Project-Based Learning for Gifted Students:

Development of 21st century skills

Dr. Christine Yu

Project-based learning (PBL) is a particular type of inquiry-based learning where the context of learning is provided through authentic questions and problems within real-world practices that lead to meaningful learning experience (Kokotsaki et al, 2016). The theoretical foundation of PBL is based on the concept of 'learning by doing' proposed by John Dewey (1938), an American philosopher psychologist and educational reformer.

PBL involves an authentic scientific problem or question that must be anchored in the real world, be interesting and be open-ended so that it presents an intellectual challenge for students, leading to complex intellectual tasks. Students will be engaged in investigation using science and technology (S&T) skills to solve the problem. Meanwhile, solving problems will require searching for sources of information, the integration of interdisciplinary knowledge and skills, use of Information and Communications Technology (ICT), communication, collaboration and teamwork.

Students will develop a product or artefact like a prototype or a report that can be shared to allow others to reflect, discuss, and revise what they have created. Such innovative approach in learning that involves a multitude of strategies is critical for students to be successful in the 21st century (Figure 1).

International Genetically Engineered Machine (iGEM) competition is the largest synthetic biology innovation event in the world. It is first developed by MIT in 2003 and initially aimed at undergraduate students but has expanded to include high school students in 2012. iGEM competition provides an ideal platform for students to take the interdisciplinary approach to solve real-world problems which sustain their passion and push the boundaries of knowledge in the field of synthetic biology. It also helps students to develop core values of the 21st century skills such as creativity, innovation, communication, collaboration, effort, excellence, and celebration.

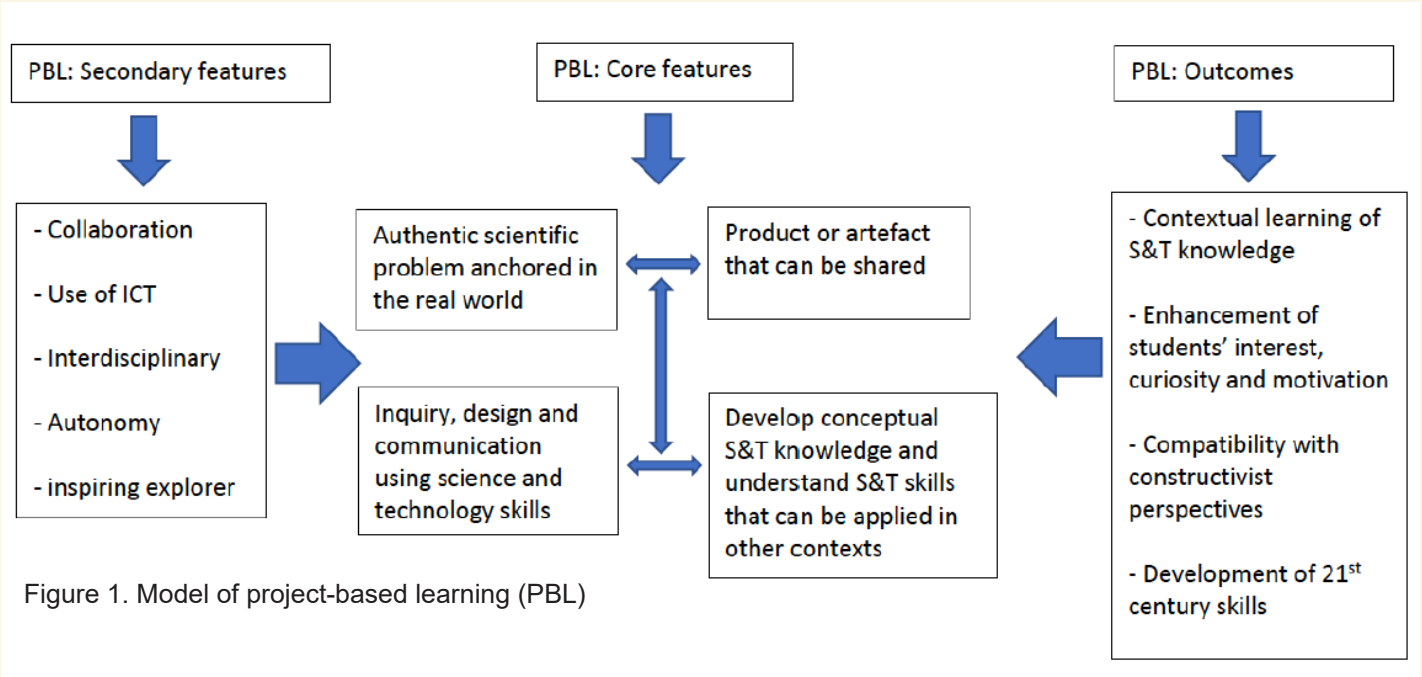


Figure 1. Model of project-based learning (PBL)

I had been involved in an iGEM project as a Principal Investigator (PI) during July 2018 to October 2019 in which a team of 11 students from a gifted program 'Biology is fun – Biotechnology' took the protein engineering approach to create mutants to enhance PET degradation capacity to tackle plastic pollution. Besides the research work, students reached out to stakeholders from diverse communities including university professors, high school students, national and international iGEM teams to collect their points of view and see how to shape the project to benefit the community. All our works have been documented in team wiki (see https://2019.igem.org/Team:HK_GTC). The team was the first individual HK high school to be awarded a gold medal.

Throughout a year of work, the team encountered and tackled many difficulties in research work and project execution. Reflective questions were asked to evaluate the learning outcomes of students. Here are student responses about what they have learnt from the project.

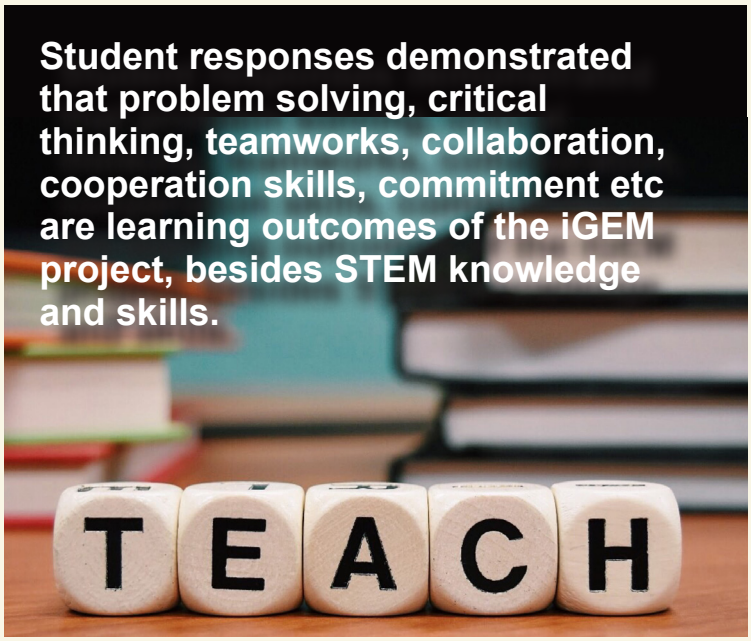
Gene Team Leader 1: From the project, not only did I learn a lot of knowledge and skill for genetic and protein engineering, I learned to persevere through difficulties. I also found out the excitement that scientific discoveries can bring.

Gene Team Leader 2: Throughout the project, apart from gaining theoretical knowledge, I also learnt a lot about practical skills when I performed different experiments. I also learnt to get along with my teammates and to provide help and advice when they encounter difficulties. The project has made me a better leader and also a better "researcher".

Human Practice Team Leader 1: This project made me realize that even though academia is the primary muscle behind the scientific movement, that ethical, arts and social aspects of the world shouldn't be neglected. Through several surveys and interviews, I could feel that the competence of my work has increased by a large margin. I also learned that team spirit is extremely important and that group work is way more efficient than solo work.

Human Practice Team Leader 2: Throughout the project, I find myself exposed to a wider and deeper range of knowledge in the field of genetics, which assisted me in broadening my horizons as well as intensified my interest in it. Plus, I have learned that perseverance and teamwork are the keys to success---although we faced numerous difficulties along our journey, we were able to work as one and we never gave up while facing obstacles.

IT Team Leader: Throughout the course of the project, I dabbled in multiple skill sets including lab work, human practices and also the wiki creation, which was my main duty. I'm extremely lucky to be able to become part of this team as I've learnt a great deal along the way, notably a more in-depth discovery of science besides knowledge from textbooks.



My roles as a project PI are as a project driver, facilitator and resource person to offer support and advice when needed, to provide the necessary scaffolding by setting appropriate learning objectives, providing feedback on their learning and to ensure learning from discussion and reflection. Besides, equipping students with knowledge and skills necessary to solve problems is also important in the development of critical thinking skills.

Thus, in preparing students for their future, it is important to guide them through the inquiry process and empower them with confidence needed to trust their own ability to think critically, analyse and formulate creative solutions to complex problems by guiding and assisting them to build their own thoughts through self-exploration and engaging them in discussion and reflection.

References

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools (Vols. 1-11).*

Dewey, J. (1938). *Experience and education*. New York, NY: Macmillan.

Dr. Christine Yu
(christinekyyuyu@gmail.com)
received a Doctor of Philosophy in Biological Science from the University of Hong Kong. She is the Department Head of Science & Mathematics, Biology Panel Head and Head of Talent Development Group in G.T. (Ellen Yeung) College. She has rich experience in mentoring students on authentic research projects. In 2019, she led GT iGEM team for the first time and the team was awarded a gold medal in the International Genetically Engineered Machine (iGEM) competition. She has been collaborating with tertiary institutions and secondary schools in the promotion of STEM education in Hong Kong. She is the author of a Biology reference book for the New Senior Secondary Curriculum. Currently, she has served as a STEM mentor of New York Academy of Science (NYAS) and as an advisor under the Production of Teaching Resource on Practical Activities in Biotechnology and Microbiology for The Open University pf Hong Kong (OUHK). In 2020, she received TOP 10 STEM Teacher Award in The Greater Bay Area STEM Excellence Award 2020.