



賽馬會「知優致優」計劃

Jockey Club “Giftedness Into Flourishing Talents” Project

Making an Electric Circuit Game

Mathematics Secondary 2

Level 1: School-based Whole-class Teaching



香港賽馬會慈善信託基金

The Hong Kong Jockey Club Charities Trust

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Background and Notes

The design of the learning and teaching plan reflects the actual circumstances of the particular school at the time of implementation. As it is developed and tailor-made to meet the specific cognitive and affective needs of students, all learning and teaching resources are for reference only.

When adapting the materials, curriculum, instructional and assessment modifications can be made in accordance with the diverse needs and abilities, learning styles and aspirations of students, professional competence of teachers, and gifted education development of the schools.

Teachers are strongly recommended to read the introduction, theoretical background and summary of the resource package to have a better understanding of the principles of Gifted Education and strategies for implementation.

This unit includes 1 foreword, 1 lesson plan, 3 worksheets and 1 marking rubric.




With reference to our resources, educators can design suitable learning activities and implement the elements of Gifted Education, based on students' needs and interests, and teaching experience, so as to unfold students' potentials to the fullest.

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Making an Electric Circuit Game

Grade: Secondary 2

No. of Lessons (Learning Time): 2 Lessons (110 minutes in total)

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| Prior Knowledge | <ul style="list-style-type: none"> - Students understand the concepts of complete circuit - Students understand the differences between series and parallel circuits |
| Learning Objectives | <ul style="list-style-type: none"> - Students should be able to apply the concepts and skills of electric circuit to make a game - Students should be able to design their own games - Students should be able to present their design and concepts applied |
| Learning & Teaching Strategies | Questioning, Group Activity, Presentation |
| Operation Mode of Gifted Education | Level 1: School-based Whole-class Teaching |
| Core Elements of Gifted Education |  Higher-order Thinking Skills  Creativity  Personal-social Competence |

Foreword / Background

Gifted education in Hong Kong aims to provide students, in particular those gifted / high ability, with opportunities to receive quality education in a flexible and versatile learning and teaching environment.

For the Project School concerned, students have interest in learning Science, being attentive and able to grasp the lesson content well. More challenging tasks can be provided to further stretch students' potential, which also enhances their sense of ownership and foster deeper engagement in learning. In this curriculum, the promotion of self-directed learning, enhancement of problem-solving skills, creativity and collaboration through challenging tasks are highlighted.

With reference to "Supplement to the Science Education Key Learning Area Curriculum Guide (Education Bureau, 2017)", the theme "Electricity" had been chosen for integrating STEM-related

activities. Six classes of Secondary 2 students participated in the implementation of the designed curriculum.

Objectives of Collaboration

The collaboration focused on the development of an enriched curriculum of STEM education with real-world context. The learning content and activities were infused with the core elements of gifted education, namely higher-order thinking skills, creativity and personal-social competence, in order to unleash students' potential.

Theoretical Framework

1. STEM education in Hong Kong

STEM is an acronym that refers to the academic disciplines of Science, Technology, Engineering and Mathematics collectively. The promotion of STEM education aligns with the worldwide education trend of equipping students to meet the changes and challenges in our society and around the world with rapid economic, scientific and technological developments.

STEM education aims to strengthen students' ability to integrate and apply knowledge and skills across different STEM disciplines, and to nurture their creativity, collaboration and problem-solving skills, as well as to foster their innovation and entrepreneurial spirit as required in the 21st century. These would provide quality learning experiences for students to enhance their interests, creativity and innovation, and to strengthen their ability in integrating and applying both knowledge and skills in solving authentic problems (Education Bureau, 2016).

2. Relationship between Gifted Education and STEM education

The implementation framework adapted the Level 1 school-based whole-class approach in Gifted Education. It seeks to infuse the three core elements of gifted education, namely higher-order thinking skills, creativity and personal-social competence, in regular classrooms for all students.

With the same goal and direction, STEM-related learning activities strengthen students' ability to integrate and apply knowledge and skills across disciplines to solve authentic problems. Students' problem-solving skills, creativity and collaboration skills are enhanced while potential in innovation is unleashed.

| Core Elements of Gifted Education | Design of Programme in STEM Education |
|-----------------------------------|--|
| Higher-order Thinking Skills | Student-centred pedagogies, such as “design and make” activities, project-based and problem-based learning, employed in STEM education can facilitate students to integrate and apply knowledge and skills. Those hands-on and minds-on activities provide opportunities for students to demonstrate their higher-order thinking skills. |
| Creativity | Students have opportunities to provide innovative solutions for problems and make concrete inventions with hands-on and minds-on tasks. Creativity can be nurtured through active participation. |
| Personal-social Competence | Group activities (e.g. hands-on tasks and discussions) provide opportunities for gifted and high ability students to communicate and collaborate with peers. |

3. 6E Learning by Design Model

Engage: To pique students’ interest and get them personally involved in the lesson, while pre-assessing prior understanding.

Explore: To provide students with an opportunity to construct their own understanding of the topic.


Explain: To provide students with an opportunity to explain and refine what they have learnt and what it means.

Engineer: To provide students with an opportunity to develop greater depth of understanding about the topic by applying concepts, practices, and attitudes. They use concepts about the natural world and apply them to the man-made (designed) world.

Enrich: To provide students with an opportunity to explore in greater depth on what they have learnt and transfer concepts to more complex problems

Evaluate: To allow both students and teachers to examine how much learning and understanding has taken place

Curriculum Design

| Phases of 6E Learning by Design Model | Content |
|---------------------------------------|--|
| EXPLORE | Designed situation - The school will have an Open Day for the public. Students are asked to prepare electric circuit games for the Open Day. |
| Creativity | <p>Prior to the lessons, individual students were provided with a self-directed learning opportunity to gain basic knowledge and skills by using electric parts, including a battery, battery box, conductive tapes and LED lights, to make a complete circuit. Students complete an individual proposal to design an electric circuit game based on those concepts.</p>  |
| EXPLAIN | Students work in groups. Groupmates share their proposals with one another, compromise the ideas and finalize the design. They draw the design and write the instructions of the game. The teacher gives them feedback for improvement. |
| ENGINEER | Students apply knowledge and skills to make their games by using materials provided by the teacher and collected by themselves. They engineer creative solutions through development, construction, refinement, assessment, and re-design. The teacher acts as a facilitator at this stage. |
| ENRICH | Students suggest the use of complete circuits in other new situations and applications in daily life. |
| EVALUATE | Students present their designs and demonstrate how to play the electric circuit games. Evaluation includes teacher feedback, peer assessment and self-reflection. |

Learning and Teaching Strategies

Students' knowledge and skills are constructed through a series of phases according to 6E Learning by Design Model. The core elements of Gifted Education are infused in suitable way in order to nurture and unleash students' potential.

In the design process, students design their electric circuit games by applying the concepts of complete circuit, including series and parallel circuits. They need to use their higher-order thinking skills (i.e. problem -solving skills) and creativity (i.e. originality). Students exchange ideas and experience in their groups, apply knowledge and skills in the process of making, and

try to achieve the best result by repeated verification and continuous improvement. Throughout the process, their higher-order thinking skills (i.e. investigative and problem-solving skills) and creativity (i.e. elaboration) are unleashed. Besides, they work collaboratively throughout the process to nurture their personal-social competence. Teacher, as a facilitator, encourages students to observe carefully, and use scientific methods and attitudes to analyze various scenarios.

Discussion

Based on lesson observation, the effectiveness of the implementation of designed curriculum is summarized below:

1. Students showed high motivation and deeper engagement in learning

The designed curriculum encouraged students to apply and integrate knowledge and skills to solve a challenging problem in real-world context. The STEM-related activities were effective in stimulating students' motivation. Students' behaviors and body languages showed high level of engagement (e.g. eager to take up a role in the group) and enjoyment (e.g. smiling faces).

2. Students demonstrated higher-order thinking skills, creativity and personal-social competence

Higher-order Thinking Skills

Students were required to apply and integrate knowledge and skills in the STEM-related activities. During the “design and make” process, they came across a lot of challenging problems. For example, some materials were of poorer quality than expected and the LED light could not light up. Students showed their problem-solving skills by replacing copper foil by aluminum foil in making the ball as aluminum is a better conductor compared with copper.

Creativity

With open and challenging tasks, students demonstrated their creativity in designing the games, with the application and integration of knowledge and skills.

Personal-social Competence

Students had many opportunities to communicate and collaborate with peers as hands-on tasks and discussions were conducted in groups. They interacted and discussed with groupmates actively using suitable subject language.

3. Suggestions

To further refine the curriculum design and learning activities, more consideration can be placed on catering learners' diversity through applying differentiated instruction. To fully explore and develop the potential of gifted and high ability students, more opportunities could be provided in the class. For example, students can be invited to lead a learning activity in order to develop their leadership skills. They can also be asked to share the methods used to tackle technical problems in order to develop their communication skills.