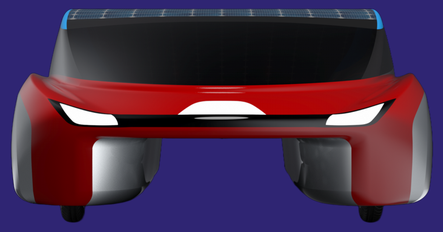
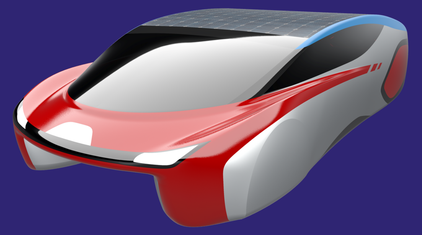
TECHNOLOGICAL AND ENGINEERING LITERACY IN SOPHIE PROJECT: NOVEL TEACHING IDEAS





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Abstract

Education in technological and engineering literacy has never been more necessary for students to face future challenges. This trend drives the college to equip students with a broad conceptual understanding of technology and its place in society, transforming them into technological and engineering literate, who are expected as active participants in the technological world, careful creators and users of technology, to meet the requirements of the future employment market. The present paper studied the effectiveness and effect of delivering technological and engineering literacy to students by participating in the 'SOPHIE' project – a tertiary engineering students project in which multi-disciplinary students from different backgrounds, work as a team to design, engineer, and build solar-powered electric vehicles to take part in the world's biggest and most prestigious solar car competition, The Bridgestone World Solar Challenge (WSC). With the era of Education 4.0, students involved in the project practice their organizational, collaborative, and project management skills through the hands-on real-world experience of creating a solar car among energy, automotive, engineering, material sciences, and IT sectors.

This research examined, analysed and evaluated the indirect measurement data collected from the Evaluation of Student's Performance (ESP), and the Survey of Employer's Views on the graduated student participants (API) conducted by the 'SOPHIE' project mentors. It also revealed that the technological and engineering literacy of the students, who participated in the 'SOPHIE' solar car project, was significantly enhanced in terms of knowledge and techniques application, problem identification and solving, time and quality commitment, communication and collaboration, self-directed continuing professional development, and professional and ethical responsibilities. Students' participation in the SOPHIE solar car project enables them to practice technological and engineering literacy; this experience aided them to adapt well to the workplace in the future and to apply their engineering knowledge, techniques, and skills to develop future technologies.

Introduction

The research examined the effectiveness and effect of delivering technological and engineering literacy using the indirect measurement data collected from ESP among 51 participants in the solar car project at IVE from the Academic Year 2018 – 2019 (AY18/19) to the Academic Year 2021 – 2022 (AY21/22). It also studied the influence on the working performance using the indirect measurement data, the API calculated from the Survey of Employer's Views, among the 29 graduates who were involved in the VTC solar car project during the period. Data in ESP and API were set up according to the Graduate Attributes (GAs) from the Hong Kong Institution of Engineers (HKIE), the professional body of engineers in Hong Kong.

Capstone Engineering Project and Project-based Learning

The Vocational Training Council (VTC) solar car project is one of the flagship projects under the Industrial Attachment & Industrial-Based Student Project (IA-IBSP) Scheme of the Engineering Discipline, Hong Kong Institute of Vocational Education (IVE). The scheme is a work-based experience scheme provided by the IVE Engineering Discipline for its final-year students. It usually takes place during the final semester of the students to let them work related to a project in the field of engineering for developing their specific or generic skills in reality and adding value to their professional development.

Regarding the purpose of the IA-IBSP scheme, it allows students to integrate and apply the knowledge they have learnt from their study, and to identify and learn new knowledge required for working in the project. It helps develop students' social connections between learning communities (student-to-student and student-to-discipline), shape students' identities as future engineers, and enhance student retention.

With the project-based learning approach of a capstone engineering project, VTC solar car project exposes student participants to a series of practical tools and methods, assisting them in constructing new knowledge, understanding and skills when building a new solar car. The construction of a solar car and the WSC included in the VTC solar car project make it works like a capstone engineering project that incorporates real-life challenges that focus on authentic problems or questions whose solutions are potentially implemented.

Technological and Engineering Literacy

Hoepfl (2020) defined that literacy in any field represents knowledge and/or competence in a specific area. The literacy that this paper focuses on is literacy in technology and literacy in engineering. Technological literacy is the ability to use, manage, evaluate, and understand technology. It focuses more on the products or outcomes of the engineering process and the relationship between technology and society, while engineering literacy focuses more on understanding the process of creating or designing technological artefacts or systems. Since technological literacy and engineering literacy are only slightly different and they are extremely closely related, the wording 'technological and engineering literacy' is used to refer to the capacity to use, understand, and evaluate technology and to understand technological principles and strategies which are required for solution development and goal achievement.

The present paper studied the performance enhancement of the student participants in terms of the following aspects drawn in National Assessment Governing Board (2018):

· Knowledge and techniques application
· Problem identification and solving
· Time and quality commitment
· Communication and collaboration
· Self-directed continuing professional development
· Professional and ethical responsibilities

Target Student Group

The VTC solar car project is operated by teaching staff and a group of students in the final year of their High Diploma program in the IVE Engineering Discipline. The project was established in 2009 with the aim of supporting the initiatives of green transportation by building its self-developed solar car, SOPHIE. After several generations of evolution, the solar car team has developed its solar-powered electric vehicles ranging from SOPHIE I to SOPHIE VI, SOPHIE 6s and SOPHIE 8 and has obtained many remarkable achievements in the international arena. To further demonstrate the possibility of green transportation and enable students to gain experience in international competition, the team has started connecting with WSC, the world's leading solar car competition held in Australia every two years, since 2013 with its SOPHIE IV.

Through the race, teams are challenged to design, engineer, and build their own solar-powered electric vehicle according to the event regulations and enter their car into one of the three classes, including challenger class, cruiser class, and adventure class, to race over 3000km across the Australian outback from Darwin in Northern Territory to Adelaide in South Australia within six days. Therefore, the VTC solar car project sets every two years as the project cycle for the team to develop a new solar-powered electric vehicle and participate in the WSC.

Figure 1 - SOPHIE IV in Adventure Calss of WSC 2013

Figure 2 - SOPHIE V in Cruiser Class of WSC 2015

Figure 3 – SOPHIE VI in Cruiser Class of WSC 2017

Figure 4 – SOPHIE 6s in Cruiser Class of WSC 2019

From the preparation and construction of the solar car to the race in WSC, the student participants face different challenges, such as interdisciplinary knowledge, hands-on science and engineering skills, self-directed learning and innovative thinking. This helps develop students' collaboration, management and innovation abilities and prepares them for unknown future careers and increasingly complex professional environments. With the rapid growth of the students in the engineering culture through their participation, the project always starts as a challenge for students and ends as a task for scientists and engineers better prepared by their nature.

Since the solar car project is the IA-IBSP of the final year students in IVE Engineering Discipline, students play lead roles in the project to develop the new SOPHIE. At the same time, the teaching staff acts as the project management team and their project mentors, providing advice and administrative support to students and the project and ensuring that the project remains on track.

Students typically participate in the solar car project for one year, as student helpers for the first half of the year, and as team members for the second half. If students have an outstanding performance during their participation, they may also be invited to be the advisors after graduation from their Higher Diploma program to provide students with technical support and experience sharing. This practice ensures that design knowledge, hands-on skills, and experience can transfer from year to year and to enable SOPHIE to progress over the years.

After participating in the WSC, the shortcomings of SOPHIE and the worth learning technologies from competitors are summarised to define the improved technical specifications and add-on features for building a better performing SOPHIE compared to the past generations.

The SOPHIE project team includes 10 to 20 student members from four Higher Diploma programs, namely the Higher Diploma in Electrical Engineering (HDEE), Mechanical Engineering (HDME), Automotive Engineering (HDAE), and Aircraft Maintenance Engineering (HDAME), every academic year. They are mainly divided into two groups, the electrical team and the mechanical team, according to their majors and interests. The electrical team is responsible for electrical systems, including the solar panels, battery pack, motors and controllers, wiring, and other accessories such as dashboards, headlights, etc. The mechanical team is responsible for the mechanical systems, including the car's aerodynamic design, carbon fibre body shell, suspension system, and other accessories like car seats, windshields, etc.

The overall project is overseen by a management team of 5 teaching staff. The management team helps coordination, administration, procurement, publicity and promotion work, and contacting industry partners, and sponsorship. It also grades and advises students' performance in the project and ensures the development of the new SOPHIE is on track to participate in the coming WSC.

The project follows a tight schedule during its project cycle, which begins in December and ends two years later in November when the WSC is completed. Improvements on the car design, specifications and features are mainly conducted in the first half year of the project cycle, and the procurement of components and construction of the car are carried out in the following one year. The vehicle must be completed and ready for testing by early May of the final year, and it is then shipped to Australia to race by the end of August. The last month of the project cycle is for reviewing the team performance in the WSC and summarizing the shortcomings of SOPHIE and the worth learning technologies from competitors.

Conclusions and Discussions

With the examination, analysis and evaluation of the indirect measurement data collected in ESP and API, it is found that the technological and engineering literacy of the students and graduates, who participated in the VTC solar car project, was significantly enhanced in terms of knowledge and techniques application, problem identification and solving, time and quality commitment, communication and collaboration, self-directed continuing professional development, and professional and ethical responsibilities.

Besides, regarding the feedback from the project mentors and the remarks on the API from the employers, both the students participants and the employers had positive reflections to the VTC solar car projects. Some of their comments towards the project are listed below as a reference.

Some Comments from Student Participants:
· The participation in the project was a highlight of my academic journey.
· It was a fantastic experience for me to turn my idea into a real thing.
· The project brought together my passion for engineering and sustainability.

Some Comments from Participants' Employers:
· The student developed a battery management system for secure the safety and efficiency of battery pack usage.
· The student made use of mechanical skills on design the aerodynamic and suspension design of cars and proved the success in the WSC.
· The student is willing to seek, listen, accept and act on the advice from different students.

Further Development

In order to further study the effect of the project on the student participants, other continuous measurement methods will be applied to the new cohort of students. The contents of the ESP and API will also be revised to cover more aspects for the study. Pre-event and during-event surveys that students joined at the beginning, and mid-term, will also be recorded for further analysis. Thus, a more complete and detail study can be conducted in the future.

References

Asunda, P. (2012). Standards for Technological Literacy and STEM Education Delivery Through Career and Technical Education Programs. Journal of Technology Education, 23(2), 44-60.

Beddoes, K., Jesiek, B., & Borrego, M. (2010). Identifying Opportunities for Collaborations in. Interdisciplinary Journal of Problem-based Learning, 4(2), 7-34.

Butterfield, A., & Branch, K. (2016). Collaboration between Seniors and Freshmen on Senior Capstone Projects. ASEE's 123rd Annual Conference & Exposition. New Orleans, LA.

Cobb, C., Agogino, A., Beckman, S., & Speer, L. (2008). Enabling and Characterizing Twenty-First Century Skills in New Product Development Teams. International Journal of Engineering Education, 24(2), 420-433.

Dym, C., Agogino, A., Eris, O., & Frey, D. (2005). Engineering Design Thinking, Teaching, and Learning. Journal of Engineering Education, 94(1), 103-120.

Gagel, C. (1997). Literacy and Technology: Reflections and Insights for Technological Literacy. Journal of Industrial Teacher Education, 34(3), 6-34.

Grant, M. (2011). Learning, Beliefs, and Products: Students' Perspectives with Project-based Learning. Interdisciplinary Journal of Problem-based Learning, 5(2), 37-69.

Hoepfl, M. (2020). Defining Technological and Engineering Literacy. Technology and Engineering Education, 80(3).

IVE Engineering of Vocational Training Council (2023).Industrial Attachment & Industry-Based Student Project Scheme. Retrieved from https://engineering.vtc.edu.hk/en/IndustryPartner.php

Jones, B., Epler, C., Mokri, P., Bryant, L., & Paretti, M. (2013). The effects of a collaborative problem-based learning experience on students' motivation in engineering capstone courses. The Interdisciplinary Journal of Problem-based Learning, 7(2), 34-71.

King, R. J. (1991). Solar cars race for the future results of the GM Sunrayce USA and the world solar challenge. Solar Cells, 31(5), 395-424.

Krupczak, J., Blake, J., Disney, K., Hilgarth, C., Libros, R., Mina, M., & Walk, S. (2016). Defining Engineering and Technological Literacy. In Philosophical and Educational Perspectives on Engineering and Technological Literacy, III (pp. 8-14). Iowa, US: Iowa State University.

Male, S., Bush, M., & Chapman, E. (2010). Perceptions of Competency Deficiencies in Engineering Graduates. Australasian Journal of Engineering Education, 16(1), 55-65.

N Janse van Rensburg, MF Grobler, & N Clarke. (2012). Preparing for the solar challenge: Critical competences acquired in undergraduate engineering education. Proceedings of the 2012 IEEE Global Engineering Education Conference (EDUCON) (pp. 1-10). Marrakech, Morocco: IEEE.

National Assessment Governing Board. (2018). Technology and Engineering Literacy Framework for the 2018 National Assessment of Educational Progress. Washington: US Department of Education.

International Technology and Engineering Educators Association (2000, 2002, 2007). Standards for Technological Literacy: Content for the Study of Technology. RESTON, Virginia

The Hong Kong Institution of Engineers (2012). The Accreditation Committee for Higher Diploma Programmes. Professional Accreditation Handbook For Engineering Higher Diploma And Equivalent Programmes. Hong Kong.

Thomas, J. (2000). A Review of Research on Project-based Learning. San Rafael, California: The Autodesk Foundation.