mika and MATHia will only permit learners to "graduate" to the next topic or section after it is satisfied that they have mastered all of the knowledge components (Fancsali, et al., 2018). When a student fails to master all of the steps within a set timeframe, the AI "promotes" them to the text section or topic. Immediately after each student's graduation or promotion, the two AIs give teachers a report documenting the factors leading to each students' "graduation" or "promotion' status. In reviewing the promotion cases, the teacher will know the skills or competencies that each individual learner failed to grasp (Fancsali, et al., 2018). At this point, the teachers can intervene and provide the remedial work needed for the students to grasp the concepts (Fancsali, et al., 2018). As this analysis suggests, the teacher will only participate when the leaners have failed to grasp the knowledge components and received a "promoted" status. In such an instance, the teacher will intervene and attempt to buttress the learners' knowledge by providing the arm's length tutoring or remedial sessions. In these sessions, learners and their respective teachers can go through the report, discuss the steps that were difficult to master, and undertake the remedial work needed to augment their knowledge of those concepts and steps.

The provision of customized learning situations creates the impression that the AI tools are ahead of the curve in terms of the effectiveness in providing tutoring solutions, but the reality is that they are still ineffective. The developers of Mika, MATHia, and other AI tools that dispense with teachers and attempt to the deliver the one-on-one experience overlooks the fact that teacher presence entails more than just the provision of accurate feedback and the teaching of steps. Recent trends in education theory and practices have underlined the essence of personalized teacher involvement in the development of learning competencies and skills like collaboration, critical thinking, and metacognition (Roll & Wylie, 2016). The theories suggest

that students need personalized support to enhance their knowledge acquisition capabilities (Roll & Wylie, 2016). Further, the studies indicate that teachers' ability to generate positive learning experiences depends on the extent of their access to personalized support (Roll & Wylie, 2016). Teachers and students who have access to personalized support will perform better than counterparts who cannot access or use support (Roll & Wylie, 2016). These studies suggest that the effectiveness of AI tools does not hinge on the extent to which they will replace teachers and provide exclusive tutoring to college students. It will depend on the extent to which they provide platforms that boost the acquisition of essential skills and competencies. Therefore, AI tools will be effective when they improve teachers' ability to personalize their student interventions.

Mika and MATHia come close to this by providing accurate reports that improve teachers' ability to identify learners who are struggling to grasp key concepts, but its failure to avail similar involvement opportunities for the "graduated" students curtails its effectiveness. The analysis of Mika and MATHia suggests that the two technologies provide feedback on promoted and graduated students. According to the argument, the "graduate" students are not in need of teacher intervention because have mastered the concepts and acquired the required knowledge components (Fancsali, et al., 2018). Nonetheless, promoted students have failed to master all or some of the knowledge components and, as such, they are in need of additional remedial work to ensure that their cognitive maturation is at par with other students within the class (Fancsali, et al., 2018). The decision to limit teacher inclusion to struggling students means that other students who have grasped concepts cannot draw meaningful benefits from their instructors (Fancsali, et al., 2018). Given that scholars have suggested that teacher support is critical to the achievement of positive learning outcomes (Roll & Wylie, 2016), failure to give all students access to teachers undermines their ability to achieve important cognitive development

outcomes. Some of the students who have mastered key concepts and achieved the requisite knowledge concepts may be in need of further guidance from lecturers or teaching assistants, but prioritizing struggling students may make it difficult for them to access that support. In the absence of support, the AI tools will do very little to attain the knowledge progress targets achieved in the real-life classroom.

As well as the weaknesses that spring from the segregated nature of tutor participation under AI tools like Mika and MATHia, the delivery of AI-based learning through pads and personal computers renders them ineffective. To successfully replicate the one-on-one learning experiences that are crucial to college students' academic performance and educational attainment, developers must develop AI tools that are not delivered through pads, smartphones, and computers (Timms, 2016). Technology firms developed tablets, smartphones, and computers to facilitate communication in modern-day office environments. They did not develop technologies with college students in mind (Timms, 2016). Therefore, an attempt to use them as the primary mode of the delivery will undercut the effectiveness of AI tools (Timms, 2016). AI technologies can only become effective when technology firms deliver them through hardware designed with a specific focus on teachers, students, and classrooms or lecture halls (Timms, 2016). Such a focus will reveal that higher learning institutions are settings where teachers and learners convene virtually and physically with the aim of developing skills and expending their knowledge (Timms, 2016). However, delivery via computers and other hardware developed solely to facilitate communication in offices will continue to weaken their effectiveness (Timms, 2016). Such hardware diminishes learners' ability to acquire knowledge by eliminating many of the mannerisms, attitudes, and traits (like humor, tonal variation, smiles, active listening, empathy, and charisma) that effective teachers use to facilitate knowledge acquisition in

colleges. Reliance on mediums like PCs, smartphones, and tablets lessens the speed with which learners acquire knowledge by eliminating the visual and auditory cues that they use to grasp key concepts.

Conclusion

Technology companies have developed many AI tools to supplement, support, and facilitate college students' knowledge acquisition, but they have weaknesses that undermine their effectiveness. Some of the developed technologies include *Freestyler, Digalo, ARGUNAUT, Mika,* and *MATHia. Freestyler* and *Digalo* are the early technologies that attempted to dispense with teachers by creating a collaborative platform where students would collaborate with limited input from teachers. Their failure to give teachers a prominent role curtailed their effectiveness. ARGUNAUT tried to address that weakness by incorporating tutors as e-moderators. However, ARGUAUT's limitation of teacher inclusion to moderation prevented it from replicating the real-world experience that is an important precursor to learners' knowledge acquisition. *Mika* and *MATHia* created new avenues for increased teacher involvement, but their focus on struggling students undermined their efficacy. Focusing teacher attention on struggling students meant that other students who graduated would not receive the teacher support needed for them to buttress their knowledge acquisition. In the long-run, the students' knowledge would regress. They would miss opportunities to improve strengthen their level of cognitive development.

Having highlighted the ineffectiveness of existing AI tools and the role that hardware has played in undermining their usefulness, this study has established that technology firms and researchers can boost the efficacy of AI tools by delivering them through mediums that are suitable for the college environment. As noted in the discussion, college is a setting in which teachers and students meet physically and virtually to expand their knowledge. During the course

of these frequent meetings, highly effective teachers used verbal and non-verbal communication techniques to facilitate learners' knowledge acquisition. In the same vein, learners interpret their instructors' verbal and non-verbal cues to enhance their knowledge acquisition. The essence of this argument is that physical interaction and the elicited verbal and non-verbal cues are critical components of the cognitive development process in lecture halls. Flowing from this logic, effective AI tools will be the ones delivered through tangible mediums that can replicate the mannerisms, traits, and attitudes of highly effective teachers.

To achieve success in the creation of these AI technologies, corporations and researchers must develop robots that can help teachers by simulating the highly interactive one-on-one learning experience in modern-day lecture halls. Such a learning experience will be a boost to the knowledge acquisition process. It will augment teachers' skills and capabilities, thereby improving students' in-class performance and academic achievement prospects. In this respect, the technology corporations must use their knowledge of robotics to develop socially assistive robots that can teach and undertake other tasks performed by teachers in the real-world environment. The robots will work alongside human tutors and students to give them the support needed for them to achieve key knowledge acquisition targets. Like human actors, the robots will have facial expressions, humor, and other traits needed to sustain learners' attention throughout the course of a single lesson. This feature, which is an important starting point for learners' knowledge acquisition, will contribute to a significant improvement in the efficacy of AI tools. The feature will also enhance teachers' instructional capabilities by improving their ability to identify, respond to, and address the needs of students who are struggling to grasp key concepts and master important learning outcomes.

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