Web-based Platform for K-12 AI Education in China

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Abstract

As human beings are entering the era in which AI becomes the new engine to drive social, economic, and scientific advancement, education is intensively being required to adapt to this trend, to equip current and next-generation with the necessary knowledge, skills, and thinking. Although AI education has achieved relative success in universities and cultivated a large number of talents and companies in the past decade, it hasn't made significant progress in K-12 education. We identify the key challenges as two gaps, one is about transferring practice from university education to K-12 education, and the other is about the inequal distribution of AI educational resources. To fill these gaps and to efficiently facilitate K-12 AI education, especially in countries like China, we designed and implemented a web-based platform, which as a focal and sharing point of K-12 educational resources to provide essential AI learning and exercising components to both students and instructors. With this platform, we've successfully conducted a series of initial trials and gained positive feedbacks. We believe a wider-range of applications of the platform will achieve promising results for K-12 AI education.

Introduction

Recent advancements in AI, especially in machine learning, have achieved phenomenal success (LeCun 2015; Jordan and Mitchell 2015; Lakemeyer and Nebel 2003). The impact of AI is now beyond the research and industrial scopes and it's attracting intensive attention from the whole society. It has become a common belief that AI will be an indispensable infrastructure of the future society and the new engine of the growing AI-economy (Bolton et al. 2018; D'souza and Williams 2017). Therefore, a consensus is forming about AI education that it's necessary for the current and next generation and should be integrated into our whole educational framework.

There have been a lot of practices in this direction (Dodds et al. 2006; Conati et al. 2018; Jungah 2019). While most of the efforts were from universities (Dodds et al. 2006) and professional level (Fiebrink 2019) (such as online courses like deeplearning.ai), some trials have been made for K-12 (e.g. aiK-12 by MIT[1]) and (Touretzky 2019). Although there are no specific statistical data about how many AI courses are available in K-12 schools, we believe that it's getting priority in schools. For example, schools in the Pennsylvania Montour School District[2] have mandated AI contents in the grades 5-8 curriculum, and they have embedded AI in STEM courses and other subjects like Music, Computer Science, and Media Arts. Additionally, the district requires the students to take a stand-alone AI Ethics course. With these kinds of efforts, AI will become new literacy in the future.

China is among the leading countries of AI research and engineering, and the development of AI is strongly supported as the national strategy. AI education is also emphasized in China (Hao 2019), as a chance to promote the intellect and competence of its large population. The Chinese government published a guideline for AI education in 2017[3]. Following this guideline, over 180 Chinese universities have established AI majors for both undergraduates and graduates. Many efforts have also been made in K-12 education. More than ten types of AI textbooks have been published for middle and primary schools. Trial courses have been tested in provinces/cities like Zhejiang, Hubei, and Shanghai. More provinces are on the way. We argue that successful AI education in China also benefits the world, not only because China has exported numerous technical talents to the world in past decades and will continue to do so, but also because the widely adopted and affordable products and accumulated experience of AI education can be deployed to other countries, especially those developing countries.

To understand the current situation of K-12 AI education in China. We conducted an online survey from July to August 2020. In this survey, we collected 218 valid responses (24 teachers, 72 parents, and 122 students) from K-12 schools. About 17.89% of subjects were from first-tier cities (like Shanghai and Beijing) and provincial capitals which are relatively developed cities in China, 27.52% were from

[1] aiK-12 by MIT: https://aieducation.mit.edu/
[2] https://www.robotlab.com/blog/ai-curricula-for-k-12-classrooms
[3] http://www.gov.cn/home/2017-07/20/content_5212053.htm.

other cities in China (smaller and less developed cities), and 54.59% were from counties and rural areas. The result indicated that, although over 84% of subjects were interested in AI education, only 48.62% of subjects had joined AI courses before. 60.09% believed that their schools were lacking in infrastructure for AI education. 55.96% thought there was no suitable AI textbook and curriculum for K-12 students. 51.38% indicated that their schools were insufficient in teaching capability for AI education. These results indicate that AI education for K-12 schools is still in the early-stage and has a long way to go.

Therefore, AI education still has many challenges to solve before widely deploying for K-12 schools. In this paper, we firstly analyze the key issues of current K-12 AI education in China. We identify two significant gaps, one is about the transferring of AI education from universities to K-12 schools, and the other is about the inequal distribution of K-12 educational resources. We believe these challenges are common on a global scale. Although the work presented here is targeting China, it gives a vision to other countries. Based on these observations, the main contribution of our work is to design and implement a Web-based platform to help eliminate the two gaps. Several important principles were taken into account when designing such a platform. Necessary AI educational resources and functional components are integrated and can be easily accessed. Based on this platform, we have conducted several pilot courses and practices. The initial results are encouraging.

Challenges of AI Education for K-12 Schools

In the past two years, we were involved in many AI education activities in both universities and K-12 schools. Based on our observations and practices, we found the current challenges of K-12 AI education mainly comes from two significant gaps.

GAP 1 - Transferring from University Education to K-12 Education

The first gap is between AI education in universities and AI education in K-12 schools. Most previous efforts like curriculum and textbook design were for university students (or for professionals), and there have been accumulated numerous educational resources (such as online courses of AI). It's straightforward for K-12 educators to transfer these practices to K-12 AI education. However, such transferring suffers some obvious issues.

Firstly, unlike traditional curricula like Math or Physics, AI education is not elementary but multi-disciplinary. It requires prerequisite courses and knowledge like Math and programming, which is feasible in universities but difficult for K-12 schools. Therefore, we cannot migrate the same learning pathway to K-12 schools and degrade the curriculum from the universities. We need the development of new curriculums dedicatedly for K-12, in which dependencies on prerequisites of Math and Computer Science are minimal, and the focus is more on the training of computational thinking and cultivation of interests in AI.

Secondly, AI education, especially machine learning, is not just about theory, it emphasizes practice. Understanding essential AI concepts and skills require conducting experiments. These experiments need not just programming skills, but also powerful computation resources and a large amount of data. While the universities can build the infrastructure for experiments in AI courses, it's difficult for K-12 schools to do so, especially for those in less developed areas.

Thirdly, it's impossible to transfer the related educational resources from the universities to K-12 schools, such as platforms, tools, demos, etc. More importantly, the required knowledge level and teaching skills for K-12 teachers are not comparable to those for instructors in universities. It's difficult for K-12 school teachers to copy or transfer the practice from the university.

Due to these reasons, a gap formed between AI education in universities and that in K-12 schools. The result of the gap is that even we've made considerable achievements in the universities, it helps little to the masses of K-12 schools.

GAP 2 - Inequal Distribution of AI Educational Resources

The second gap is about the distribution of K-12 AI educational resources. Due to the unbalanced economic development level within the country (Wei and Fan 2000), the foundation and supportive resources of AI education are inequal in different areas. Economic inequity has a more influential impact on AI education compared with other courses like Math and English since AI education relies more on computational infrastructure and equipment. It also causes the unbalanced distribution of scarce qualified AI educators. Only a small proportion of K-12 schools have enough teachers to set up the AI curriculum. A small number of schools, like those in most developed areas (e.g., Shanghai and Beijing), can spend high budgets to acquire high-quality resources (including experienced teachers, computational resources, learning materials, educational tools, etc.). Many other schools, especially those from less developed areas, can hardly access these resources.

Such inequity has become the key barrier for K-12 AI education, which will amplify economic inequity as the future economic success depends increasingly on intellect.

A Web-based Platform for K-12 AI Education

To deal with the two gaps, we propose a Web-based platform[4] (named 'Mo', accessible from http://momodel.ai) for

[4] A walk-through video can be found here: https://youtu.be/o2dgUfdFqy0.

K-12 AI education, especially for students after grade 5 in primary schools to students in senior high schools (normally 11-18 years old). In this section, we discuss the principles of the platform, its system design, and how its components can help eliminate the two gaps.

The form of platform, as a service providing model, is a solution to deliver services to a large population at relatively low cost (Kenney and Zysman 2016). For K-12 AI education, instead of deploying isolated tools and systems, an easily accessible public platform without geometric and resource constrains is more desired, not just because it provides an affordable way of accessing AI infrastructure and resources, but also because such a public platform enables interactions and sharing among participants, and helps form a learning community for K-12 AI education.

Among various platform types, we choose to develop a Web-based platform, since it's most widely used and has a low cost to access. In designing this Web-based AI education platform, we set the following principles:

1. The platform should be easy-to-use and easy-to-access, to empower teachers and engage students, who lack previous AI experiences.

2. The platform should facilitate the sharing of AI educational resource, and make quality resources affordable.

3. The platform should support not only learning but also practicing, as well as evaluation of learning effects.

4. The platform should be scalable, to support a large scale of deployment and usage.

As shown in Figure 1, the overall architecture of the Mo platform has four layers:

- **The computing resource layer** provides the computational resource (including GPUs) for the platform. This layer is scalable and elastic, utilizing distributed servers and clusters. Physical servers (and clusters) can join this layer easily, and we develop the interfaces to different cloud computing providers, so when the computational burden is high, cloud servers (including GPU servers) can be initialized and added into the resource layer dynamically. Various parties including different K-12 schools can contribute their resource to this layer, e.g., the HPC center of Zhejiang University has contributed a cluster to the platform since 2019. Such resource sharing is the key to realize Principle 2 and 4 so that K-12 schools can have a powerful computational environment at a low cost.

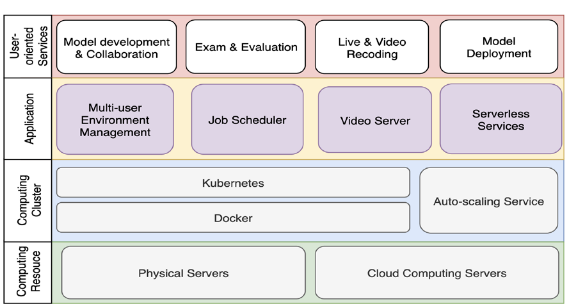

Figure 1. The overall architecture of Mo platform

- **The computing cluster layer** manages the computational resources and provisions of the containers for applications and services in the platform. We use Docker and Kubernetes to build a container cluster to host JupyterHub, application servers, databases, and other services. We make the optimization so that each Jupyter pod consumes a minimal resource (1/4 core CPU, and 250MB Ram). GPU resources are separately managed by queueing and scheduling services, so they can be shared among users. The auto-scaling service monitors the system load and controls the scale of the underlying computational resource.
- **The application layer** provides the components to support platform functions. A multi-user environment management is utilized to maintain the backend libraries and environment for users' Jupyter Notebooks. The job scheduler is used to coordinate modeling tasks. The video server provides a video streaming service. And there are some other serverless services like dataset validation, messaging, etc.
- **The user-oriented service layer** handles user interaction. The core is a JuypterLab for model development and collaboration. Other components include exam and evaluation support, video recording, easy-to-use model deployment, etc.

Next, we present the main features of the Mo platform and discuss how they can help eliminate the two gaps.

Online Learning Environment

The essential features of the platform are based on the Jupyter Notebook environment (O'Hara et al. 2015), with customized JupyterHub[5] as its backend, and JupyterLab as its frontend. Jupyter Notebook based learning environment has several advantages:

- It provides an easy-to-use and easy-to-access Web-based IDE for student-friendly coding. Based on that, we provide users with a ready-to-use workspace with necessary libraries (like Numpy, Pandas, and Pytorch) installed and other features like data preview so that users can start data analysis and modeling easily (Perkel 2018).
- In addition to programming, Jupyter also supports markdown, which enables presenting various learning materials (including multimedia contents).
- Jupyter is a popular choice for programming and conducting data science (Perkel 2018). After finishing their K-12 education, students could continue to use it in their future post-secondary education or in their work.

Based on Jupyter, we've made several extensions, making it more feasible for AI education. The main extensions include:

[5] JupyterHub: https://jupyter.org/hub

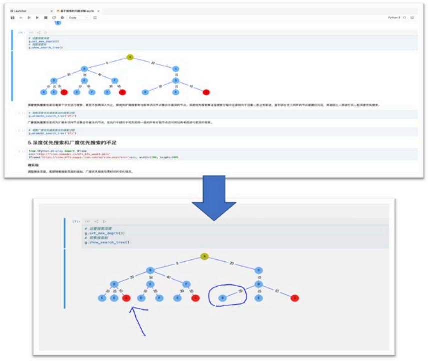

Figure 2. Presentation mode

- **Presentation mode**: Jupyter is for programming, but is not friendly for teaching in the classroom. Therefore, we created a function called “presentation mode” (Figure 2), which can instantly transform a Jupyter Notebook to slides presentation. And in this presentation mode, you can still run the python code in it.
- **Video streaming**: Recorded videos lectures and live video streams can be embedded in Jupyter Notebook. Instructors can share their teaching with others. But unlike the traditional MOOC, in addition to watching the video, students can also do practice with the associated codes, which is helpful for learners to learn AI (Figure 3).
- **GPU support**: Machine learning, especially deep learning, needs GPU. For many K-12 schools, the cost to purchase and maintain a GPU cluster is not affordable. Therefore, in the Mo platform, we provide easy-to-use GPU support (Figure 4). Users can directly run their code on GPU. Each user has 10 hours of free GPU usage, which is normally sufficient for a course.

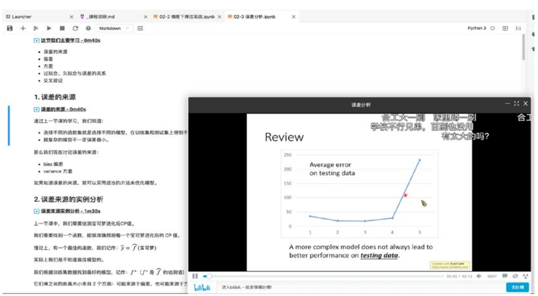

Figure 3. Video streaming in Jupyter Notebook

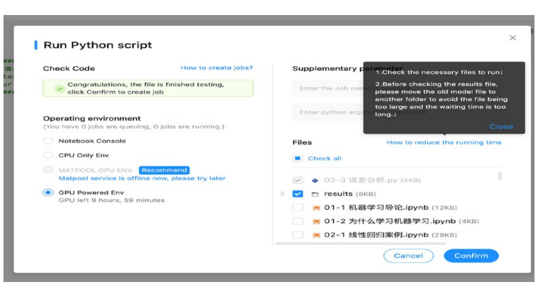

Figure 4. GPU support

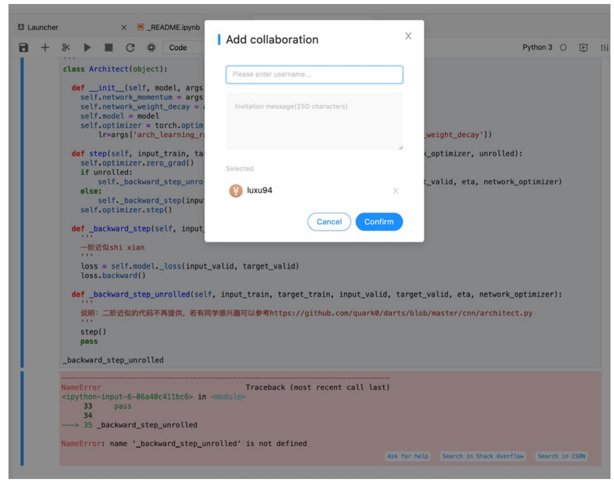

Figure 5. Collaboration in the Notebook

- **Collaboration**: Mo provides a number of tools for collaboration. For example, once there is an error in coding, students can ask for others to help (Figure 5).

In additon to these, there are some other features integrated ino the Jupyter environment, including easy model deployment, code sharing, module reuse, document integration, etc.

Sharing and Community Support

The Mo platform supports active online communities for AI teachers and learners, not just from K-12 schools, but also from other parties such as the universities and developers. They can share and collaborate on the platform.

There are multiple channels of communication and collaboration, including a forum for question and help (similar to Stackoverflow), discussion group, and collaboration in the classroom, as shown in Figure 6.

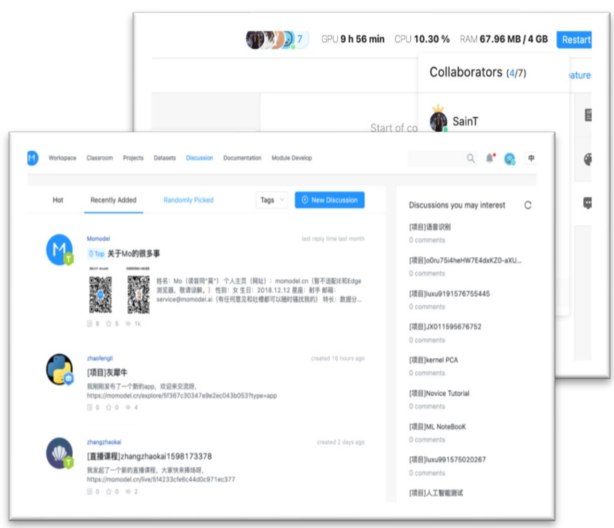

Figure 6. User communities on Mo

Figure 7. Online live broadcasting

The communities can also carry out online and offline activities regularly, such as offline experience sharing and online live broadcasting (Figure 7).

Crowdsourcing of Educational Resources

A key feature of the Mo platform is the support of the crowdsourcing of educational resources. Many learning materials and organizations of them were contributed by the users. For example, there was an AI textbook published in 2019 for senior middle schools in Zhejiang. While the textbook's content is fixed, the supplementary learning materials (such as datasets, explanatory figures, supportive further reading, code for illustration, and exercises) were continuously added to Mo by users who were school teachers. In this way, the platform facilities the accumulating and sharing of teaching resources among K-12 schools.

Exercises and Evaluation Support

Mo provides a set of exercises and tests, along with associated datasets. The automatic scoring function is also provided so that students can easily evaluate their performance during AI education.

Playful Experimentation

For many students, especially students with rare programming experiences, it's better to demonstrate AI applications firstly before getting into details. Therefore, the Mo platform provides a portal of playful experiments to try different AI applications, to train critical thinking and problem-solving capability, and to arouse students' interests (Figure 8). If the students have such a learning desire, they can then dive into implementation details in Notebook.

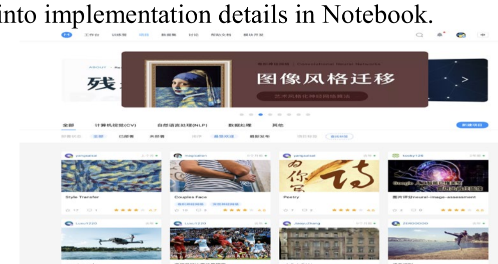

Figure 8. Playful experiments

In summary, we believe that the Mo platform provides an affordable, rapid, and elastic way to fill in the two gaps mentioned above. For the first gap, the platform provides effective channels for accumulating and transferring educational resources from AI researchers, teachers, and developers to K-12 education. The learning environment and learning experience are optimized for the K-12 context, and it's easy to use for K-12 teachers and students. For the second gap, various educational resources including computational resources can be shared within the country. This is crucial for those from less developed areas. In addition, this kind of Web-based online platform is particularly desired in the current Covid-19 pandemic period, which may last for several years.

Evaluation and Case Studies

The Mo platform was initiated in 2017 and has now become a comprehensive AI education platform and a focal point of various K-12 AI actors (including educators, students, education nonprofits, and industry collaborators) and resources. The platform is now being involved in many efforts of promoting K-12 AI education in China. In this section, we present the current progress of deploying the platform in different sectors of K-12, and the evaluation results of its usage.

Senior High Schools

Zhejiang province launched its first AI textbook for over 600 senior high schools in 2019 and started a large-scale AI education within these schools. Although Zhejiang is a developed province in China, it still suffers the issue of inequal development. Only a few teachers from several top schools are capable to conduct AI courses. To solve this problem, we, along with the Department of Education of Zhejiang Province, launched a series of training activities on the platform, including three training programs for high school teachers since January 2020. We also developed an online version of the textbook, teacher training materials, project guides, assessments, and standards, and distributed them on the platform. After trials of using the platform in online/offline classrooms, the results and feedback from 113 teachers and 482 students are positive: over 73% of AI course teachers are now familiar with the necessary knowledge of AI. 82% of students feel the platform can help them perform better in the classroom. 86% of teachers and 75% of students believe they can get valuable educational resources and experiences from other users on the platform (especially from those senior teachers). Figure 9 shows one of the trail lectures in one senior high school with the platform.

In this next phase, we plan to migrate the resources and experiences from Zhejiang to other provinces in China, especially those less developed areas.

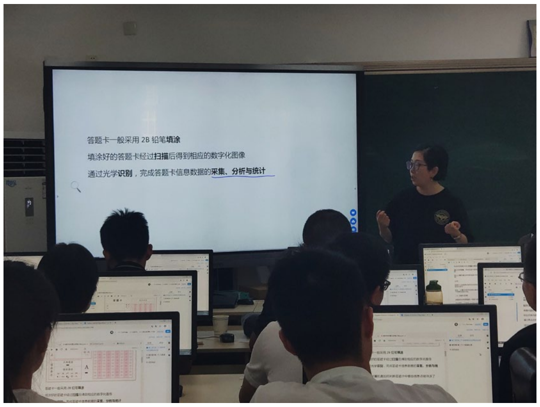

Figure 9. Trial lecture in senior high school.

Vocational High Schools

The second trial is in vocational high school. Vocational high schools aim to prepare their students for specific vocations. AI education is helpful to promote their future opportunity in careers. The challenge is that students in vocational high schools normally have less knowledge about Math and other subjects, compared with other high school students. Therefore, we adopted the playful experiment portal described before and designed a specific curriculum based on that[6], as shown in Figure 10. It emphasizes the application scenarios of AI. Students can firstly understand these applications, and then try to change the parameters of models to understand the essential ideas of model training intuitionally. Students can dive into the implementation details of the model if they are interested.

Since it launched in 2019, over 15,000 students have rolled in this course with positive feedback, and it's now being promoted to other vocational high schools on a nationwide scale.

Primary and Secondary Schools

We are also working on designing AI courses for primary and secondary schools, and have done some trials. We designed a one-hour short course on the platform based on a customized MNIST experiment, which lets the students understand the limitations of manual programming and how machine learning can eliminate these limitations. More than 20,000 students, teachers, and parents joined this trial course and gave us very positive feedback.

In addition to these efforts, there were many other activities during the past two years, including over 500 hours of online lectures, AI competitions, etc. These activities helped the students and educators to form AI education communities, especially during the Covid-19 pandemic period.

Figure 10. Playful experiment.

Feedback and User Survey

To evaluate the effects of the platform in helping the implementation of K-12 AI education, we conducted multiple user surveys on the platform. Table 1 shows the main feedback from both teachers and students.

As we can see, the feedback from both teachers and students is quite positive. Users also gave us some concrete comments about the platform, here are some examples:

	Questions	Yes	No
Teachers (212 people)	Do you think the Web-based form of teaching can help AI education?	197	15
	Do you think the educational resources provided by the platform help?	206	6
	Are you able to use the platform easily?	193	19
	Is your teaching level promoted after using this platform?	199	13
Students (274 people)	Is it easy to get familiar with the Notebook environment?	225	49
	Can you get help easily on the platform?	248	26
	Do you think the community helps?	245	29
	Do you feel the platform is useful in learning AI?	251	23

Table 1. User survey feedback (n=486)

[6] An example can be found here: https://momodel.cn/learn/license_plate_recognition

"The online learning environment is easy-to-use for me and my students…. I used to teach VisualBasic in my school. When I started to teach AI with python, my students and I spent a lot of time to set up and manage the necessary libraries. But with Mo platform, we don't need to care about this, and are now more concentrating on the essential teaching."

-- from a senior high school teacher.

"The curriculums provided on the platform is well designed, with interesting case studies... And I can get help from other users, making the AI not so difficult!"

-- from a senior high school student.

"I used Mo platform in my classroom and asked my students to use their browsers and follow my instruction to do experiments. The experience was good, and most students can run and even change some settings within 40 minutes class, which was impossible before."

-- from a junior high school teacher.

AI Ability Valuation

We also evaluated the users' AI ability and interest level before and after using our platform. For AI ability, we designed a quiz about the basic AI knowledge (with four categories: AI basic knowledge, machine learning concepts, AI application knowledge, and understanding of classic AI models). We asked users to complete when they registered on the platform, and after they completed the courses on the platform, we asked them to complete another quiz (with the same knowledge level). Over 1800 junior high school students participated in this evaluation. Figure 11 shows the result, which indicates users' ability and understanding of AI improves after using the platform.

At the end of the quiz, we also ask the users how they are interested in AI learning. Before using the platform, about 82% of students stated they are interested, and after using the platform, the proportion increased to 93%.

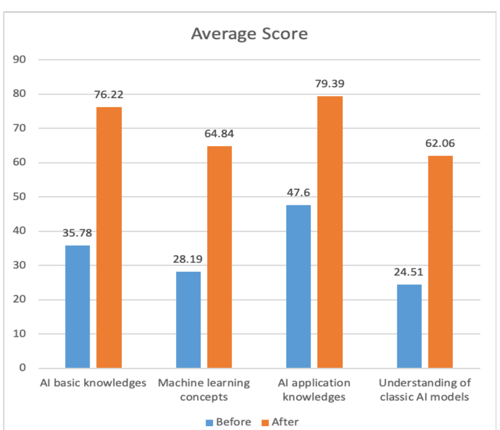

Figure 11. The average quiz scores of users before and after using the platform.

To summarize, although the platform is still in its early stage, it has shown its powerful capability to support scalable K-12 AI education, and the pilot studies show its potential to be promoted to the nationwide context.

Conclusion

In conclusion, in this work we identify the challenges of AI education for K-12 schools as two significant gaps, one is between university AI education and K-12 AI education, and the other is about the inequal distribution of AI educational resources. To fill these two gaps, we proposed and designed a Web-based platform named Mo, as a focal point to share various educational resources. The initial practices showed positive results and potential power for wider deployment.

Several works are planned as future works. Firstly, we would like to further promote the platform to more schools in different provinces or even outside China, and collect more data and feedback to further improve the platform. Secondly, based on the previous experience and evaluation results, we are designing the optimal pathway of AI educations for different K-12 sectors. Thirdly, we are designing the mobile version of the platform to make it even more accessible.

Acknowledgments

This work was supported by the National Key Research and Development Project of China, National Natural Science Foundation of China (U19B2042), Fundamental Research Funds for the Central Universities, Artificial Intelligence Research Foundation of Baidu Inc., Zhejiang University and Cybervein Joint Research Lab, Zhejiang Natural Science Foundation (LY19F020051), Program of ZJU and Tongdun Joint Research Lab, CAS Earth Science Research Project(XDA19020104), and Social experimental research on AI empowering education (2019AAA0105403).

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