賽馬會「知優致優」計劃
Jockey Club "Giftedness Into Flourishing Talents" Project

Wearable Electronic Clothes

Integrated Science Secondary 2

Level 2: School-based Pull-out Programme

CENTRE FOR UNIVERSITY & SCHOOL PARTNERSHIP
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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 information sheet.

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.

Wearable Electronic Clothes

Grade: Secondary 2
No. of Lessons (Learning Time): 6 Lessons (540 minutes in total)

Prior Knowledge	- Students understand the concepts of complete circuit - Students understand the differences between series and parallel circuits
Learning Objectives	- Students should be able to apply the concepts and skills of the following: Science: Concepts and skills in connecting electric circuits Information and Communication Technology: Programming with mBlock Math: Basic Mathematical concepts and computation thinking Visual Art: Designing and decorating the wearable electronic clothes - Students should be able to design their own wearable electronic clothes - Students should be able to present their design and concepts applied - Students should be able to demonstrate their scientific inquiry, computational thinking, critical thinking, problem-solving skills and creativity
Target Students	S2 students with outstanding performance in STEM education and related subjects, especially in Science.
Learning & Teaching Strategies	Questioning, Hands-on Group Activities, Presentation / Performance
Operation Mode of Gifted Education	Level 2: School-based Pull-out Programme

Foreword / Background

For the Project School concerned, students have interest in learning Science. Some gifted / high ability students demonstrated their potentials in school-based whole-class learning (L1 of Gifted Education) on the topic "Making an Electric Circuit Game". Hence, a pull-out programme is designed as an extension of the regular curriculum to further foster their talent. This pull-out programme of STEM education is a 'Design and Make' project on wearable electronic clothes.

Generally speaking, gifted students are strongly sensitive about problems, and their analytical and integrating abilities are greater. They also enjoy thinking on a broader scale and show particular interest in activities that require observation and exploration. Therefore, project learning is an ideal learning mode for them as it provides flexible learning opportunities. In this project, a series of activities is used to teach gifted students how to grasp knowledge in different areas, and to give full play to their potentials in various aspects, such as integration, application, analysis and evaluation. It also helps develop student's creativity, critical thinking and problem-solving skills.

Objectives of Collaboration

The collaboration aims to tailor-make a pull-out STEM education programme for talent development of a group of gifted / high ability students. With the understanding of their performances and characteristics, advanced content, creativity, critical thinking and problem-solving skills are integrated in the curriculum.

Criteria for Selection of Students

Students are selected based on their performance in the school-based whole-class learning (L1 of Gifted Education) on the topic "Making an Electric Circuit Game", and their personal interest and performance in science assessment. In connection to multiple intelligences, their logical-mathematical and visual-spatial intelligences are also considered.

1. Behavioural characteristics of students with high potential in Science (Education Bureau, 2017)

- Persistent in learning science, high concentration, hard-working and motivated
- Interested in science books and science related television programmes or videos
- Enjoy solving problems in science
- Organize data or analyze an observed phenomenon to discover patterns or relationships
- Good at observing, exploring, questioning, investigating things in detail
- Understand scientific methods, able to formulate hypotheses and conduct experiments carefully
- Skillful in using laboratory equipment, able to improvise with science equipment
- Demonstrate creativity in invention and/or experimental designs

- Demonstrate task commitment in science projects (sticking with investigations in spite of difficulties or problems)

2. Criteria for selection for the STEM education pull-out programmes

Teachers are advised to use multiple methods and channels, such as classroom observation, behavioural information, parent / peer groups, self-recommendation, students' products and assignments, awards in local and/or international science competitions, to select students with high potential in Science (one of the subjects in STEM education) to take part in the school-based pull-out programme. A single test or tool is not reliable in the identification of a scientifically gifted student.

Theoretical Framework

1. Curriculum design for pull-out programmes

According to Gallagher (1985), the learning content, process and environment of the basic curriculum need to be modified to match the characteristics and the needs of the gifted / high ability students. VanTassel-Baska et al. (1988) advocated that a gifted curriculum should attend to the content mastery and the learning process. Hence, gifted students should be taught with advanced content, higher-order thinking and problem-solving skills.

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. 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.

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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

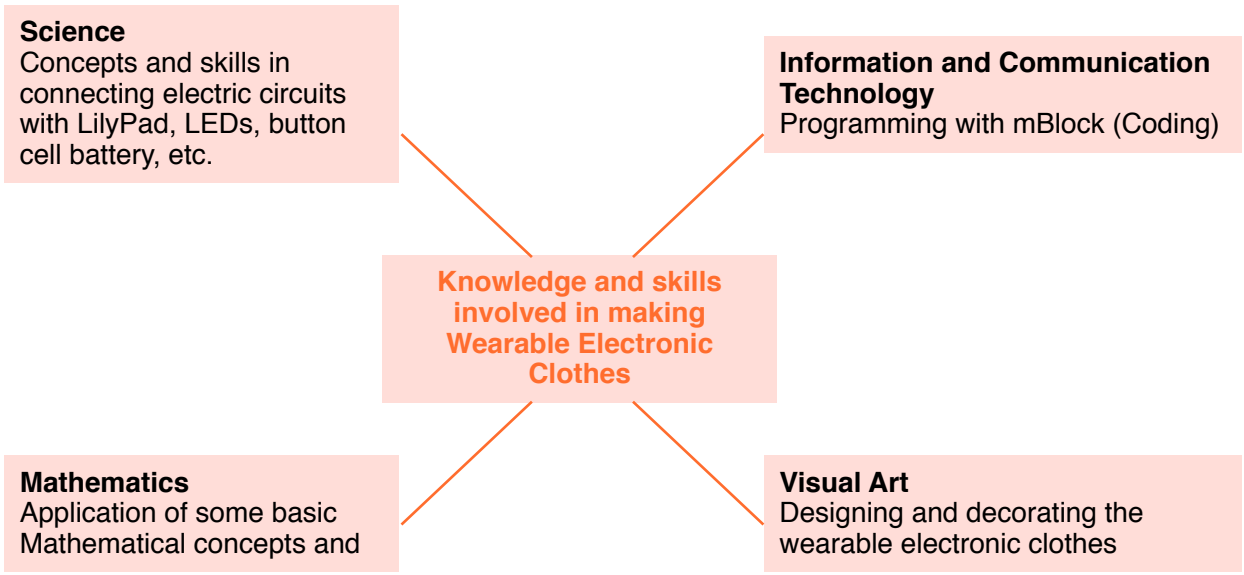
Lessons	Main Focus
1 - 2	Workshops - Students learn the required skills for the successful completion of the 'Design and Make' Project. The hands-on skills to prototype designs are taught. Topics include circuit design, soldering, Arduino coding etc. The workshops are conducted by two S5 student instructors.
3 - 6	'Design and Make' Project - It requires students to develop custom electrical, mechanical, and software components. The project includes design and making processes. In the design process, students design their wearable electronic clothes by applying the concepts of the electric circuit, coding, art etc. In the making process, students apply knowledge and skills in making clothes. With repeated verification and continuous improvement, students try to achieve the best result. Teacher, as a facilitator, encourages students to observe carefully and use effective questioning techniques to promote higher-order thinking.
Showcase Presenting the final products in a live fashion show	

Learning and Teaching Strategies

"Wearable Electronic Clothes" is the theme of this STEM education pull-out programme. The programme aims to provide Secondary 2 students with high potential in science and programming with advanced learning content, develop their scientific inquiry, computational thinking, critical thinking, problem-solving skills, and creativity. 6E Learning by Design Model which provides a student-centred framework for instruction may help foster the potential of gifted / high ability students.

The curriculum involves the application and integration of knowledge and skills across subjects, to make wearable electronic clothes using LilyPads, LED lights, conductive thread and other electric parts. Students are more motivated to learn the advanced and challenging content , compared to the usual subject curricula at their age level. Moreover, the content consists of real-world contexts involving interdisciplinary subject knowledge and skills. It can nurture the learning needs of gifted / high ability students.

The interdisciplinary subject knowledge and skills involved:



Students apply knowledge and skills through a series of phases according to 6E Learning by Design Model:

Phases of 6E Learning by Design Model	Content
ENGAGE	Workshops - Students learn the required skills for the successful completion of the 'Design and Make' Project. The hands-on skills to prototype designs are taught. Topics include circuit design, soldering, Arduino coding etc. The workshops are conducted by two S5 student instructors.
EXPLORE	Prior to the lessons, individual students were provided with a self-directed learning opportunity to gain basic knowledge and skills of LilyPad. Students participate in workshops to learn programming with mBlock.
EXPLAIN	Students work in pairs to discuss their designs with the knowledge and skills learnt.
ENGINEER	Students apply knowledge and skills to make their wearable electronic clothes 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 concepts in other new product designs.
EVALUATE	Students present their products in the fashion show. Evaluation is based audience feedback and self-reflection.

The teacher should act as a facilitator to motivate students to learn actively, and may use effective questioning techniques to promote higher-order thinking. Last but not least, the teacher should maintain a warm classroom atmosphere so as to encourage more teacher-student and student-student interaction, which is beneficial to learn in depth.

Discussion

The programme proves that by providing a suitable learning environment, together with activities and teaching strategies that suited the needs of students, students can build their knowledge and skills of STEM education through 'Design and Make' projects. Students can cultivate a persistent spirit of exploration, understand the close relationships between STEM education and daily life, as well as improve the quality of life by applying and integrating knowledge and skills.

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

1. Students were devoted in learning

Gifted / high ability students were more than happy to take up the challenges.

2. Students abilities can be demonstrated and stretched

Mastering of knowledge and skills in advanced content

Through a series of activities, students were motivated to learn about and explore the theme "Wearable Electronic Clothes" from integrated perspectives. Not only could they grasp subject knowledge and skill, they were also empowered to apply the skills they had learnt. They had a comparatively more extensive and deeper understanding of some concepts and skills of STEM education. Moreover, their creativity, critical thinking and problem-solving skills were developed throughout the learning process.

Students can master the skills of using basic electric parts and programming quite well after participating in workshops with the accelerated curriculum. When opportunities were provided for them to make greater use of their abilities, they experienced a heightened sense of satisfaction and enjoyment.

Creativity shown in the designs

Through the project, students were able to design and make clothes based on their own interests. Many of the products were very creative. From their selection of colour and design, the deep meanings of their product are shown.

3. The teacher acted as a facilitator

Students were encouraged by the teacher to learn through facing new challenges, daring to try, thinking comprehensively, and grasping the higher-order thinking skills related to the learning project. The teacher acted as a facilitator by asking effective questions.