Engaging High School Teachers in Artificial Intelligence Concepts and Applications

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Introduction and Justification

Artificial Intelligence (AI) applications have become an integral part of our lives, from social applications on smartphones to crewless vehicles. However, as they remain in the domain of "computer magic," these new advancements of knowledge processing and reasoning using AI tools will not be of a great benefit to humanity, unless a complementary education environment is provided to help students and communities become involved in this scientific revolution early, ethically, and systematically. Introducing and exploring AI concepts and basics earlier in the students' learning journey will help address the future AI job market needs as well as AI ethics issues and will open the door for new innovative AI applications in all segments of life. The long-term goal of this research is to help in shaping a safe pathway to AI-based learning environments for human progress.

AI is expected to lead the new revolution in the social, economic, health, and technology areas. Currently, the fast development of AI-based products is accompanied by huge investments from large companies and governments. In the U.S., both the previous and the current administration fully support AI research and development efforts. For example, on February 11, 2019, President Trump issued Executive Order 13859 to maintain American leadership in artificial intelligence [1]. With respect to this executive order, France A. Córdova, Director, National Science Foundation (NSF), included the following statements [2].

> *"NSF has a long and rich history of supporting transformative research in artificial intelligence and machine learning and is an essential contributor to growing the workforce needed to advance AI research and development" ... "Advances in AI are crucial for the U.S. science and engineering enterprise, and nearly all sectors of our 21st-century economy. Many of the transformative uses of AI that we are witnessing today are founded in federal government investments in fundamental AI research that reach back over decades. Building the foundations of tomorrow's AI innovations will require new interdisciplinary collaborations, resources, and strategic visions — principles that NSF has championed in its support of fundamental AI research" ... "The AI innovations that NSF has funded have helped the U.S. capitalize on the full potential of this critical research area, and we are eager to (continue to) strengthen our economy, advance job growth, and better our society."*

At the beginning of 2021, Congress passed H.R. 6216, the National Artificial Intelligence Initiative Act of 2020 [3]. One of the purposes of this law is to "prepare the present and the future United States workforce for the integration of artificial intelligence systems across all sectors of the economy and society." Two initiative activities (Activity 3 and Activity 4) address AI education directly. Activity 3 calls for "support for educational programs at all levels, in both formal and informal learning environments, to prepare the American workforce and the general public to be able to use and interact with artificial intelligence systems, as well as adapt to the potentially

transformative impact of artificial intelligence on society and the economy," while Activity 4 addresses "support for interdisciplinary research, education and training programs for students and researchers that promote learning in the methods and systems used in artificial intelligence …" Based on the above law, on June 10, 2021, NSF and the White House Office of Science and Technology Policy (OSTP) formed the National Artificial Intelligence Research Resource Task Force (NAIRR TF) [4]. This task force "will write the road map for expanding access to critical resources and educational tools that will spur AI innovation and economic prosperity nationwide."

The massive investment in time and resources by large businesses and governments will accelerate the presence of more products that will stimulate human-machine competition in the job market and at the same time will create a new work environment that can accommodate thousands of qualified workers.

Here, a hands-on project-based AI workshop created to engage and educate high school teachers is designed, implemented, and assessed. Its major goal is to change teachers' perceptions of AI through increased knowledge of AI topics.

While the major emphasis of this work is on the content and organization of the workshop, an educational research question (To what degree the high school teachers engage with AI through a hands-on project-based workshop?) is also addressed. This question can be subdivided into three parts, (1) *loss of fear* caused by better understanding of AI concepts, practices, and applications, (2) *acceptance* caused by increased knowledge of AI and practical exercises, and (3) *implementation* of AI concepts and project-based exercises as course topics in teachers' classes enabled by workshop notes, slides, videos, and a list of URLs that offer additional training.

Previous Work

According to the "One Hundred Year Study on Artificial Intelligence" (AI100) published in September 2021 [5], during the last five years AI has gained more attention from governments, public agencies, and organizations. Thus, more than 60 countries engaged in national AI initiatives and are seeking more international collaboration. These efforts include a range of governance approaches and programs to ensure public safety, consumer trust, product reliability, accountability, and oversight of AI products. Littman *et al*. [5] further suggest the importance of increasing governments' investments in AI research to align with development and needs in the private sector to stop brain-drains from academia to industry. In addition, the same study mentioned that "the governments should support K-12 educational standards to help the next generation live in a world infused with AI applications and shape market practices concerning AI's use in public-facing applications."

The bright future for AI and humanity is based on the ability of nations, governments, and communities to establish the balance between advancing the AI applications and adapting the educational system at all levels (K-16) to accommodate these accelerated changes, as well as accepting AI as a tool for human advancement. The current K-12 educational system and other pre-college educational systems are mainly designed to accommodate the primary social and

scientific learning objectives according to the academic level of the students and the knowledge that can be offered by their instructors. However, the available AI learning resources are mainly designed for learners at the college level [6]. Even though pre-college students may be exposed to AI applications through games, text-to-image generators, natural language processors, and self-driving cars, it is hard for them to develop any depth in understanding of AI concepts and tools without proper resources.

Two aspects can briefly describe the AI future; the first is the increasing demand for AI specialists with different backgrounds (not only the specialists from computer science) which will help in exploring additional AI applications, and the second is an increase in the acceptance of AI in the community as a knowledge-based scientific tool and not as a magic replacement for humans. These two aspects can be targeted gradually by adopting and enforcing an educational system for high school students that will help in producing the seeds for the new AI job market from many students still in their early learning stages and increase the users' understanding of the role and ethics of AI as early as possible.

AI is a quickly emerging field of research with broad applications in the STEM workforce and industry in general. However, at this time, there are only a few curricular standards or educational guidelines for introducing pre-college students to fundamental knowledge and skills related to the field of AI like the NSF-supported grant "Developing K-12 Education Guidelines for Artificial Intelligence" awarded in 2019 [7]. There, the principal investigator (PI) aims to develop guidelines for teaching and learning dealing with AI in K-12 school learning environments. Some of the AI learning modules and student learning outcomes are presented in [8], [9]. Internationally, there are many examples of AI implementations in education. For example, in Estonia, teacher perceptions of AI as a tool for supporting education [10] were positive while students' (fourth to sixth graders) motivations to learn AI in China were gender dependent [11]. In India, over a million children significantly increased their reading and comprehension skills using AI tools [12].

Context

An important goal of this work is to provide an example of how authors built a successful collaborative AI educational environment consisting of university professors and high school teachers in the Southern Colorado area. A creative simple learning approach is constructed to help teachers understand AI-based solutions (e.g., fuzzy logic, neural networks, and evolutionary techniques) for the problems and procedures from their daily lives and their local environment.

The content of the workshop is designed based on authors' extensive experience in teaching and in AI research applications (optimization, decision making, classification, and recognition). In addition, the authors' multidisciplinary scholarly backgrounds shaped the decisions on how to introduce AI concepts and ethics to the teachers through simple, stand-alone, learning modules that, in turn, the teachers can use effectively when introducing AI topics [13] – [15].

Teachers spend approximately 20-40% of their work on tasks that could be automated [16]. Teachers come with the perception that AI will replace them; instead, the workshop described here

showed them how AI can help them. A heightened awareness that AI can complement their teaching methods and create an efficient way of assessing students is a benefit to not only the teachers but their students as well. In education, there are four major areas that are affected by AI applications: content, teaching methods, assessment, and communication. When acceptance of AI is achieved, this framework can have an overarching effect on the educational landscape. This workshop includes three stages: development, planning and implementation, and assessment.

Workshop Development

In this stage, new learning modules that can be used during teacher workshops or as online resources for future training are developed. The module topics include:

1) Intelligent behaviors and intelligent systems
2) AI ethics
3) AI applications and examples:
    a. AI as a classification tool (e.g., email spam filters, categorizing emails into primary, social, and promotion inboxes, as well as labeling emails as important)
    b. AI as a recognition tool (e.g., smartphone face recognition app, checks deposits through a smartphone app)
    c. AI as a memory tool (e.g., online shopping personalization)
    d. AI as a decision-making tool (e.g., AI autopilot for commercial flights, fuzzy logic system to optimize washing parameters in the washing machine)
    e. AI as an optimization tool (e.g., ridesharing apps (Uber and Lyft), Google Maps to optimize traveling time and distance, AI scheduling for commercial fights, etc.)
    f. AI as a prediction tool (credit scores decisions, risk assessment for individual customers, prediction of fraudulent transactions.)
4) AI tools for education and classroom activity support (*analytic AI that assists with customizing plans for ELL, IEP, 504c; interactive AI like Siri or Alexa that assists with open learning for students; functional AI that assists students with special needs to calm, motivate and stimulate them and visual AI that "sees" for visually impaired students and narrates the content for them.*

    Artificial intelligence in K-12 education touches four main areas, *instructivist, constructivist, teacher support, and system support.* What teachers do not realize is the focus of each of those areas. *Instructivist* touch students' teaching in a manner which automates and adapts all forms of computer-based support for K-12 students. *Constructivist* refers to variables such as the points of learning where the data deals with visual, auditory, and kinesthetic stimuli. *Teacher support* relates to specific applications or materials that enhance the learning for students. *System support* relates to the impact of AI on teaching and learning in K-12.

Each learning module is designed to include all the required definitions and concepts related to the module topic. Because of the time limitation, the main goal of face-to-face training is to discuss a maximum number of AI applications.

Workshop Planning and Implementation

In this stage, AI concepts and basics are introduced to the local high school teachers interested in AI (not only STEM teachers) through a one-day workshop at Colorado State University Pueblo (CSU Pueblo). These AI workshops are used to introduce basic AI concepts and applications to a maximum number of new audiences for the first time using professional and scientific approach.

This discovery research was implemented by the CSU Pueblo faculty partnering with high school teachers from District 60 and District 70 in Pueblo, Colorado. In general, schools in both districts have more than 44% Hispanic and marginalized students. So, this was an excellent opportunity to involve the maximum number of minoritized and marginalized students in this research to learn more about AI and contribute to future work. This is consistent with the CSU Pueblo's mission to serve the Hispanic minority community and the Southern Colorado region. Nine high school teachers from Districts 60 and 70 in the Pueblo, Colorado area participated in this workshop. An initial and a post-training survey were used to measure the impact of the training and obtain a better understanding of teachers'/students' readiness to further engage in hands-on AI experiences and training.

Based on the developed AI modules, an appropriate workshop agenda was created. Invitations with workshop agendas shown in Table 1 were sent out to nine high school teachers from districts 60 and 70. All nine attended the Artificial Intelligence Workshop on Jan 15th, 2021.

Prior to the workshop, participants received and completed an initial survey shown in Figure 1 so the organizers could evaluate teachers' prior knowledge of AI.

Table 1. Workshop agenda

Time	Activity
9:00 am-9:05 am	Self-introduction
9:05 am-9:20 am	Introduction of the Research and Detailing the Purpose of the Workshop
9:20 am- 9:50 am	**Part one:** Artificial Intelligence's Types, Applications, and Future
9:50 am-10:00 am	Hands-on Example: Machine Learning Research (Object Recognition)
10:00 am- 10:10 am	Part one Discussions
10:10 am-10:30	Why AI4K12? D. Touretzky of AI4K12 Presentation
10:30 am-10:40 am	Free Time
10:40 am -11:10 am	**Part two:** Artificial Intelligence's Applications to Support Education
11:10 am-11:20 am	Discussion of Applications and their use in the Classroom
11:20 am-11:30 am	Free Time
11:30 am- 12:00 pm	Wrap up/Conclusion/Closing Thoughts/synthesis/ Future Collaborations/ Completing Exit Survey

1) How much do you know about AI?

Select one answer that best describes what you know about AI:

a. I know nothing about AI
b. I know little about AI
c. I am not sure
d. I know much about AI

2) Are you aware of any applications that you currently use that are AI?

Yes No

3) What barriers do you perceive in using AI in the classroom? (Select all that apply)

a. I don't have AI tools in the classroom
b. I am not familiar with using AI tools in the classroom
c. The school does not have funds for AI tools in the classroom
d. The students will not buy in to using AI
e. N/A

4) What would you like to know about AI?

Rank what you would like to know about AI? (1 most wanted 4 least wanted)

1-……. 2-……3-…….4-.....

a. AI tools to support education
b. AI general applications
c. AI concepts and techniques
d. How to introduce AI concept and techniques at the K-12 curriculum

5) Do you believe that AI can be a threat? Yes Not sure No

Explain: ……

6) Do you believe your students have knowledge of AI? Yes Not sure No

7) For future workshops and meetings, I prefer …… style.

a- In person b- Virtual (Zoom) c- both in person and virtual

8) Comments you would like to share with us:

Figure 1. The initial AI workshop survey

Our participant pool included high school teachers. The initial survey was necessary to prepare the workshop according to the teachers' prior knowledge of AI. For example, if the teachers had little or no prior knowledge of AI the workshop would have to start with basic concepts, not to overwhelm the participants. The initial survey also focused on how the participants wanted to use AI in the classroom. Part of the workshop focused on specific applications that they could implement into their curriculum immediately. Understanding teachers' needs also influenced the types of applications that were introduced in the workshop.

Upon completion of the workshop, the participants were given an eight-question exit post-training survey shown in Figure 2. There were six quantitative questions using a five point or a three-point Likert scale as well as two qualitative questions. The two qualitative questions were also used as pedagogical tools based on experiential learning best practices. Question 7's goal was to elicit a

positive self-reflection while Question 8 reinforced learning through internalization and summarization.

1. Exiting this workshop, I learned something new about AI concepts, applications, and ethics (1 - strongly disagree to 5 - strongly agree).
2. I have a better understanding of AI and how to integrate it into Education as a result of today's session (1 - strongly disagree to 5 - strongly agree).
3. I feel that the workshop met my expectations as a teacher (1 - strongly disagree to 5 - strongly agree).
4. The workshop provided useful material/ideas that I can use as a teacher (1 - strongly disagree to 5 - strongly agree).
5. Would you be willing to participate in a new AI project (1 - no, 2 - maybe, 3 - yes)?
6. Overall, I would rate the workshop (1 - poor to 5 - excellent).
7. What did you enjoy about today's workshop?
8. What did you learn in the AI workshop?

Figure 2. The exit AI workshop survey

Assessment of Results

Assessment of the Initial AI Workshop Survey

From teachers' responses to the questions on the initial survey, it was realized that teachers' knowledge levels varied substantially (Question 1), as was the nature of how they envisioned to use AI in class. For example, Question 2 responses determined teachers' awareness of the everyday use of AI (60% Yes and 40% No). Question 5 addresses teachers' fears of AI. Here, 40% of teachers believed that AI can be a threat, 20% did not, while 40% were undecided. In Question 6, teachers shared their beliefs about their students' knowledge of AI. 20% believed that their students have some knowledge of AI, 20% believed that they do not, while 60% were not sure. While teachers' responses were not surprising, still they provided a great insight for determining the content of the workshop.

Assessment of* the *Exit AI Workshop Survey

At the end of the AI workshop, the teachers participated in the exit survey of Figure 2. Results of the first four questions were all positive (Question 2: 62.5% Strongly agree and 37.5% Agree; Question 3: 75% Strongly agree and 25% Agree, and Question 4: 62.5% Strongly agree and 37.5% Agree). For emphasis, Question 1 results are presented in Figure 3 showing that all teachers learned something new about AI. Also, Question 6 responses were all positive (62.5% Excellent and 37.5% Very good). However, Question 5 responses, shown in Figure 4, were somewhat puzzling. While the majority of teachers expressed willingness to participate in new AI projects, 12.5% did not. It could be assumed that the AI workshop satisfied their curiosity and their current needs.

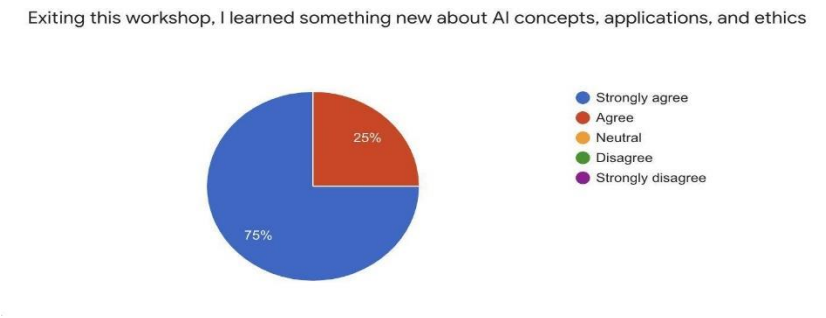

Figure 3. Teachers' learning perceptions

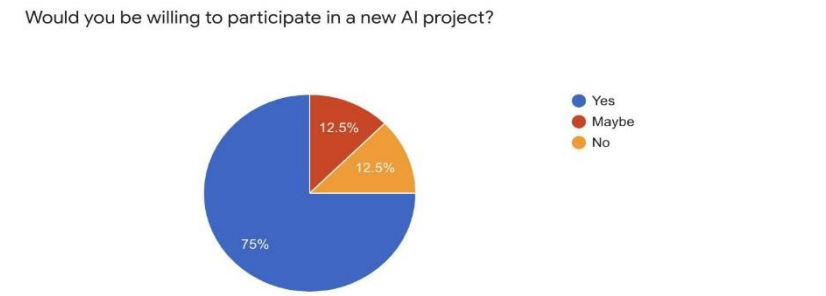

Figure 4. Willingness to participate in a new AI project

In summary, the quantitative questions' responses showed that the teachers achieved a greater understanding of AI concepts and ways to apply them in the classroom. They felt the workshop was beneficial and provided excellent resources to take back to their colleagues.

The responses to the two qualitative questions were all positive. Here are some examples of teachers' testimonials on what they enjoyed about the workshop.

> *(1) I really enjoyed seeing the AI aspects of daily life. (2) I just am glad I get to bring this information back to my supervisor and collaborate… This was exciting; Dr. Massey always provided me the greatest lesson material, so this was nothing short of awesome, as was expected. (3) Differing perspective on AI and how educators can apply AI in a classroom.*

From the teachers' perspective and Question 8, major takeaways from the workshop were the knowledge of how to search for specific resources and whom to contact to collaborate. The websites, resources, and applications were free and can be used in education, something most of the participants had not thought about. The teachers perceived that all tools come with a high price tag and hadn't considered that there could be ones that are free. As certain aspects of AI have been emphasized, the participants have been realizing that there are many AI applications all around them affecting their daily lives; that AI ethical issues concern them; that some of the teaching/assessment tools they are using are in fact AI apps; that their students can access these free AI tools for their own out-of-class education and that help is close by, if needed.

One K-12 teacher is in the process of integrating AI content into a course that he will be teaching in the fall. The course focuses on coding and AI and much of the content has been taken from a

course he just completed. The course was an introduction to artificial intelligence. One of the teacher's takeaways from the course was how much AI is embedded in many of the tools he was using in his course. According to Mr. Miller, "what I didn't realize was the consideration of ethics into the process of using these vast tools and the implications of not knowing" (personal communication, April 29, 2021).

Lessons Learned, Conclusions, and Future Work

The myth that artificial intelligence will replace teachers was dispelled. The barriers of an environment of mistrust versus lack of knowledge can be defeated by educating the educators via workshops. While there are threats from AI, a strong set of ethical rules, when applied, can minimize risks. Participants realized that there is a learning curve when implementing artificial intelligence in a class setting. The desire to integrate learning simulations supporting hands-on activities to enhance student learning is a good motivator for teachers to learn AI. Also, budget considerations for implementing AI in education, while important, are manageable. There should be an understanding of what the role of the teacher is, how to gain parental acceptance, and how to promote the overall acceptance of AI in education.

The authors believe that the engagement of high school teachers in this and similar AI workshops is crucial in changing teachers' perspectives on AI and empowering them to include AI topics in high school curricula. While this work describes the design and implementation of a small AI workshop it is hoped that this can be scaled up so that the citizens can be educated in AI well enough to be able to make informed decisions on AI aspects directly influencing their lives. This is especially true now, since the world is in the midst of a number of controversies dealing with biased data sets for training of neural networks, ChatGPT unfair uses, or the Elon Musk's call for a moratorium on AI development.

Results from this research will be used as preliminary findings while planning large-scale regional research activities related to AI that could be supported by NSF, Amazon Machine Learning University or the Department of Education. A collaborative network consisting of local schoolteachers interested in AI and AI-active university professors will be created to further promote and implement AI in the K-12 curriculum. Partnership modalities with the AI4K12 organization will be investigated to improve AI literacy among the K-12 students.

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