Artificial Intelligence and Machine Learning for All Students

A Meta-Synthesis

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Abstract

This meta-synthesis investigates the increasingly powerful and promising fields of artificial intelligence and machine learning as these technologies filter into the sphere of education. Smart technologies have been quickly gaining momentum in our society and have piqued the interest of many educators and administrators that are considering early adoption and applications of these new and promising technologies that may be able to offer teachers, administrators, and students new ways to access information and student learning. However, it is not without some resistance toward these technologies, that we consider their diverse applications in classrooms. This research of 43 articles address the applications, caveats, biases, and possibilities that these new, smart technologies using artificial intelligence and machine learning can offer to improve the education of students with and without disabilities.

1. Introduction

1.1. Background

Schools have always been and will always be a mirror of our society at large. Our students are the product of our society, and our societal issues and demands are reflected in our classroom just as they are seen in our communities.

Near the end of the eighteenth century, the Industrial Revolution began in the United States and caused societal changes in communities throughout the country. Just as society was changing, social reformers criticized the current education system as not meeting the needs of the students coming from families that worked in industrial occupations (Ireh, 2016).

Early educational reformers like John Dewey believed that "in an industrial society the school should become more industrial." At that time it was believed that "industrial" education was more engaging and stimulating to the child. Prevailing wisdom gave that the material was more approachable as it was immediately relevant to their daily world and students could easily make connections between curriculum and their experiences (Ireh, 2016).

As the industrial revolution progressed, more and more children entered school, yet many students had difficulty advancing through school. It was argued that if schools were to meet the needs of their students, they would need to provide a curriculum that benefited children of the working class, and if they wanted students to stay in school, they would need to provide students with the education and skills needed for occupational success. The increase in the number of students from working class families forced schools to adapt curriculum offerings to the needs of these children and prepare them for the world of work (Ireh, 2016).

Today, in classrooms throughout the United States, we are facing similar social reformations in classrooms by the means of the "Technology Revolution." As our society, and our world, is becoming more globally connected through technology, educators and education reformers push education technology into our classrooms. Just as in our society, technology has increased significantly in our classrooms, but classroom practices are often stagnant. The added usage of iPads and computers are not increasing student performance, and are not meeting the technological skill needs in our work forces (Jenkin, 2015). More often than not, the technologies used in the classroom have become a replacement for traditional practices and are not always used to their full potential, nor do they meet the demands of professional skills required for work forces outside of the classroom.

Being current with societal demands is not new to education. Many educators understand the importance of current practices to engage students and help them meet their full potential. Long before technology infused its way into our daily lives, educators used differentiated instruction to help students learn on their own path of understanding and help each individual make sense of ideas (Scalise, 2009). With the boom in education technology, many new software programs entered the marketplace. As the technology developed and changed, so did the programs offered to districts and educators. Today, technological curriculum replacements and supplements change the way students and teachers interact with education. Formative assessments are used to guide instruction during the process of learning. The process of assessment and deciding what content is offered to each child can be seamless and immediate with artificial intelligence.

Differentiation and creating a technological classroom based on the theory of universal design becomes faster and easier with instant feedback to the teacher and learner when delivered on a computer based platform. Often time machine learning technologies are designed to stretch a child's opportunity to learn, and can identify areas of interest and heightened engagement to give the student a choice among objectives. Many different networks of learning can be made available through machine learning and artificial intelligence, allowing students to make choices as they go, personalizing learning under the assumption that no two students are alike and, therefore, differentiation is required to customize their learning to fit each student's path of understanding.

Currently, schools stand in the middle of old and new models of schooling with tensions between the two rising (Erstad, Eickelmann & Eichhorn, 2015). The demands on the teacher are consistently increasing while support in the classroom is consistently decreasing, necessitating creative and innovate ways to meet the needs of differentiating instruction and preparing students for the world of work. Teacher attrition and class sizes are rising, while teacher wages and budgets for students are stagnant (Erstad, Eickelmann & Eichhorn, 2015).

While artificial intelligence and machine learning cannot solve the larger issues of retaining high quality teachers and fixing the budget issues of public schools in the United States, these technologies may alleviate some of the pain and pressure current teachers are experiencing in their profession and meet the technological demands of society, offer individualized instruction for learners, and empower teachers to focus their efforts on helping strengthen individual student learning and less on whole group instruction and reteaching.

Even given that artificial intelligence is used in arenas such as finance, manufacturing, medicine and other sectors, artificial intelligence has not made great headway in education, even though it gives the impression that it would be very beneficial considering educational reliance on standardized testing (Ramaswami, 2009). Considering how schools are being held accountable for passing standardized tests, it seems appropriate to tailor formative machine learning to help students make progress at their individual level to accelerate learning for performance on standardized tests. But even more progressively, artificial intelligence could potentially replace standardized tests all together and show student progress at their individual level from the beginning of the school year to the reporting period. However, with the education climate being steadfast on accountability from standardization it may be difficult for artificial intelligence programs to be accepted at federal levels (Ramaswami, 2009). There is nearly no intelligent software being utilized for large summative testing—but it is easily possible.

There are many artificial intelligence products available in the marketplace worldwide that are highly individualized, deeply personal to student learning needs, and focus on intervention for individualization (Ramaswami, 2009). Educational reformers argue that one-size-fits all testing is a thing of the past and old outdated models of learning and assessment will, and should be, disrupted by technological innovations that specialize in personalized instruction. Traditional classroom testing could be completely phased out, but teachers and policy makers would be rich with student data.

Some educators fear that when technology replaces traditional education they become less valuable in the classroom, but the opposite may be true. Teachers will always be hugely valuable in education, as humans will always benefit from interpersonal interaction. Artificial

intelligence allows teachers to focus on other facets of the job outside of the curriculum and can direct teachers to instruct with more precision on exactly what students are prepared to learn. As said by Rama Ramaswami in her article, *Is the Future Now for A.I.?,* "AI can't replace human teachers, but if it is done well, it has a role in the classroom. Educators can use all the help they can get."

The current public school classroom teacher faces many challenging obstacles as they educate a very diverse population with many different home languages, backgrounds, and abilities. Teachers are challenged with rising classroom size, challenging behaviors with little support, incredibly diverse learning needs, and requirements of standardized testing. Allowing artificial intelligence and machine learning to take over some of those responsibilities may alleviate some of the pressure from the teachers and actually create a more individualized learning plan for all students.

1.2. Author's beliefs and experiences

My professional experiences and philosophical beliefs have stemmed from a natural and authentic journey into the world of education. I had a very typical and average public education experience growing up in Alaska, completing most of my education in Anchorage public schools. My empathetic nature and love of caregiving led me into a long journey of becoming a teacher. No one in my family went to college – in fact, the rhetoric from my family was that college was a waste of time and the only way to be successful in a career was to have good work ethic and to show up. Being an independent woman with a passion for working with children, that would not work for me. I began my own journey despite my family's beliefs. I started taking classes and working towards advancement at an optional school. Education would become an

important part of my life, and I want to imbue my love for learning into the lives of all of my current and future students. From my own experiences, I believe that education is key to overcoming adversity. If I had followed in the footsteps of my family, I wouldn't have been able to become the teacher that I am today, and I couldn't positively impact the lives of so many young children as they become successful adults and lifelong learners.

From my experience working in an optional school environment, I gained a whole new perspective on education. Optional schools are an alternative option to a traditional public school education and generally focus on recognizing individual strengths, needs and interests of each learner. I was excited about being in the school and teaching children in a holistic and genuine manner. I found the type of teacher I wanted to be; I found the type of experience I thought was best for children; I found the motivation I needed to complete my degree and start my career as an educator. I did my teacher preparation programs in predominantly optional school settings. I also took a intercultural exchange residency in St. Paul, Alaska and volunteer taught in Malawi and Swaziland for a summer. I always had the freedom to teach children in a setting that supported my philosophy of education and gave me the freedom to make choices that were best for my students. My personal beliefs aligned with the pedagogy of the schools I had taught in—the belief that: all children are curious and want to learn; when children are respected they will be respectful; children will have enthusiasm and motivation for learning when it is meaningful and relevant; children learn best when we nurture the whole child socially, physically, emotionally, creatively, and educationally; education should be differentiated to individual interests, experiences, aptitude, skills, and knowledge; content areas should be integrated into what the child is interested in; children are held responsible in their educational

journey; education is guided through play and exploration; children are encouraged to solve problems; assessment is used to guide learning; and environments should be child-centered. I was excited to get a job doing something that I excelled at and that I enjoyed. Until I didn't get offered a job one of those optional schools. I took the first job that I was presented with. I have been working at a Title I public school in Anchorage, Alaska for the past five years. When I was hired, I was told that I would be working in a direct instruction school and I would be evaluated on the effectiveness of my direct instruction strategies. I was trained in whole group direct instruction, whole group classroom management strategies, and how to keep my instruction fast-paced to keep students engaged. As a teacher, I have done very well in my role at this school. I believe I bring balance to my classroom and do the best that I can within the given parameters of my job expectations—like so many of my colleagues do, as well. This school is not unlike many of the public schools I have been to, nor is it unlike my own personal experience as a child in Anchorage public schools. It does not, however, align quite as well with my own personal philosophy of education and the pedagogy that I believe is best for the future of learning.

The main difference of my teacher preparation programs and my current placement at a more traditional school is the accountability of what to teach and when to teach it. In my previous experiences I could choose the curriculum, adapt instruction to the child's interests, and integrate curriculum into projects and themes students want to study. Now, I am responsible to teach the current curriculum in the order directed and to teach certain lessons and concepts within a certain timeframe. Like all good teachers, we differentiate instruction to students, we respond to the instruction and provide interventions, but in the end it still feels like I'm "spoon-feeding"

concepts and ideas that students either aren't academically ready for, or they aren't interested in learning because they cannot personally see how it is relevant to their interests or goals, despite our best efforts.

As I reflect on my experiences, I question if the traditional public school or "factory model" of education is still relevant to our society, and if it is the most efficient use of teachers' or students' time. How do we meet all the demands of a public school classroom and still cater instruction to meet the needs of every individual learner? Our industrial revolution is over and we are bursting with amazing feats in technological advancement in all aspects of human life. I believe it is time our public schools not only catch up with the technology revolution to meet the current needs of teachers and students, but lead the way in making knowledge and education accessible to all students through new and exciting technological endeavors. The technology that is available today can change the face of education all across the world.

Having a technology rich classroom is not something I ever thought I would be interested in, but given my perception of the current state of public schools, I believe it is one of the best ways to free up valuable teacher time to focus on more important aspects of the job. I believe it can intellectually stimulate students in ways that direct instruction cannot. I believe students see technology as being more relevant to their future and, therefore, they become more engaged with what they are learning. As technology erupts in our society, many schools are pushing back on technology use in education under the premise that students already have enough exposure to technology outside of school. That is true, however, I believe that most students in low-income Title I public schools are not literate in appropriate technology use, nor are they exposed to the

technology use that is going to benefit them in future careers which are becoming more and more reliant on technology.

As a student myself, technology use in my schooling was minimal, even though I grew up during the initial years of the technology revolution. Schools seem to be consistently behind in catching up with technology in relation to the private sector. How can we prepare students for work outside of the classroom when they are often taught in an environment not suited to teach them the skills demanded in the workplace? Today, most schools have plentiful technology, and this technology is often used in meaningful ways. However, there is still much opportunity for technology to have a truly transformative impact for students, teachers, and administrators alike.

We use programs like the Google Classroom suite to replace worksheets, pencil and paper, and give students a new way to present their projects. We have programs like IXL that give students a series of questions for independent practice on grade level subjects. What is rarely used in schools, which has the most potential to make student learning more tailored, with more accurate data, and more accessible to all students is the cutting edge field of artificial intelligence and machine learning.

Artificial intelligence is a broad term to describe a suite of technologies wherein complex algorithms “learn” from vast amounts of historical data to produce valuable insights or tailor experiences for individuals (Press, 2017). Some commonly known examples of artificial intelligence and machine learning include: email spam filtering, Netflix movie recommendations, Google search results, self-driving cars, disease diagnosis, and a host of other applications.

Within the educational arena, artificial intelligence and machine learning have been able to differentiate instruction based on student responses and personalize education for all students

based on algorithms that target students at their zone of proximal development to accelerate learning. These types of programs are not age or grade based and provide a much more detailed and granular learner profile than any report card or teacher ever could (The Economist, 2017).

Artificial intelligence and machine learning can be impactful outside of classroom instruction. For instance, machine learning algorithms are being used within a number of educational applications, ranging from high school to college, to identify students at a high risk for dropout. This provides staff and administrators with an opportunity to provide early intervention and improve graduation rates and student outcomes (Lakkaraju, et al., 2015).

For teachers, artificial intelligence and machine learning can save valuable teacher time on lesson planning and grading, as those tasks can be accomplished within the application, leaving teachers with more time to focus on other important facets of providing a more whole-child approach to education. Teachers can work on creating opportunities for hands-on activities, social engagement, peer relationships, and guided instruction based on feedback from the applications (The Economist, 2017).

This type of technology has the potential to transform the role of the teacher in the classroom. During portions of the day where students are using machine learning applications, teachers can act as a tutor using the feedback they receive to guide student understanding. They can pull groups of students to do mini lessons based on the detailed data that comes from the application or do other small group focus studies (The Economist, 2017). In an era of ever increasing classroom sizes, teachers could be empowered to more efficiently use their time to interact with students in more meaningful ways.

Artificial intelligence and machine learning also have the potential to not only reach more students figuratively, but literally as well. Students in rural areas, where quality education can be scarce, can be provided with a tailored education experience – without the typical costs or infrastructure required to operate an entire school (The Economist, 2017).

I also believe artificial intelligence and machine learning can eliminate the need for isolated progress monitoring assessments, as student progress would be constantly recorded and interventions could be provided instantly and seamlessly.

Students with learning disabilities can receive accommodations within the applications and the tailored learning experiences can be made to meet their needs. Artificial intelligence and machine learning can improve the lives of students with other impairments as well. For instance, Microsoft has created an application for people with vision impairments that can describe in detail whatever a wearable camera "sees." This system utilizes machine learning to perpetually increase its accuracy by "learning" from new examples. Similarly, Google uses machine learning to automatically caption YouTube videos for people who are hearing impaired. IBM's Watson project has developed software which simplifies and clarifies idioms and figures of speech for people with autism or dementia to clarify written content. I can also see this as being useful for students whose first language is not English.

As a professional teacher working in a arguably regressive instructional regime, I have formulated the following research questions:

1. What are the barriers to using artificial intelligence and machine learning programs in public school settings?
2. How can artificial intelligence impact student engagement and learning?

3. How will artificial intelligence benefit students with and without learning disabilities?
4. How can artificial intelligence specifically aide students with physical impairments?

Like one of the great scientists of my generation, Bill Nye the Science Guy, said, “no problem is too big when humans and technology collaborate” (Goldschein, et al., 2017). My hope is that through open mindedness toward technological advancements in the fields of artificial intelligence and machine learning, we can transform the face of traditional public education in a way that alleviates stress, pain, and the feeling of an equivocal educational experience.

1.3. The purpose of this meta-synthesis

This meta-synthesis, which focuses on artificial intelligence and machine learning for all students in public education, has several purposes. One purpose is to review journal articles related to the use of artificial intelligence and machine learning technologies in classrooms for all students—specifically what barriers are there to using these programs. Another purpose is to review journal articles on how artificial intelligence impacts student engagement and learning, I am specifically interested in how artificial intelligence and machine learning can reach students in rural settings where education is not easily accessible, and in large class sizes where teachers aren’t easily able to make one-on-one connections on a regular basis with each learner. In addition to this purpose, I am analyzing journal articles for the benefits and drawbacks artificial intelligence and machine learning may have for students with and without learning disabilities. Further, I will be analyzing technologies that use artificial intelligence to aide students with physical impairments. My final purpose in conducting this meta-synthesis is to identify thematic

significances in the articles and connect them to my own teaching experiences in public education classrooms with meeting students' individual needs in education.

2. Methods

2.1. Selection criteria

The 43 journal articles and documents included in this meta-synthesis met one or more of the following selection criteria.

1. The articles explored the use of artificial intelligence and machine learning programs in educational settings.
2. The articles explored issues related to the use of artificial intelligence and machine learning for students with and without disabilities.
3. The articles explored issues related to the impact of artificial intelligence on student engagement and learning.
4. The articles were published in peer reviewed journals related to the field of education.
5. The articles were published between 2005-2017.

2.2. Search procedures

Database searches and ancestral searches were conducted to locate items for this meta-synthesis.

2.2.1. Database searches

I conducted Boolean searches within four databases that index articles related to the field of artificial intelligence and machine learning in regards to educational and classroom applications. The four databases included the: (a) Education Resource Information Center (ERIC, Ebscohost); (b) Education Journals (Proquest); (c) Education and Technology Journals

(Google Scholar); (d) Education and Technology Journals (IEEEXplore). Searches were conducted using the following specific search terms:

1. (“Artificial Intelligence”) AND (“Classroom”)
2. (“Artificial Intelligence”) AND (“Classroom”) AND (“Children”)
3. (“Artificial Intelligence”) AND (“Education”)
4. (“Artificial Intelligence”) AND (“Education”) AND (“Machine Learning”)
5. (“Artificial Intelligence”) AND (“Teaching”) AND (“Technology”)
6. (“Demands on Teachers”) AND (“Technology”)
7. (“Differentiation”) AND (“Technology”)
8. (“Machine Learning”) AND (“Education”)
9. (“Machine Learning”) AND (“Primary Education”)
10. (“Technology”) AND (“Education”) AND (“History”)

The various database searches yielded a total of 27 articles that met my selection criteria (Aberšek & Aberšek, 2012; Balakrishnan & David, 2010; Chin et al., 2010; Chrysfiadi & Virvou, 2015; Clark & Whetstone, 2014; Du Boulay, 2016; Doom, 2016; Erstad, Eickelmann, & Eichhorn, 2015; Gadanidis, 2017; Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015; Heffernan et al., 2016; Ireh, 2016; Jenkin, 2015; Kotsiantis, 2012; Lakkaraju et al., 2015; Lin, Wang, Chao, & Chien, 2012; McArthur, Lewis, & Bishary, 2005; Nabiyev et al., 2013; Pareto, 2014; Parkavi, Ramar, & Ramesh, 2013; Porter, 2017; Ramaswami, 2009; Roll & Wylie, 2016; Scalise, 2009; Timms, 2016; Wallace, McCartney & Russell, 2010; Woolf, Lane, Chaudhri, & Kolodner, 2013).

2.2.2. *Artificial Intelligence Journals*

Due to the modest amount of current and applicable articles regarding artificial intelligence and machine learning as it relates to education in a classroom setting in the above mentioned databases, I also conducted searches within the *International Journal of Artificial Intelligence in Education.*

These searches yielded a total of six articles that met my selection criteria (Chou & Chan, 2016; Kinshuk, Chen, Chang, & Chew, 2016; Koedinger & Aleven, 2016; Passonneau, McNamara, Muresan, & Perin, 2017; Rosé & Ferscheke, 2016; Walker & Ogan, 2016)

2.2.3. *Technology and Education Magazines and Online Resources*

To augment the articles about artificial intelligence and machine learning as it relates to education in a classroom setting in the above mentioned databases, I also conducted searches within popular technology and education magazines on online resources

These searches yielded a total of seven articles that met my selection criteria (Ark, 2015; Biedelman, 2018; Davison, 2016; Gaskell, 2016; Rizzotto, 2017; Petrilli, 2018; The Economist, 2017)

2.2.4. Ancestral searches

An ancestral search involves reviewing the reference lists of previously published works to locate literature relevant to one's topic of interest (Welch, Brownell, & Sheridan, 1999). I conducted ancestral searches using the reference lists of the previously retrieved articles. These ancestral searches yielded three additional articles that met my selection criteria (Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011; Stone et al., 2016; Zubrzycki, 2016).

2.3. Coding procedures

I utilized a coding form to categorize the information in each of the 43 articles. This coding form was based on: (a) publication type; (b) research design; (c) participants; (d) data sources; (e) findings of the studies.

2.3.1. Publication types

For this meta-synthesis, articles were evaluated and classified by publication type (e.g. research study, theoretical work, descriptive work, opinion piece/position paper, guide, annotated bibliography, review of the literature). *Research studies* use a formal and systematic method to gather and/or analyze quantitative and/or qualitative data. *Theoretical works* discuss existing literature to analyze, expand, or further define a specific philosophical and/or theoretical assumption. *Descriptive works* describe phenomena and experiences but do not disclose systematic methods of attaining data. *Opinion pieces/position papers* explain, rationalize, or advocate a particular course of action based on the author's opinions and/or beliefs. *Guides* give instructions or advice explaining how practitioners might implement a new program and/or policy. An *annotated bibliography* is a list of cited works on a particular topic, followed by a descriptive paragraph explaining, evaluating, or critiquing the source. *Reviews of the literature* critically analyze the published literature on a topic through summary, classification, and comparison to identify essential themes of previously published work (Table 1).

2.3.2. Research design

Each empirical study was classified by research design (e.g. quantitative research, qualitative research, mixed methods research). *Quantitative* research is the collection and analysis of numerical data to relay information. *Qualitative* research utilized language to describe issues, experiences, and phenomena. *Mixed methods* research is the combination of both

quantitative (e.g. numerical) and qualitative (e.g. non-numerical) research methods conducted within a single study (Table 2).

2.3.3 Participants, data sources, and findings

I identified the participants in each of the studies (e.g. middle and high school students, elementary and middle school students, and college level students). I also identified the data sources that were analyzed for each study (e.g. data sets from artificial intelligence and machine learning programs, questionnaires and surveys, and assessments). Finally, I summarized the findings of each study (Table 2).

2.4. Data analysis

I used a modified version of the Stevick-Colaizzi-Keen method previously employed by Duke (2011) and Duke and Ward (2009) to analyze the 43 articles included in this meta-synthesis. I first identified statements found to be significant in each article. For the purpose of this meta-synthesis, I considered statements to be significant when they addressed issues related to: (a) automation of basic activities; (b) teacher feedback; (c) individualized learning, modified learning opportunities, and differentiation; (d) teacher's role; (e) safe educational risk taking; (f) accessibility; (g) balancing time spent with technology and traditional instruction; (h) remote instruction; and (i) potential caveats and biases in artificial intelligence. I then created a list of non-repetitive, verbatim significant statements with paraphrased formulated meanings. The formulated meanings represented my understanding and interpretation of each significant statement. Lastly, I grouped the formulated meanings from all 43 items into emergent themes that represented the crux and content of the entire body of literature used for this meta-synthesis (Table 3).

3. Results

3.1. Publication type

I located 43 articles that met my selection criteria. The publication type of each article is located in Table 1. Fifteen of the 43 articles (34.8%) included in this meta-synthesis were research studies (Aberšek & Aberšek, 2012; Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011; Balakrishnan & David, 2010; Chin et al., 2010; Clark & Whetstone, 2014; Doom, 2016; Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015; Kotsiantis, 2012; Lakkaraju et al., 2015; Lin, Wang, Chao, & Chien, 2012; Nabiyev et al., 2013; Pareto, 2014; Parkavi, Ramar, & Ramesh, 2013; Scalise, 2009; Wallace, McCartney, & Russell, 2010). Ten of the 43 articles (23.2%) were theoretical works (Chou & Chan, 2016; Du Boulay, 2016; Gadanidis, 2017; Ireh, 2016; Koedinger & Aleven, 2016; McArthur, Lewis, & Bishary, 2005; Porter, 2017; Rosé & Ferscheke, 2016; Stone et al., 2016; Timms, 2016). Ten of the 43 articles (23.2%) were opinion pieces/position papers (Ark, 2015; Beidelman, 2018; Davison, 2016; Gaskell, 2016; Jenken, 2015; Petrilli, 2018; Ramaswami, 2009; Rizzotto, 2017;The Economist, 2017; Zubrzycki, 2016). Five of the 43 articles (11.6%) were descriptive works (Erstad, Eickelmann, & Eichhorn, 2015; Heffernan et al., 2016; Kinshuk, Chen, Chang, & Chew, 2016; Passonneau, McNamara, Muresan, & Perin, 2017; Walker & Ogan, 2016). Three of the 43 articles (6.9%) were a review of literature (Chrysfiadi & Virvou, 2015; Roll & Wylie, 2016; Woolf, Lane, Chaudhri, & Kolodner, 2013).

Table 1

Author(s) & Year of Publication	Publication Type
Aberšek & Aberšek, 2012	Research
Ark, 2015	Opinion Piece/Position Paper
Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011	Research Study
Balakrishnan & David, 2010	Research Study
Beidelman, 2018	Opinion Piece/Position Paper
Chin, Dohmen, Cheng, Oppezzo, Chase, & Schwartz, 2010	Research Study
Chou & Chan, 2016	Theoretical Work
Chrysfiadi & Virvou, 2015	Review of Literature
Clark & Whetstone, 2014	Research Study
Davison, 2016	Opinion Piece/Position Paper
Du Boulay, 2016	Theoretical Work
Doom, 2016	Research Study
Erstad, Eickelmann, & Eichhorn, 2015	Descriptive Work
Gadanidis, 2017	Theoretical Work
Gaskell, 2016	Opinion Piece/Position Paper
Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015	Research Study

Heffernan, Ostrow, Kelly, Selent, Inwegen, Xiong, & Williams, 2016	Descriptive Work
Ireh, 2016	Theoretical Work
Jenkin, 2015	Opinion Piece/Position Paper
Kinshuk, Chen, Chang, & Chew, 2016	Descriptive Work
Koedinger & Aleven, 2016	Theoretical Work
Kotsiantis, 2012	Research Study
Lakkaraju, Aguiah, Shan, Miller, Bhanpuri, Ghani, & Addison, 2015	Research Study
Lin, Wang, Chao, & Chien, 2012	Research Study
McArthur, Lewis, & Bishary, 2005	Theoretical Work
Nabiyev, Vasif, Karal, Hasan, Arslan, Selahattin, Erumit, Kursut, & Cebi, 2013	Research Study
Pareto, 2014	Research Study
Parkavi, Ramar, & Ramesh, 2013	Research Study
Passonneau, McNamara, Muresan, & Perin, 2017	Descriptive Work
Petrilli, 2018	Opinion Piece/Position Paper
Porter, 2017	Theoretical Work
Ramaswami, 2009	Opinion Piece/Position Paper

Rizzotto, 2017	Opinion Piece/Position Paper
Roll & Wylie, 2016	Review of Literature
Rosé & Ferscheke, 2016	Theoretical Work
Scalise, 2009	Research Study
Stone, Brooks, Brynjolfsson, Calo, Etzioni, Hager, Hirschberg, Kalyanakrishnan, Kamar, Kraus, Leyton-Brown, Parkes, Press, Saxenian, Shah, Tambe, & Teller, 2016	Theoretical Work
The Economist, 2017	Opinion Piece/Position Paper
Timms, 2016	Theoretical Work
Walker & Ogan, 2016	Descriptive Work
Wallace, McCartney, & Russell, 2010	Research Study
Woolf, Lane, Chaudhri, & Kolodner, 2013	Review of Literature
Zubrzycki, 2016	Opinion Piece/Position Paper

3.2. Research design, participants, data sources, and findings of the studies

As previously stated, 15 research studies were located that met my selection criteria (Aberšek & Aberšek, 2012; Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011; Balakrishnan & David, 2010; Chin et al., 2010; Clark & Whetstone, 2014; Doom, 2016; Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015; Kotsiantis, 2012; Lakkaraju et al., 2015;

Lin, Wang, Chao, & Chien, 2012; Nabiyev et al., 2013; Pareto, 2014; Parkavi, Ramar, & Ramesh, 2013; Scalise, 2009; Wallace, McCartney, & Russell, 2010). The research design, participants, data sources, and findings of each of these studies are identified in Table 2.

Table 2

Authors	Research Design	Participants	Data Sources	Findings
Aberšek & Aberšek, 2012	Quantitative	34 college students	E-learning tools; comparisons	Teaching technology without pedagogy is empty and useless, but artificially intelligent learning tools, when implemented well, can increase student performance.
Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011	Mixed Methods	108 9th and 10th grade students from two high schools (one low and the other high achieving)	Pretest; survey; questionnaire; post-test	In the tutoring models (a type of artificial intelligence and machine learning program that users interact with), all students displayed advantages to having a learning companion in their machine learning tutoring. Interestingly, female students showed more positive attitudes toward content when their learning companion was female as opposed to male

				students who showed no preference. This study relates to artificial intelligence and machine learning for students because it helps program developers and educators to identify what components of tutoring programs students will be more engaged in and can make better choices in meeting the needs of learners as they interact with artificial intelligence and machine learning.
Balakrishnan & David, 2010	Quantitative	Data sets from 513 school-aged children identified as having a type of learning disability	Rough sets and decision trees; comparisons	Rough set machine learning algorithms can be highly effective in predicting students with learning disabilities and can identify the signs and symptoms of the specific learning disability. This means that

				well-designed artificial intelligence and machine learning programs used in schools can help educators properly identify students with learning disabilities, so that teachers can provide appropriate accommodations for those learners in all areas of the classroom.
Chin, Dohmen, Cheng, Oppezzo, Chase, & Schwartz, 2010	Quantitative	6 teachers and 1,034 5th grade students	Pretest; teachable agents; summative assessments	There are many valid concerns for the future of technology in the classroom, but artificial intelligence in the form of teachable agents (learning companions that students demonstrate their learning to, learn from, and interact with) can add value to student learning without taking away from the content taught in the traditional

				curriculum despite "lost-time" in traditional learning settings. They can also prepare students to learn new content from regular classroom instruction even when not directly using the software. When students use these artificial intelligence programs they are better able to understand future concepts not yet introduced in regular classroom instruction as a way to build background knowledge.
Clark & Whetstone, 2014	Mixed Methods	35 teachers from 15 participating elementary school and 2,542 students in	Survey; data sets from artificial intelligence software platform	The usage of the machine learning software was strongly related to improvement in student ability and the combination of usage with regular instruction

		grades K-5th grade		resulted in significant gains for low-performing students.
Doom, 2016	Mixed Methods	16 teachers from 7 districts and 112 students in K-6th grade	Surveys; pre- and post; student comprehension scores	Results indicate that there is no significant impact on student achievement in relation to teacher perception of blending tradition learning and artificially intelligent learning programs. All students made gains, but what this research study specifically proved was that when teachers were uncomfortable with the technology or had negative assumptions of technology, students still made growth in their learning in the same way as students with classroom teachers having positive biases toward technology. So, even when instructors have

				their own personal beliefs and assumptions, if teachers use the technology, learning will not be negatively impacted.
Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015	Quantitative	34 high school students	Socio-economic characterization; computer monitoring	Including new technologies in the classroom can come with its own set of problems and drawbacks including student engagement, staying on track, and committing to learning with so many easily accessible temptations on the computer. Some artificial intelligence and machine learning programs are starting to include functions allowing the monitoring of student interaction with software programs using performance sensors during technology usage in the classroom. This can show the teacher if the

				student is in the program and working at an appropriate rate. These inclusions can provide high level information to the teacher on individual student management and intervention in regards to student fatigue, stress and attention. The research concludes that monitoring student progress in the program can signal to the teacher when the learner may need intervention to interacting with the technology (teacher motivation, help, breaks, etc.).
Kotsiantis, 2012	Quantitative	354 college student records	Classification and regression algorithms; sequential	Integrated machine learning systems can cater to the individual needs of an institution or student.

			pattern analysis; clustering; web mining	
Lakkaraju, Aguiah, Shan, Miller, Bhanpuri, Ghani, & Addison, 2015	Quantitative	Two school districts with combined data sets from 24,787 students in grades 6^{th}-12^{th}	Historical data; lists of student attributes	Machine learning approaches can predict students at risk of not graduating on time due to adverse attributes allowing schools to be proactive in improving educational outcomes for identified students.
Lin, Wang, Chao, & Chien, 2012	Mixed Methods	40 people	Questionnaire; facial-recognition software	Facial-emotional recognition to respond to learners emotions in tutoring systems increases user motivation and learning.
Nabiyev, Vasif, Karal, Hasan, Arslan, Selahattin, Erumit,	Mixed Methods	Four teachers and 59 students in 10^{th} grade	Course grades; interviews; questionnaire	Artificial intelligence based distance education models can be responsive to the needs of students, but preferences of not using screens for learning was

Kursut, & Cebi, 2013				shown in the population of students who are more familiarized with traditional learning on paper with pencil.
Pareto, 2014	Mixed Methods	443 students with and without disabilities ranging from grade 2nd-8th	Tests; pre- and post; questionnaire; game-logging database; survey;	Artificial intelligence tutoring programs that are game-based can engage primary students both with and without special needs, and students can learn from these games.
Parkavi, Ramar, & Ramesh, 2013	Mixed Methods	900 secondary students from nine schools in a single district	Questionnaire; school records	Student grades could be predicted based on students attributes not related to education, such as parental occupation, allowing institutions to identify at-risk students and provide early-interventions.
Scalise, 2009	Quantitative	521 high school and university students	Assessment	Artificial learning differentiation approaches were not often used by students when they were

				given the choice of modification. This means that when accommodations were built into artificial teaching programs many students with learning disabilities elected not to use them even when made available.
Wallace, McCartney, & Russell, 2010	Mixed Methods	Junior and senior university students enrolled in computer programming courses	Survey; comparisons between game-based vs. non-game-based projects; observations	Artificially intelligent game-based learning is effective in student engagement based on student feedback and instructor observation.

3.2.1. Research design

Eight of the 15 studies (53.3%) utilized a mixed methods research design (Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011; Clark & Whetstone, 2014; Doom, 2016; Lin, Wang, Chao, & Chien, 2012; Nabiyev et al., 2013; Pareto, 2014; Parkavi, Ramar, & Ramesh, 2013; Wallace, McCartney, & Russell, 2010). Seven of the 15 studies (46.7%) used a quantitative research design (Aberšek & Aberšek, 2012; Balakrishnan & David, 2010; Chin et al., 2010; Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015; Kotsiantis, 2012; Lakkaraju et al., 2015; Scalise, 2009).

3.2.2. Participants and data sources

The majority of the 15 research studies included in this meta-synthesis analyzed data from students ranging from elementary school to college, Some of the research studies included collected data from teachers and some of the research studies included data collected from students with disabilities. Six of the studies (40%) analyzed data collected from middle and high school students (Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011; Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015; Lakkaraju et al., 2015; Nabiyev et al., 2013; Parkavi, Ramar, & Ramesh, 2013; Scalise, 2009). Four of the studies (26.7%) analyzed data from elementary and middle school aged children (Chin et al., 2010; Clark & Whetstone, 2014; Doom, 2016; Pareto, 2014). Three of the studies (20%) analyzed data from college level students (Aberšek & Aberšek, 2012; Kotsiantis, 2012; Wallace, McCartney, & Russell, 2010). Two of the studies (13.3%) analyzed data from a selection of various aged people (Balakrishnan & David, 2010; Lin, Wang, Chao, & Chien, 2012).

Data sets from artificial intelligence and machine learning computer programs and the utilization of surveys and questionnaires provided the main data sources used in the research studies. Ten of the 15 studies (66.7%) used data sets from artificial intelligence and machine learning computer programs (Aberšek & Aberšek, 2012; Balakrishnan & David, 2010; Chin et al., 2010; Clark & Whetstone, 2014; Gonçalves, Fdez-Riverola, Rodrigues, Carneiro, & Novais, 2015; Kotsiantis, 2012; Lakkaraju et al., 2015; Lin, Wang, Chao, & Chien, 2012; Pareto, 2014; Wallace, McCartney, & Russell, 2010). Four of the 15 studies (26.7%) used surveys and questionnaires to collect data (Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011; Doom, 2016; Nabiyev et al., 2013; Parkavi, Ramar, & Ramesh, 2013). Other data sources were also used in the research studies including, pre and post-test assessments, summative assessments, student grades, student demographic and records analysis, and observations.

3.2.3 Findings of the studies

The findings of the 15 research studies included in this meta-synthesis can be summarized as follows.

1. When it comes to creating and choosing artificial intelligence and machine learning programs for teaching students new concepts or building on to their current knowledge, most students respond well to having a teachable agent/learning companion that they can relate to. Gender and cultural identity need to be considered to encourage students to feel included and be responsive to the learning environment.

2. Well-designed artificial intelligence and machine learning programs can work with teachers to identify important risk factors for students including those with learning disabilities and/or students who are at risk of adverse learning outcomes.

3. Artificial intelligence and machine learning programs can work collaboratively with traditional instruction to create a well-rounded blended learning environment and provide interventions for students at their appropriate level, and they can even build on student understanding and pre-teach concepts related to what the class is working on.

4. Game based learning in artificial intelligence and machine learning programs serve as a motivational and engaging tool that teachers struggle with in a traditional setting – keeping up with the fast paced expectations of students.

5. Some students, specifically those with learning disabilities, may choose to not use provided accommodations even when they are offered.

6. Computers could track student work and provide teachers with opportunities to intervene when students are struggling.

7. The more comprehensive and integrated artificial intelligence and machine learning programs are, the more feedback and data teachers can use to help students and, subsequently, the more valuable the programs can be.

3.3. Emergent themes

Seven themes emerged from my analysis of the 43 articles and documents included in this meta-synthesis. These emergent themes, or theme clusters, include: (a) redefining the teacher's role within the classroom; (b) teacher feedback; (c) individualized learning, modified learning opportunities, and differentiation; (d) safe educational risk taking; (e) accessibility and remote instruction; (g) potential caveats and biases in artificial intelligence and machine learning; and (h) ideas for development. These seven theme clusters and their formulated meanings are represented in Table 3.

Table 3

Theme Clusters	Formulated Meanings
Redefining the Teacher's Role within the Classroom	● Schools that use a learner-centered pedagogy are more effective at integrating new artificially intelligent technologies that are tailored to students' learning needs in the classroom. ● Artificially intelligent tutors will likely take over traditional instruction as the teacher of new information, but cannot replace a teachers' role as mediators and human beings, facets highly important for the whole learning process. ● When teachers emphasize casual integration of artificial intelligence, students perform well on summative tests. ● Incorporating new technologies in the field of artificial intelligence and machine learning added value to teacher instruction and did not hinder student achievement considering "lost" instructional time given to the technology. ● Learning companions within artificially intelligent environments can serve as motivation for students by increasing engagement, responsibility, and completion of tasks. ● Artificial intelligence tutoring programs can effectively be used with traditional instruction as a small group rotation for intervention or enrichment depending on student need.

	● Results from artificial intelligence tutoring software were greatest when students were actively engaged, and engagement increases when teachers monitor student activities. ● Combining artificial intelligence education with traditional instruction can free up teachers to work with students in smaller groups. ● With large, and often increasing class sizes, blending artificial intelligence education is more successful than traditional instruction, but not as successful as one-on-one human tutoring. ● Integrating artificial intelligence education into classrooms as one-on-one computer tutors, with teachers working with small groups, is beneficial to student learning. ● Despite the teacher's perception or belief about new technologies being incorporated into their classroom instruction, student growth or regression was not impacted. ● With artificially intelligent classroom models, teachers still serve as the important role as facilitators of the learning process, and the use of these technologies gives teachers more flexibility in connecting subjects, student grouping, and collaborating with other schools, companies, or other learning organizations. ● When artificially intelligent education introduces students to themes or instructs students, the teacher is able to focus on deeper learning with his or her students.

	● Schools that adopt new technologies as educational resources, give teachers a new role as directors for student learning. ● Research supports the importance of teachers in the education of students using artificial intelligence for instruction as students require adjustments and guidance in their learning environments, resources, and different needs. ● New technologies create a different type of demand on teachers by facilitating new ways of working with students, accessing information and communication, and applying new technologies in the classroom. Some new technologies can initiate opportunities for the teacher to help students problem solve and more deeply understand what they are learning across content and domains. ● Using artificial intelligence software to supplement classroom instruction will help students understand concepts better and help them improve their skills faster. ● Meeting students' needs requires teachers to personalize, inspire interest and creativity, demonstrate value, and differentiate instruction and motivation. Incorporating artificial intelligence can help teachers meet these demands for the many learners in their class. ● Teachers can serve as tutors to help with academic work and work with students on building positive character, curiosity in learning, and

	self-awareness in small groups while artificially intelligent machines teach students core academics. ● Teachers save time by not having to spend time on grading or lesson plans for academic instruction and instead use that time to plan interventions based on student data. ● Relationships students build with artificial intelligence can complement human relationships by creating deeply engaging effective learning experiences. ● No matter how much a teacher achieves in the classroom, society will continue to expect more from education and since we are unable to meet the demands of society, nor many of the educational needs of students, artificial intelligence can meet some of the 21st century skills digital natives are comfortable with in an environment that is personalized to their traits and affect. ● Many students are failed by the current educational practices and artificial intelligence may be the answer to mitigating that problem. ● Artificial intelligence can transcend traditional learning institutions and have a greater impact on lifelong learning, continuing education, and professional development. ● Teachers are overwhelmed with their job responsibilities and one solution for that problem can be from the use of smart technologies.

Teacher Feedback	● When teachers are included in the conversation of data analysis, not just data collection, they are better at integrating the data to provide customized learning solutions tailored to student needs, content area, and student demographics. Artificial intelligence data collection can provide instant feedback on student aptitude directly to teachers. ● Allowing teachers to be closely connected to student data collected from artificial intelligence software, in areas of academics, social, behavioral, and emotional development, can help teachers understand the whole child better. ● Students who used teachable agents in artificially intelligent software programs prior to teacher instruction demonstrated a deeper casual understanding of the content and built longer chains of inference with related content, which teachers could then respond to in their instruction. ● Artificially intelligent machine learning systems can help teachers and school administration identify student who are at–risk of unfavorable school outcomes, such as dropping out, and what might be causing them to struggle in school. The programs can provide schools with insights and interventions to assist the student in overcoming their learning challenges. ● Machine learning algorithms in education can help schools make predictions of student outcomes, scheduling students and classes, and automating grading and organizational tasks.

	• Data-mining through artificial intelligence and machine learning provides teachers with new methods to track student learning and development. • Data from tailored and customizable learning experiences allows teachers to adjust their instruction and help at-risk students by intervening when students are not understanding concepts at the individual or whole class level. • Teachers, administration, and students can use integrated machine learning systems to organize their learning needs, make predictions about their learning, and meet their diverse educational needs. • Machine learning can predict for teachers and students how a student will perform in their class and what grade they will likely receive based on student data. • Machine learning algorithms can predict students who will likely not graduate on time, allowing teachers to provide intervention. • Data mining using machine learning algorithms have helped teachers and administration provide extra support and better tutoring for at-risk students based on predictions of grades, dropping out, and other adverse educational outcomes from socio-economic data. • Advanced technologies can provide teachers with more insights and data analysis to help them make more informed decisions for their students.

	● New technologies can assess current instruction and guide teachers to respond to their own instruction in real time by guiding teachers to ask higher-order questions to engage students and encourage higher achievement by students. ● Machines as teacher observers use algorithms to detect specific findings in teacher instruction and can help teachers monitor student engagement and guide teachers in teaching at a student's zone of proximal development for optimal growth. ● Students' assignments and tests can be analyzed by machine learning algorithms for data collection and response to instruction. ● Data mining and machine learning will improve classroom instruction regardless of how technologically enriched the instruction may be. ● Artificial intelligence has the power to make standardized tests obsolete as artificial intelligence products provide more meaningful data that is less disruptive to the student, and it can tutor students in fundamental concepts and then assess the students' knowledge. ● Augmented realities and artificial intelligence can very accurately read psychological responses to stimuli constantly in real time and even predict student actions; if the technologies can understand a learner's relationship to a subject unconsciously then standardized testing may be unnecessary.

	● Artificial intelligence powers teachers' ability to deliver information to students.
Individualized Learning, Modified Learning and Differentiation	● Machine learning algorithms have been faster, more accurate and less labor intensive in the detection of students with learning disabilities. ● Artificial intelligence and machine learning can easily diagnose a child's disability at an early age to help families, teachers, and schools know to implement early intervention services for that child. ● Females and minority students, specifically those from poverty, felt more confident and had greater learning gains when their artificially intelligent learning companions were of their same gender or racial identity—especially when the learning companion spoke in a similar vernacular as the student. ● Quality education will always require actively engaged human teachers, but artificial intelligence can enhance learning at all levels by personalizing instruction. ● Students using artificially intelligent tutoring programs were better able to transfer their understanding from one specific content area to other seemingly unrelated domains. ● Artificially intelligent programs provide students with the capability and centralization to see and apply cause and effect relationships to their learning.

	● Learning through artificial intelligence is able to incorporate many elements of pedagogical models for deep and complex learning. ● Artificially intelligent tutoring systems are able to collect background information on student understanding and what they haven't yet learned to cater instruction to the individual child's learning needs. ● Artificial intelligence can be used to dynamically modify and adapt the learning process to the child's knowledge level and understanding. ● Blending traditional instruction with artificial intelligence education provides all students with initial instruction, but then has the ability to embed scaffold supports, enrichment, and hints to guide student instruction. ● Personalization of artificial intelligence in education provides students with a holistic, learner-centered educational experience while also meeting the demands of systematic changes in education. ● Because individuals learn at different speeds, start at different points, and come from different backgrounds, artificial intelligence education reflects a more complex reality than traditional classroom practices. ● Artificial intelligence uses adaptability to create more tailored and customizable learning for students. ● Teachers can have access to data that monitors the effects of fatigue, stress, and attention in real time at the individual level and are then able to intervene and manage students appropriately.

	● Artificial intelligence can read user emotional expression and can choose how to respond to that learner and can deepen the application's level of human interaction. ● Students with and without special needs were engaged in learning mathematical concepts from teachable agents in artificially intelligent learning programs. ● Because of the variety of gaming and instructional models at varying difficulty levels that can be made available in artificially intelligent operating systems, students with a wide-range of ages and ability are able to have appropriate and meaningful learning opportunities at their skill level. ● Artificial intelligence in education is very personalized and can focus on intervention and the individual's education and can accelerate higher order thinking or remediation when needed. ● Artificial intelligence can help students learn to mastery, experiment in learning, and have a personalized learning experience that could have a lasting effect on education. ● Students have greater academic achievement when they receive a personalized education. ● Artificial intelligence in education has the possibility to truly understand each learner as an individual by adjusting educational experiences in response to students' emotional and intellectual engagement. The

	software can customize all experiences to maximize learning and interest, creating truly unique interactive experiences for personalized mastery-based education. ● Artificial intelligence allows students to choose the form or shape of their artificially intelligent instructors for a lesson. ● To truly provide learners with an individualized education, the only way to achieve it is through artificial intelligence. Their digital abilities and limitless access to information allows them to understand content and students better than teachers can, given the constraints of teacher time and classroom size. ● Instruction can be differentiated with different types of media, interactivity, and student responses that can collect data and deliver custom content seamlessly. ● Machine learning systems will learn as the students learn, providing rapid advances in our understanding of how students learn and provide rich data to accelerate development and personalize education. ● Learning tutors in artificial intelligence can accelerate learning in children. ● Artificial intelligence in education can adaptively create social relationships with their learners to model learning and provide adaptive cognitive support for students with disabilities.

	● Artificial intelligence has the ability to make project based learning the pinnacle of educating students to make all learning relevant to the individual.
Safe Educational Risk Taking	● In artificially intelligent and machine learning models, students can serve as the tutee, but can also serve as the tutor to their artificial intelligence learning companion to help students solidify their learning in a safe, nonjudgmental environment. ● Students using artificial intelligence for instruction developed positive affect and attitudes toward the content area. ● Students can control their own learning process from choosing their teachers and undertaking assessments at their own time. ● The learning models can look the same or different for all students, wherein students, regardless of ability, aren't singled out as having a different learning path as their same age peers. ● Disenfranchised countries and people living in poverty can access education at a more affordable cost than attending tuition-based educational institutions. ● Scaffolding and differentiation within learning models can be designed imperceptibly during student learning.
Accessibility and Remote Instruction	● Low achieving students have had the greatest benefit and educational gains from artificially intelligent software programs.

	● Low performing students made significant gains in their understanding when teachers combined their regular instruction with artificial intelligence tutoring. ● Artificially intelligent learning environments could be able to contextualize the learning process for students by considering their location, environment, proximity, and living situation to generate better learning experiences based on these factors. ● Traditional education leaves struggling students with years of cumulative knowledge gaps; artificial intelligence can make foundational skills accessible to students with significant learning gaps. ● Immersive technologies, such as augmented reality, with artificial intelligence reshapes student relationships with information. ● Artificial intelligence can create educational experiences for collaboration from vastly different locations in the globe and can pair students heterogeneously, homogeneously, or by interests. ● Classrooms can take any form as an abstract place where human connection, collaboration, and learning can exist. ● Artificial learning environments can be much more cost effective as they reduce costs in real estate, human labor, and materials. ● Artificial intelligence has the ability to translate material to different languages rapidly and with fair accuracy, which will provide access to

	educational materials to students in different countries who don't have access to textbooks and materials in their spoken language. ● Students with the greatest poverty had greater improvements in ability using artificially intelligent learning programs. ● Artificially intelligent learning technologies have a similar social influence on students as relationships with peers, teachers, and communities. ● Artificial intelligence based learning systems can impact remote instruction in many ways by connecting learners together, providing access to materials and learning tools, and engaging students in meaningful ways. ● Pressure to contain costs and serve a large number of students can be alleviated with the blending of formal classroom educational experiences and self-paced, individualized education through artificial intelligence.
Potential Caveats and Biases in AI and ML	● Student attitudes and unproductive behaviors can be impacted by the learning environment within the artificially intelligent software. ● Technological innovation is constantly changing, while research is lagging as researchers have difficulty keeping up with the pace of innovation. ● Increased complexity in the classroom with addition artificially intelligent educational programs can be a challenge for teachers as they

	often serve as the bridge to student learning and applying knowledge to real life applications. ● Some research supports the notion that education systems that have invested heavily in computers haven't seen the improvement they were expecting. ● New technologies can be disruptive to student learning. ● Removing the distraction of screens and electronics from the classroom can encourage engagement between the teacher and the student. ● Because technology changes and evolves so rapidly, some people believe students should only be learning core skills instead of how to use and manipulate technology. ● Teaching is about human interaction and children shouldn't learn through machines at a young age. ● Students who are in the habit of using traditional pencil and paper methods of learning were resistant to giving up those methods even when they found artificially intelligent learning systems to be successful in terms of learning and problem solving. ● Student engagement is directly correlated to results in productive learning in artificial intelligence learning environments. ● Encountering political hurdles in the advancement of artificial intelligence in the classroom may have an effect on how well and how

	far the new technologies can be used, considering privacy issues of data mining with teachers and parents. ● Learning how to integrate face-to-face human interaction with artificially intelligent technologies remains a challenge for research. ● Ethics in artificial intelligence provide challenges to development as software can be developed to lie, manipulate, or encourage deep relational interactions with learners. ● If we are unable to adopt new strategies afforded by artificial intelligence in student learning, our educational systems will likely fail to meet the challenges students will have facing them in the future.
Ideas for Development	● Gender differences will need to be considered in the development and implementation of artificial intelligence software considering the extensive research on brain-based differences between how the different genders learn, get help, problem solve, and respond to motivational techniques. ● Teachers will be the most successful at implementing new artificial intelligence and machine learning software into their classrooms when professional development strategies are truly integrative by providing on-going support, on-the-job training on data collection and analysis, and adjusting teaching to respond to student data.

	● Intelligent computer based learning can be a very useful tool for education, but will require careful design and extensive testing to rule out any unfavorable outcomes. ● Teaching and learning happens in the classroom; when considering new research and changing practices, students will learn and achieve more when our society invests more time and resources into the classrooms as well. ● Design must engage students by matching challenges and difficulties with incentives and motivational activities. ● Game-based learning in artificially intelligent systems increase student engagement. ● Effective questioning from learning agents in artificially intelligent programs helped students transfer their learning to real life applications. ● Learning agents in artificially intelligent programs need to be designed to meet the cognitive and social development of young children for them to be appropriate. These programs may not be appropriate for children under the age of 8. ● Artificial intelligence education has the potential to be incorporated in the classroom in ways outside of the computer or iPad and can be embedded in other devices such as robots, sensors and smart classrooms making the educational experience more engaging to help students learn and to help teachers teach more effectively.

	● Data mining from smart classrooms could lead to new understandings of how people and learners behave in life. ● New technologies cannot impact education in isolation, but rather as a resource to a complex system that must always consider pedagogy, environment, and instruction. ● Combined efforts of engineers, psychologists, and educators are needed to create the most appropriate educational model that encompasses artificial intelligence and is easily accessible and usable in education.

4. Discussion

In this section, I have summarized the emergent themes from my analysis of the 43 articles included in this meta-synthesis. I have connected these emergent themes to my present teaching practices and to my personal and professional experiences as a consumer and educator of smart technologies. I will also provide personal and professional experiences and discuss how these theme clusters will continue to impact me as an educator.

4.1. Redefining the teacher's role within the classroom

The need for revaluating the teacher's role in the classroom stems from the increasing and overwhelming workload, stress, and pressure teachers are under in today's society in combination with the development of new technologies that change the way people interact with and access new information in the world around them. Considering the many advancements in smart technologies in today's society and the general lack of changes in content delivery in educational institutions, many students will be unprepared to work in environments rich with these technologies and the 21st century skills that these jobs require. Private schools and public schools in wealthy communities do not face the same challenges that most public schools are burdened by, and are often afforded more opportunity to deviate from the traditional teacher's role as lecturer to tutor, mentor, and facilitator of rich educational experiences. Moving from traditional instruction to individualized learning with support in high-quality critical thinking skills is of paramount importance to students who will need to compete in a shifting job market.

Societal and individual student demands that are placed on teachers are increasingly difficult to meet. With automation of tasks such as grading, assessment, and initiating new content, teachers are able to utilize rich data to increase instruction, compliment information

students are learning, build background, and encourage inference making across domains. With increasing expectations and class sizes, and decreases in planning time and professional development, artificial intelligence learning systems can mitigate many of the pressures in the classroom and allow educators to focus on the most important parts of teaching.

These statements demonstrate that the teacher's role within the classroom is highly important in creating an educationally rich environment and can arguably make the teacher able to do their job better, reach more students, and enrich the learning experiences of their students. Until our society is able to provide teachers with small class sizes, time for professional development and rich meaningful lesson planning, and appropriate supports for adversity in the classroom, artificial intelligence may be the best way to give all students and teachers equality in their education and instruction. Artificial intelligence will enrich the instruction that students receive by freeing up teachers' time to focus on deeper learning opportunities, while providing teachers with superior feedback on student learning to make their instruction or tutoring the most appropriate and attainable for learners. Artificial intelligence and smart technologies in the classroom can seem intimidating to teachers, but I believe that including these advancements in learning into our teaching practices can make our jobs as educators less task-oriented, less stressful, and more impactful to student learning and acquisition. Students will in-turn be more prepared for new job skills and real world knowledge that will be required of them in competitive job markets.

Artificial intelligence technologies will never replace the importance of teachers in quality instruction, but can make teachers even more meaningful, valuable, and essential to building a broad foundation of skills and knowledge in students.

4.2. Teacher feedback

Data-driven decision making has been an important aspect of teacher feedback in education throughout formal learning institutions. Data collection and analysis has been highly mandated by policy makers and administration as a means to make data based decisions in districts and schools, as well as to criticize poor performing schools. Educators are often left out of the analysis part of data-driven decision making and serve mostly as data collectors, especially in regards to high-stakes standardized testing, which is often criticized for harming students' attitudes toward learning, showing poor correlation to students' ability, and introducing added pressure for teachers to teach to the test, not to ability. Artificial intelligence and machine learning uses data-mining techniques to collect incredibly precise data on students' emotions, affect, social behaviors, background, academics, and much more. The data is much more useful and provides teachers, administrators, and policy makers with more data points which help them to understand the whole child. In fact, a large amount of research supports the idea that artificial intelligence and machine learning can make standardized testing obsolete. Data that machine learning and artificial intelligence can provide is much more accurate in collecting data and understanding what students know and have not yet learned, and there technologies are able to collect the data in a much more harmonious and less intrusive way—creating less problems with disrupting student learning and causing adverse reactions from students and teachers. Artificial intelligence can be so subtle and precise that it can accurately pick up on nearly unidentifiable physiological reactions to certain stimuli that can provide data for teachers on students'

familiarity with certain content based solely on how their body responds to the material. If we have accurate data on how a student unconsciously reacts to information they know or do not know, then the whole idea of testing student ability in those instances becomes unnecessary—we wouldn't need to test students to collect duplicative test data that supports them knowing or not knowing that specific content.

Even more valuable, teachers can strengthen their instruction based on the rich student data they can receive from artificial intelligence and machine learning programs. The data can guide interventions, enrichment, and instruction for teachers and provide them with more information on student learning and their learning process at large. Artificial intelligence education has been able to accurately identify students with learning disabilities and provide teachers with interventions for those students. Data-mining algorithms have also been able to identify at-risk students for adverse educational outcomes, such as failing courses or dropping out of school, to guide teachers and administration to provide supports for those students.

If a teacher is not using technology in their instruction of students, they can still benefit from artificial intelligence and machine learning in their classroom. Artificial intelligence and machine learning is able to assess student engagement, understanding of content, and the quality of teacher questioning to provide feedback on teacher instruction and change teaching practices to make instruction more valuable for learners, even if students themselves don't interact with these systems.

Even if schools shy away from using artificial intelligence and machine learning programs in their classrooms on computers or screens, the feedback teachers and schools can

collect and analyze from artificial intelligence can be highly beneficial for teaching, learning, and helping students achieve to their highest potential.

4.3. Individualized learning, modified learning and differentiation

Personalization in education is possibly the greatest way that artificial intelligence can change educational experiences for learners. The "one size fits all" approach to teaching is a great disservice to our children and to our society. All people have different interests, aptitudes, and funds of knowledge—why shouldn't that be reflected in educating different people?

Instruction using artificial intelligence and machine learning can start at different places, take different paths and end completely different depending on the user and the data the program receives from that user. Artificial intelligence can make learning completely customizable and individualized. Research suggest that students, specifically those that are female or other marginalized groups, learn best when they work with peers, tutors, or instructors that look and speak like them. Artificial intelligence allows the teacher or the student to choose who or what their learning companion will be—the options could be endless.

Individualization, modified learning and differentiation is embedded in artificial intelligence. It can consider all facets of a student and create a learning program that is the most engaging and meaningful for that individual. Students have the power to make choices based on their interests and passions and make learning revolve around their ability and thirst for knowledge. Passion projects and project based learning could be the center of which all other content and instruction revolve.

4.4. Safe educational risk taking

Many students are personally bridled by their fear of embarrassment, looking or feeling "stupid," or negative peer reactions in their learning and acquisition of new knowledge. There are many ways that teachers can create environments where students feel safe and valued, so that they will take those risks to expand their depth of learning. Still some students may not respond as easily to teacher initiatives for students to make those leaps especially if they have had negative experiences in previous settings in school or at home and in the community.

Artificial intelligence and machine learning education can provide students with the opportunity to take safe educational risks in an environment where they can be their true and authentic self without any fear of negative reaction. Students who might be afraid of teaching a peer a new concept in the classroom might be more willing to take that risk with an artificial learning companion in their smart program.

When students feel like they struggle in an area they often build negative attitudes and behaviors toward that subject. A student who has experience performing poorly in math will say they hate math or even act up in math class to try to get out of having to display their lack of understanding in front of their teacher or classmates. Artificial intelligence education can provide supports in developing positive attitudes as well as academic supports for learners that do not single them out from their classmates. All programs can look similar and different at the same time, making students unaware that some classmates may be at a different ability level than themselves.

4.5. Accessibility and remote instruction

Artificial intelligence education opens the door for learners in remote education settings or in places where education is of low quality or unaffordable. Artificial intelligence requires less

resources and less additional expenses that many societies have difficulty providing. Many students who have accessibility issues to information or schooling can more easily access vast amounts of materials and learning experiences through artificial intelligence. These programs can also respond and react to student information to provide materials in their language, customize learning to their life experiences, and make learning more personalized for their unique needs.

Students with learning and physical disabilities can equally access learning through efforts of artificial intelligence. Many artificial intelligence initiatives had been underway due to the unique learning needs for people with disabilities. These programs are able to expose them to knowledge and learning in ways they haven't been able to experience before.

4.6. Potential caveats and biases in artificial intelligence and machine learning

Making any radical changes to the status quo of any field as huge as education comes with a whole host of caveats that need to be considered. We have to protect our profession and be certain that the decisions we make impact our students positively and do no harm. The biggest concern for the implementation of artificial intelligence and machine learning education in the classroom is that the programs need to be developed with learning needs of students with all ability levels in mind. Because artificial intelligence and machine learning grows and improves based on data collected from large amounts of student input, it has the possibility to assemblage student learning needs based on the greatest amounts of data it has received; this can create biases toward the mean and ignore outliers, which could easily be the fewer amount of students with learning disabilities.

When considering new, smart technologies and the capabilities they have in not only influencing learning, but also influencing the social and emotional relationships children form with technologies, we have to be skeptical of the ethical dilemmas that may present with these technologies. These dilemmas can include the relationships students may form with their learning companions, ensuring that programs are designed to not manipulate learners, and making sure students are rich with face-to-face human interactions.

Some philosophies of education and followers of those philosophies disapprove of the use of technology in the educational setting on the premises that too much screen time can be damaging to nurturing the whole child, children may already experience over exposure to technology, and education should be about human interaction. And, with the global connection artificial intelligence can have on education, many stakeholders are concerned for the privacy issues that can arise from the data-mining these programs can use on student performance, background, and socio-economic information.

4.7. Ideas for development

The most important consideration for developing new artificially intelligent learning software in classrooms is the inclusion of student individualization and diverse backgrounds. Female, minority, impoverished, and students with disabilities need to have personalized learning experiences that are developed with their individual, unique learning needs in consideration.

Many technological advances in education have gone to the wayside either as they become archaic or because teachers did not receive proper and on-going professional development for the technology to become successfully integrated. With artificial intelligence

and machine learning, teachers need to receive proper professional development and receive continued support in the classroom.

Age appropriate practices need to be considered when integrating technology in the classroom and may be inappropriate for young children. Teachers and psychologists have to be involved in the development and research process of artificial intelligence and machine learning to ensure that development supports best practice.

Developers of smart technologies have been quite successful at incorporating engagement strategies and are able to monitor student engagement for teacher feedback, but artificial intelligence is only successful when learners are actively engaged and thus makes engagement hugely important to the development of these programs.

5. Conclusion

The findings of this meta-synthesis have opened my eyes to the magnificent and monumental applications for artificial intelligence and machine learning in the sphere of education. These advances in technology, while still largely in the research and development phase, can be incredibly valuable in the inclusive classroom. While a host of caveats and barriers have emerged from the research on the development of artificial intelligence and machine learning in the classroom, I believe that these applications can prove invaluable to teachers and students. In some educational environments, artificial intelligence and technology in general may not be necessary, but in the general public school classroom, artificial intelligence and machine learning can accelerate student knowledge and help students to compete in the work force of the future.

With the many challenges that teachers face in the classroom, artificial intelligence and machine learning can alleviate the pressures on teachers while building a highly engaging and personalized learning experience for students. I believe that with careful design, backed by adequate research, artificial intelligence and machine learning can impact student engagement and learning in ways that the educational field has never before experienced.

Advancements in artificial intelligence and machine learning have proven to be advantageous for people with impairments and disabilities. It will have to encompass thoughtful, careful design, but can open the doors for students with disabilities to interact with information and learning in new and exciting ways.

As a teacher, lifelong learner, and consumer of new technologies, I am not simply excited for the ways that artificial intelligence and machine learning can simplify many tasks in my life, but also for the many ways these technologies can expand my ability to learn and interact with information throughout the world. I look forward to sharing those emotions with my students so that they may experience things in their learning that they otherwise wouldn't have the opportunity to experience. The findings of this meta-synthesis indicate that there is much to consider and develop to make these applications the most appropriate for student use, but the benefits can be astronomical to the quality of life and education to students with and without disabilities.

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