IMPLICATIONS OF PROJECT-BASED LEARNING FOR THE DEVELOPMENT OF AUTONOMOUS TECHNOLOGY

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Abstract

Hong Kong has been promoting the use of electric vehicles (EVs) since early 2010. Based on information from the Hong Kong Environmental Protection Department (EPD), there were 49,005 EVs registered in Hong Kong as of January 2023, which is a significant increase from just 100 in December 2010. However, the growth rate of installed EV chargers and charging stations in Hong Kong lags. Additionally, the lack of charging infrastructure is a major hurdle for EV adoption, particularly in the densely populated urban areas of Hong Kong. Therefore, Hong Kong Vocational Training Council and their industry partner – Totex International Limited have collaborated on a research project aimed at developing an automatic mobile EV charger platform to provide charging services for EVs. Collaboration with institutions and industrial organizations is an important aspect of education and research learning. Furthermore, collaboration between institutions and industry has many benefits, it can provide students with opportunities to work on real-world projects and gain practical skills. Provide students and institutions with networking opportunities and connections that can lead to internship and job opportunities.

The development of autonomous mobile EV chargers has provided opportunities and coached to Higher Diploma students via Project-Based Learning (PBL) program. This research project provided opportunities for students to carry out Final Year Projects and Industrial Attachments with themes relevant to their current study. Engineering students can get involved in different phases of background research, design and development as well as testing and commissioning of the mobile EV charger. The autonomous mobile EV charger platform provides a fully automatic EV charging service to the user. In addition, it can automatically connect through the recharging station to a typical power outlet. The autonomous mobile EV charger was equipped with different types of sensors and it can automatically move to the designated location through Simultaneous Localisation and Mapping (SLAM). Integrating the signal from a 3D camera and lidar, SLAM enables to create of a location map and determines the wanted position. Furthermore, a smartphone app was developed and coupled with IoT hardware to provide real-time monitoring and the current status of the mobile EV charger. This collaboration project emphasizes the provision of PBL opportunities by exposing students early to the world of work, thereby nurturing work-ready graduates. The success of the collaboration project was founded on strong learning and teaching outcomes in Higher Diploma Engineering education touching on key industries driving economic growth in Hong Kong.

Keywords: *Project-based learning (PBL), Technical education, Mobile charging technology, Autonomous, Electric vehicles*

Introduction

In response to global climate change, the Government of the Hong Kong Special Administrative Region announced the Hong Kong Roadmap on Popularisation of Electric Vehicles (EVs) in March 2021. The Roadmap setting out the long-term policy objectives and plans to promote the

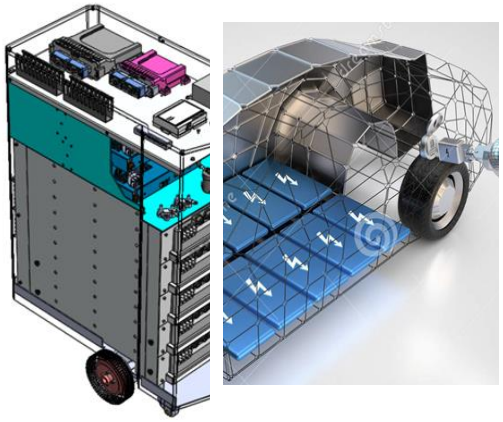
adoption of electric vehicles in Hong Kong. Expand the EV charging network, promote trials for electric public transport, and promote education and training on EV maintenance to drive the popularisation of EVs and to achieve carbon neutrality before 2050 (The Environment Bureau of the Government of the Hong Kong Special Administrative Region, 2021). According to the Hong Kong Environmental Protection Department (EPD), there were only 100 pure battery EVs in December 2010. The number increased by nearly 500 times to over 49,005 in 2023, representing about 5.3% of the total number of vehicles (Environmental Protection Department of the Government of the Hong Kong Special Administrative Region, 2023). However, the growth rate of installed EV chargers and charging facilities in Hong Kong lags. Based on the information provided by the EPD, there are 3,981 EV chargers for public use including 2,981 medium chargers (≤ 20kW) and 998 quick chargers (> 20kW) installed in Hong Kong and covering all 18 districts in various types of buildings (Environmental Protection Department of the Government of the Hong Kong Special Administrative Region, 2023). The lack of EV charging facilities has become a prime issue to promote EVs. Therefore, Jockey Club Heavy Vehicle Emissions Testing and Research Centre (JCEC) of the Hong Kong Institute of Vocational Education (IVE) Engineering Discipline and their industry partner – Totex International Limited have collaborated on a research project aimed at developing an autonomous mobile EV charger platform to provide a fully automatic charging service for EVs. The project features collaborative teaching and learning where the industry partner and institution supervisors work together to provide opportunities and coached Higher Diploma students via Project-Based Learning (PBL) program.

Vocational Training Council (VTC) was established in February 1982 under the Vocational Training Council Ordinance to provide quality Vocational and Professional Education and Training (VPET) in Hong Kong. VTC encourages teaching and learning with the engagement of industry exposure and in a Project-based environment to encounter complex systems and processes in a competitive environment. In addition, VTC emphasizes the provision of PBL opportunities by exposing students early to the world of work, thereby nurturing work-ready graduates. Since 2021, the industry collaboration PBL project has been established to focus on the development of an automatic EV mobile charger platform. The project team aims to develop an autonomous mobile EV charger to provide a fully automatic EV charging service to EV owners and an opportunity for future smart mobility development in Hong Kong. Furthermore, educating students is one of the core values of the PBL project. It can provide students with board-based engineering knowledge, skills, and value that are essential in the workplace. The PBL project also provides students with an opportunity to apply theoretical knowledge acquired from lectures to the workplace, gain hands-on experience, and encourage students to think outside the box and develop collaboration and communication skills. PBL is designed to be engaging and relevant to students, which can increase their motivation and engagement in the learning process, thus leading students to understand new technologies and practice engineering skills.

Industry Collaboration

Since 2021, the autonomous mobile EV charger PBL project has been established by JCEC and their industry partner – Totex International Limited. The core value of the autonomous mobile EV charger PBL project is to increase students learning outcomes and equip students with professional knowledge and practical skills. The project team consists of professional engineers, teachers, and Higher Diploma students from Mechanical Engineering and Electrical Engineering working together and aims to design and develop a fully automatic EV mobile charger platform for EV charging services (Figure 1). Students are inspired and make use of design thinking to design an innovative and sustainable mobile charger. The mobile EV charger PBL project is enhancing work-based learning by infusing industry collaboration into the core curriculum. Students focused on the works tasks set out by real industry partners in an authentic context, including through real interactions with industry partners, tackling challenges of the projects, and achieving the target progressively in a real-world context. Furthermore, students engaged with this work integrated learning to output designs by using autopilot and machine vision technology, the mobile charger automatically moves to the designated parking space and identifies the position of the vehicle charging socket for charging. When the process of charging is completed, the mobile charger will automatically return to the charging station and recharge its own

battery with a 220V/13A AC supply (Figure 2).



a. Mobile EV charging platform

b. Auto plugin to the EV charging socket

Figure 1: Autonomous mobile charging platform for electric vehicles.

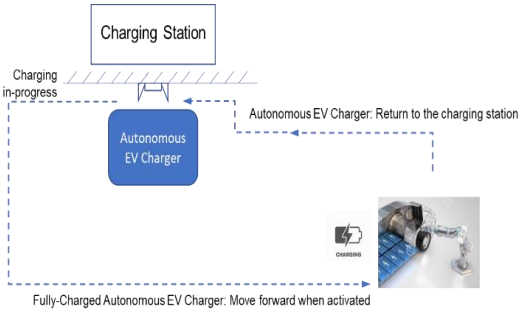


Figure 2: Autonomous mobile EV charger process flow within car park range.

Engagement with industry partners is the critical factor for the success of the PBL project, including the student Industrial Attachments scheme and student Final Year Projects. Also, they are considered a valuable learning experience by academics, students, and employees of the host organizations. First of all, students can apply the knowledge gained from school lectures, tutorials, and laboratories to design and develop the mobile EV charger. Also, students can get the opportunity to work on real-world projects, to gain knowledge and experience through background research, experiment, data analysis, and application of findings to different challenges. The PBL project challenges students to think critically about complex problems and to create possible solutions. This can help students to develop problem-solving skills that are essential for success in the real-world. These experiences also broaden their view in terms of problem-solving, design concepts, and technology application, thus students' self-confidence was highly enhanced. In addition, the PBL project requires students to work in teams, which helps them to develop collaboration and communication skills. This is particularly important in today's workforce, where teamwork and communication are essential. Furthermore, PBL was examined for increasing students' interest, self-confidence, and self-efficacy, which was highly related to the core elements of the autonomous mobile EV charger PBL project such as collaborations in group work, time management, and contextual problems reflecting students' real-world experiences (Baran & Maskan, 2010). PBL project showed positive attitudes toward learning itself, team communication, and collaborative behaviour which were discussed in the literature. Cheung et al. (Cheung, Chow, & Chiu, 2016) evaluated the design thinking process and adopted to the team operation. The process is divided into five stages, including Empathize, define, ideate, prototype, and test. As a result, it is without doubt that the PBL project has positively enhanced students' extra-curricular performances. Students are involved in the industry collaboration project and are motivated to learn and develop theoretical knowledge and hands-on experience. PBL projects also provided an opportunity for students to develop new skills and enhance professional engineering knowledge, which can help them to accommodate different learning style and allows for more personalized learning experiences.

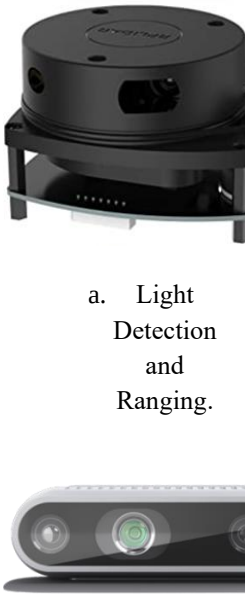
Knowledge transfer

The project team of the autonomous mobile EV charger PBL project was formed by professional engineers, teachers, and Higher Diploma students from Mechanical Engineering and Electrical Engineering working together to develop a fully automatic mobile charger and to impel the knowledge transfer. Students are encouraged to participate in the PBL project because there are many benefits that they can get in the real-life work environment. Students participated in the project with an opportunity to acquire professional competence and practical experience in real-life work environments from industry partners. Furthermore, students have the opportunity to apply theory learned in the classroom, including

mechanical engineering and electrical engineering to design and fabricate the mobile EV charger to pursue smart city development in Hong Kong.

To impel the transfer of knowledge, Mechanical Engineering students are mainly responsible for the mechanical design of EV chargers and the mechanism of a robot arm. For the mechanical design of the EV charger, students need to apply their mechanical knowledge gained from the courses "Mechanical Engineering Design" and "Mechanics of Materials", to consider the mechanical structure and the selection of adequate materials that are appropriate to the application of mobile EV charger. In addition, the mechanism of a robot arm is to position the EV charging plug into the charging socket of the target EV. As shown in Figure 3, the robot arm integrated with machine vision technology and artificial intelligence technology to assist the EV charger to locate and identify the EV's charging socket position in terms of X, Y, Z, and angle position. Mechanical Engineering students transfer the sensing technology acquired from the course "Automation" to improve the accuracy of the robot arm. The sensing technology including Light Detection and Ranging (LiDAR), Radar, Ultra-sounds and Infra-red was developed and integrated in the mobile EV charger (Figure 4). On the other hand, Electrical Engineering students are responsible for the design of electrical systems and automation navigation systems. Students have the opportunity to apply the battery management system (BMS) technology learned from the course "Electrical Power Systems" for the battery system of EV chargers. The BMS technology managed and monitored the status of the rechargeable battery installed inside the EV charger. Also, the BMS is used to protect the battery from operating outside its safe operating area, monitoring the battery state and balancing between each battery. For the automation navigation system, students applied system navigation knowledge from the course "Control and Automation Systems" for path planning, environment perception, and system control of the EV charger. In addition to the knowledge transfer from the classroom into the EV charger PBL project, VTC encourages students to thrive in various fields and further contribute to the industry and society. Therefore, the project team has coached a number of students in participating in various competitions, including ROBOCON and WorldSkills. The ROBOCON and WorldSkills Competition provided an excellent platform for students over the world to compare notes and exchange their professional skills. Students overcome the challenges and showcase their talents in the international arena.

Figure 3: Robot arm for charging plug insertion.



a. Light Detection and Ranging.

b. Intel Real-sense.

Figure 4: Sensing technologies of the robot arm.

Conclusions

In conclusion, the autonomous mobile EV charger PBL project provided opportunities and coached Higher Diploma students in Mechanical Engineering and Electrical Engineering. The PBL program not only enhances the professional knowledge and technical skills of students but also enriches their employability skills, including teamwork, leadership, presentation and communication skills, time management, and abilities to problem-solve and persuade. In addition, Students have the opportunity to put theory into practice and to be involved in the skills competition to explore their strengths and skills.

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Definitions and Abbreviations

BMS	Battery Management System
EPD	Environmental Protection Department
EV	Electric Vehicle
IVE	Institute of Vocational Education
JCEC	Jockey Club Heavy Vehicle Emissions Testing and Research Centre
LiDAR	Light Detection and Ranging
PBL	Project-Based Learning
SLAM	Simultaneous Localisation and Mapping
VPET	Vocational and Professional Education and Training
VTC	Vocational Training Council

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