Personalized Hands-on Training Via a Hybrid Intelligent Teacher System

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Abstract: In this paper, we propose a student-centered hybrid intelligent teacher system, and show how this system advances in a case study in teaching robotics. The key innovation of this system is to focus on the combination of a human teacher and a cloud teacher, which is a textual-based conversational agent for answering the questions from students in Mechanical Engineering via machine learning technologies. The basic underlying idea is to train the agent by utilizing open-source artificial intelligence tools from Google's DeepMind, such that the agent can understand and answer the questions raised by students with an acceptable confidence value. Specifically, it is expected to customize a training database combining VEX hardware assembling, Auduino and Solidworks programming. Moreover, Big Data Analytics can be conducted accordingly based on students' historical questions. An Android-based mobile application is produced. As a result, students can raise their questions conveniently and get instantaneous feedback with a 24-7 service. The method has demonstrated its effectiveness in a university general education course (UGEB2303 Robots in Action).

Keywords: Personalized education, Chatbot development, Big data analytics, Robotics teaching

1. Introduction

Nowadays, technology in education is playing a growingly essential role in teaching and learning. Many studies have demonstrated that machines perform better in modern education than human teachers in certain areas, like automatic assessment, functional chatting services, and big data analysis (Selwyn, N., 2019). Technology in education is expected to bring fundamental changes to the relationship between students and teachers, and to promote learning outputs.

Still, it is important to note that technology is a tool used in education and not an end in itself. The promise of educational technology lies in what educators do with it and how it is used to best support their students' needs. Although machines surpass human teachers in some specific tasks, they need to be carefully placed by their designer (Wajcman, J., 2017). Thus, an optimal teaching and learning system relies on an elegant collaboration of technologies, their designer, and the executor.

2. Hybrid Intelligent Teacher System

2.1 System Description and Main Component

As a teacher of engineering, I firmly believe in a superlative combination of teacher and technology, which enables students to take a more active role in learning, interacting with their peers, and creatively making their contributions to society. Based on the Johnson's Technology Integration Model (Johnson, D. L., and Liu, L., 2000) and the Technology Team-Teaching Model (Jong, J. S., 2008), a student-centered hybrid teacher system is innovatively developed with students as the centre (see Figure 1)

In the proposed system, the following features are worth clarifying:

- **Human teacher**: A real person helps students acquire knowledge and competence effectively and efficiently. S/he could develop or apply various educational technologies and devices to accelerate students' learning. The role of a teacher can go beyond teaching, such as being a counsellor, mentor, role model, and so on. His/Her basic functions include: 1) Design and manage the cloud teacher; 2) Maintain a desirable relationship between students and the cloud teacher; 3) Breed curiosity and cultivate creativity; 4) Provide nuanced feedback; 5) Expedite students' access to innovations, knowledge, experience, peers, and community; and 6) Supply humanistic care such as empathy, trust, inspiration, and encouragement.
- **Cloud teacher**: The instrumental element or educational technologies could be any format of carriers that facilitate teaching and learning, bringing cause-effect results through its implementations in the system. Basic features of the cloud teacher include: 1) 24/7 functional Q&A service to students; 2) Big data analysis for individualized education (hence, precision education) (Zhang, K., and Ayse, B. A., 2021); 3) Accessible and online experiential training; 4) Automatic assessment and invigilation; 5) Intelligent teaching assistance based on robots and AI; and 6) Related software like APPs, websites, micro-modules, or integration with hardware.
- **Collaboration** between human teacher and cloud teacher in a hybrid mode: 1) Human teacher designs and manages cloud teacher; 2) Cloud teacher gives human teacher a better way of teaching and learning in various aspects, like automatic and formative assessments; 3) Cloud teacher is able to establish students' profiling and helps human teacher in making predictions and course preparation; 4) Cloud teacher analyzes students' on-the-spot inputs, and provides instant feedback to human teacher, who can give timely interventions to students; 5) Cloud teacher saves time and energy of human teacher such that s/he can perform more effectively; 6) Human teacher fine-tunes cloud teacher based on user experience and feedbacks.

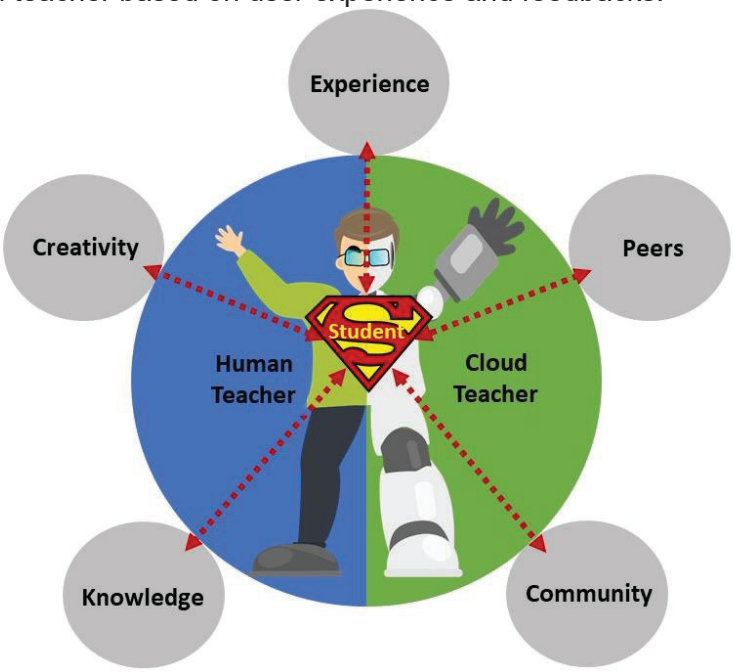

Figure 1: A diagram of the student-centered hybrid intelligent teacher system

- **Creativity**: The capacity of students to produce original ideas or objects. The created item may be intangible (such as an idea, a scientific theory, a musical composition, or a joke) or a physical object (such as an invention, a printed literary work, or a painting).
- **Experience**: Personal reflection or skills students learn by doing. Acquisition of experience entails a hands-on approach to learning. It makes learning an experience that moves beyond the classroom and strives to bring a more involved way of learning (Vosniadou, S., and Brewer, W. F., 1987).

- **Knowledge**: It is the combination of data and information, in addition to expert opinion, skills, and apprehension, which results in a valuable asset that aids decision making.
- **Peers**: A social group of people with similar background, social status and learning objectives. Members of the group are likely to influence each other's beliefs, behavior and learning efficiency (Scardamalia, M., and Bereiter, C., 1994).
- **Community:** A group of people who share common academic goals, and collaborate on learning materials. In a learning community, the goal is to advance collective knowledge, and meanwhile, support the growth of individual knowledge (Martin Nunezi, J. L., and Lantada, A. D., 2020).

2.2 The goal of Hybrid Intelligent Teacher System

The main idea of this system is to take advantages of both human teacher and cloud teacher to maximize students' learning outcomes. Our efforts are devoted to achieving the following objectives:

- to boost students' self-motivation, engagement, curiosity and passion for learning;
- to bridge the gap amongst knowledge, creativity, and real implementations;
- to establish an ecosystem for multi-dimensional theoretical and experiential peer learning with individual-to-individual, individual-to-group, group-to-group learning;
- to enhance learning outcomes and train passionate professionals who can contribute to the community and society.

The effectiveness of this system will be illustrated by a real case study in teaching robotics in the following section.

3. Individualized Hands-on Training in Computer Programming

3.1 Chatbot Development for Arduino Programming in Teaching Robotics

We have built a "cloud teacher", which is a *textual-based conversational agent* for answering questions from students in Mechanical Engineering via machine learning technologies. The main idea is to train the agent by utilizing open-source artificial intelligence tools from Google's DeepMind, such that the agent can understand and answer questions raised by students with an acceptable confidence value (Figure 2). In addition, the answers with associated confidence value will be reviewed by a panel of teachers in Mechanical Engineering while further training on the agent could be launched based on review results. *Big Data Analytics* can be conducted accordingly based on students' historical questions, and prescribed teaching can be provided. Specifically, different reading references and exercise quiz questions will be provided according to students' historical questions. In this way, personalized hands-on training materials are obtained such that each student could learn the computer language Arduino in a suitable way.

We combined the cloud teacher with the flipped online laboratory in teaching robotics (General Education Course UGEB2303 Robots in Action in the academic year 2020-2021, 2021-2022, and 2021-2023, 30 students per a semester).

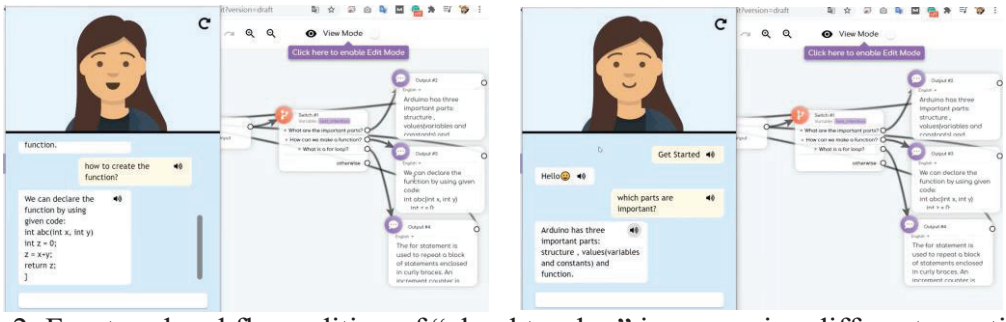

Figure 2: Front-end and flow editing of "cloud teacher" in answering different questions for Arduino programming

3.2 Impact on Teaching and Learning

To show the positive influence on the hands-on learning, we have conducted the following methods as evaluation plan:

a) Survey on the online laboratory learning experience towards the end of the course UGEB2303.
b) Survey on the user-experience on the conversational intelligent agent towards the end of the course UGEB2303.
c) Focus group interview with a small group of volunteer students of the courses UGEB2303.
d) Feedbacks and discussions from course website of UGEB2303 and small group forum.
e) Weekly reflection meetings with technicians and student helpers to monitor the progress and propose future developments and improvements.
f) Presentation of the project and summarized feedbacks at seminars and conferences.

The monitoring data have been collected by the evaluation methods above and illustrates the usefulness of this work:

a) The results of feedback from students have been collected. Rate of positive feedback is 83.3% (25/30) in the Survey on the online laboratory learning experience for the course UGEB2303.
b) Rate of positive feedback is 77.4% in the Survey on the user-experience with the conversational intelligent agent towards the end of the courses UGEB2303.

The following table shows the elevated learning outcome of UGEB2303 by using the proposed method. It provides 21.2%, 33.8%, and 11% boost of performance in Quiz1, Quiz2 and Final project.

Table 1. *Impact on the Learning Outcomes in UGEB2303 Robots in Actions*

	Quiz1	Quiz2	Final Project
UGEB2303 in 2019-20 without the hybrid teacher system	9.72/15	9.13/15	34.79/50
UGEB2303 in 2022-23 with the hybrid teacher system	11.78/15	12.22/15	38.62/50

3.3 Influence and Sustainability of this Work

The ability of programming with C, MATLAB and Arduino is assumed and required in a wide range of courses across different engineering programmes. The developed mobile app can be used directly in these courses such that the course instructors do not need to review or re-teach basic computer programming. The general approach of AI-powered conversational agent can also be explored in other subject areas across different faculties for sustaining effective virtual teaching and learning in the new normal.

a) Impact in the Department of Mechanical and Automation Engineering: Besides the course UGEB2303 that already adopted the cloud teacher, more colleagues and courses will try the innovative pedagogy in the coming semester, including some courses in the same department: MAEG3080 (expected 30 students) and EEEN2020 (expected 40 students).
b) Impact in the Faculty of Engineering: Some Faculty foundation courses with computer language programming training would adopt this pedagogy, like programming with C, MATLAB, SolidWork, etc. ENGG1110 Problem Solving By Programming will be one of the first Faculty foundation course adopt this method in the following semester.

c) Local impact in Hong Kong: The Center for Artificial intelligence Research (CAiRe), Hong Kong University of Science and Technology, displayed interests in implementation of the developed cloud teacher in some courses for possible collaboration.
d) Impact worldwide: Based on the developed cloud teacher, we further collaborate with Cardiff Metropolitan University and made a proposal together called “AI-assisted Automated assessment system for remote robot laboratory platform”.
e) Prize received: Poster Silver Award – Pedagogical Innovation in CUHK Teaching and Learning Innovation Expo.

4. Conclusion

A student-centered hybrid intelligent teacher system is proposed and illustrated in this paper. It shows how this system displays its advantages in teaching robotics. The key innovation of this system is to fuse a human teacher and a cloud teacher, which is a textual-based conversational agent for answering the questions from students in *Mechanical Engineering* via machine learning technologies. The basic underlying idea is to train the agent by utilizing open-source artificial intelligence tools from Google’s DeepMind, such that the agent can understand and answer the questions raised by students with an acceptable confidence value. Specifically, it is expected to customize a training database combining VEX hardware assembling, Auduino and Solidworks programming. Moreover, *Big Data Analytics* can be conducted accordingly based on students’ historical questions. An Android-based mobile application is produced. As a result, students can raise their questions conveniently and get instantaneous feedback with a 24-7 service. The effectiveness of this method is given by a case study in a university general education course.

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