Interdisciplinary Learning in Secondary Schools From Multiple Prespectives

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Abstract
The purpose of this study is to investigate how interdisciplinary learning enhances lower-form students' learning in Hong Kong secondary schools and is also to provide a practical example for teachers in secondary schools to promote interdisciplinary learning beyond the existing curriculum. The research was carried out with 121 secondary 2 students aged 12 to13 in the school year of 2019-2020. Students participated in a STEM project called "Renewable Energy". First, in the project, teachers taught the subject knowledge that related renewable energy during the Mathematics, Geography and Integrated Science lessons. Second, students had to complete different learning tasks during their lesson, such as statistical poster, drawing and created an experiment. Third, students had to combine the outcome of the learning tasks by setting up a booth to present their findings for other students and teachers. Quantitative and qualitative data were used to investigate students' learning in the project for all subjects. After the completion of the project, the students were invited to answer a questionnaire. The questionnaire included a Likert scale and an open-end question in order to get more in-depth information of the attitude and motivation of the students towards the project on Mathematics, Geography, Integrated Science and the overall view of the project in multiple perspectives. The analysis and discussion will be launched in the conference.

Keywords: Interdisciplinary Learning, STEM education, Project Learning, student attitude, motivation

Introduction

Knowledge is deeply interconnected and interwoven. Interdisciplinary Learning (IL) is one of the key trends in education in different countries. IL can enhance students' motivation and help them to acquire different skillsets. Therefore, interdisciplinarity research and STEM education have been promoted in high education and secondary schools respectively. However, all the subjects are taught separately and independently in secondary schools in Hong Kong. Therefore, Hong Kong Education Bureau has promoted the IL via project-based learning in order to let students have a better understanding of the inter-connection among different subjects. In addition, IL also provides students a platform to acquire various skills of the 21st century, namely: critical thinking, teamwork, collaboration, communication and problem solving. Moreover, IL is to associate students' learning highly with innovation. Even though IL is deemed beneficial to secondary school students, the implantation rate is still low among secondary schools. Some limitations such as lack of teaching and learning materials related to IL, time constraints and low teacher readiness hinder teachers to implement IL. In order to promote IL more effectively, the view of students and teachers should be considered. Moreover, studies on IL are relatively fewer in the Asian context, especially in Hong Kong. Therefore, this study aims to evaluate the IL from the perspectives of both students and teachers and it also provides a practical example that specially fits for the Asian context.

Theoretical Backgorund

Interdisciplinary Learning

IL refers to "leaners intergrade information, data, techniques tools, perspectives, concepts, and/or theories from two or more disciplines to craft products, explain phenomena, and solve problems in ways that would have been unlikely through single-disciplinary means"(Mansilla, 2016). Various researches propose that IL can be beneficial for students' learning. First, Lattuca, Voigt, and Fath (2004) propose that IL promotes learning through sociocultural and cognitive dimension. In sociocultural dimension, IL may enhance the evolution of students' epistemological beliefs with cultural and social interaction. In the cognitive dimension, IL provides strong interconnection for the prior knowledge and new knowledge, and also enhances student's motivation with providing a real-life situation problem. Second, Klein and Newell (1997) suggests that students acquire different skillsets to solve the economic, technological and social problems. Nevertheless, secondary teachers believe that they are experts in their subjects, but they seldom see themselves as lacking knowledge in other disciplines. Second, teachers have to use a lot of time to prepare the IL materials. Third, the schedule and curriculum of traditional discipline-specific schools have limitations in promoting IL.

Interdisciplinary Learning with multi perspectives

In order to investigate the effectiveness of the IL, Greeno (1997) proposes three general perspectives to investigate how and why interdisciplinary learning, namely, behaviorist perspective, the cognitive perspective and situative perspective. Each perspective relates to a different aspect of learning. First, reasoning, problem solving,

and the conceptual understanding are concerned in behaviorist perspective. Second, sense-making of a community and practices of inquiry are concerned in situative perspective. However, later on, Lattuca et al. (2004) argues that learning practices do not belong to cognitive, situative or behaviorist perspective only. They propose through different kinds of theoretical lenses to investigate IL. First, they suggest IL engages students' Prior knowledge and experience using cognitive theories. Second, they propose that IL encourage effective thinking by situated learning theory. Third, they believe that IL promotes (construct meaning???) (constructive learning) in the classroom by Constructivist. Fourth, they suggest that IL motivates student to learn by students' epistemological beliefs. Finally, IL develops multiple perspectives on issues and problems. Based on the above theories, they identify some key ideas about how IL succeeds: '(a) to forge connections to students' prior knowledge and experience; (b) to assist students in developing complex understandings in particular subject areas; (c) to promote the development of sophistical views of knowledge and learning; (d) to influence thinking skills; (e) to build students' capacity to recognize, evaluate, and use differing (multiple) perspectives; (f) to engage students' interests and to enhance motivation; and (g) to enact constructivist and active leaning strategies.' (Lattuca et al., 2004). The Lattuca provides all round perspective to evaluate of IL. Therefore, the theoretical framework is adopted from Lattuca et al. (2004) in this study.

Cognitive Theory is a psychological approach using the humans' thought to explain the change of human behavior (Shuell, 1986). In education, Cognitive Theory states that learning is a goal-oriented, active and constructive process, and is also based on students' mental activities.

Situated Learning Theory explains how students acquire different skillsets and extend the theory to study the relationship between social communities and learning (Lave & Wenger, 1991).

Constructivism is a belief that knowledge is constructed by leaners' prior knowledge or own experiences (Steffe & Gale, 1995).

Epistemological Beliefs analyses people's learning, work and subjectivity through understanding the nature of learning and knowledge (Yapici & Akbayin, 2012).

Backgorund of the Study

In the school year 2016-2017, Finland promoted phenomenon-based learning among secondary schools as one of the main concerns in the new National Curriculum Framework, the concept of phenomenon-based learning which develops from IL. According to the new NCF, every Finland secondary school had to intergrade different subjects together and created a theme, project or course for students-based learning. The change engaged students' learning motivation and academic performance. Therefore, several educators believe that Finland education system is a success.

In order to promote IL in Hong Kong secondary schools, project based-learning has been launched. However, not many schools have adopted it because of lacking

teaching time, unrelated to public examinations, unfamiliar with the project learning and limited teaching resources. Therefore, EDB launched a scheme for secondary school teachers, which called "I-journey"-programme for secondary school teachers (Interdisciplinary Learning & Entrepreneurship Education). In phase one, the project-proposal was designed and modified with the support of Finland teachers and professors in a 5-week visit in Finland. In phase two, The STEM project called "Renewable Energy" was implemented in my school in the school year after phase 1 and supported by Hong Kong professors. This study draws upon the data generated in the project.

Singfiance of the Study

In the previous studies, the content of IL has been developed by research. Therefore, it may not fit for the existing curriculum. In this study, the project will be developed in the existing secondary school curriculum in Hong Kong. Furthermore, there are relatively few studies on IL in the Asian context, especially in Hong Kong. Therefore, the evaluation of the project on students' attitudes and motivation in multiple perspectives will be conducted.

Research Questions

Adopting Lattuca et al. (2004)'s multiple perspectives on IL, the study will investigate whether the project can promote IL effectively in following dimensions or not?
a. connections to students' prior knowledge and experience
b. development of complex understanding in particular subject areas
c. development of sophistical views of knowledge and learning
d. students' interests and motivation

Methodoloy

The development of the project is based on the phenomenon-based learning. All S.2 student participants aged 12-13 participated in the project in the school year of 2019-2020. They were grouped into six groups for the project about Renewable Energy. The title of the project called "Save the World! Start from you!". Geography, Mathematics and Integrated Science are involved in this project. Students had to learn the energy from global perspective to Hong Kong situation. They had to extend the knowledge to their personal dimensions. Finally, authentic learning was embedded in this project. Firstly, all students were required to attend a talk organized by China Light & Power Company Syndicate, providing the situation about the demand and consumption of Energy in Hong Kong. Secondly, students had an opportunity to create their own solar charger and used it for science investigation.

The learning outcome

The learning objective of this project were as follows: (1) to enhance students' awareness of the connection of knowledge among Geography, Mathematics and Science. (2) to develop moral and civic values, as well as positive attitude. (3) to develop students' genic skills such as study skills, collaboration skills, ICT skills,

problem solving skills, analytical skills, presentation skills and critical thinking and (4) to develop the culture of reading.

Aligned with another school-based scheme

In order to align with Hong Kong curriculum, contest-based reading and Bring Your Own Device (BYOD) scheme were also integrated in this project. In contest-based reading, students were required to read a traditional reference book, an e-book, an article or online materials that suggested by their subject teachers to broaden their horizon of knowledge about energy. In the BYOD scheme, every student had his own iPad for the project. First, teachers mainly used Google Classroom to deliver and collect the learning materials as well as students' assessments respectively. Second, students also used OneNote to take their own notes and collaborated with their classmates. Third, students had to know how to use excel to plot the graph for presentation and to manage basic computer drawing. Lastly, students had to use the camera of iPad to record their experiments for their peers' and teachers' evaluations.

Learning outcomes

At the end of the project, the display of students' achievements was used to exhibit students' work. Students had to combine the outcomes of the learning tasks to set up a booth to present their work for their fellow students and teachers. It included (1) to express sustainable energy with pictures and notes from global perspective. (2) to design a Statistical Poster with the theme "Electricity in Hong Kong". (3) to create their own solar chargers and the reports of their science investigation. The implementation plan of the project is shown in table 1 below:

Table. 1 The implementation plan of the project

Month	Subject	Learning Objective/ Learning Tasks	Assessment
Oct	Kickoff	All students attended a talk organized by China Light & Power Company Syndicate and the project was introduced to students.	
Oct - Nov	Geography	Subject knowledge What are the main energy sources in the world? Major renewable and non-renewable energy sources Do we have other options? Advantages and disadvantages of renewable energy How to meet future energy needs in a more sustainable way? Energy solutions at different levels Attitudes To cultivate a sense of responsibility for energy	To express sustainable energy with pictures and notes from global perspective

		conservation To understand the need to change lifestyles and habits to save energy	
Nov - Dec	Mathematics	Subject knowledge To collecting data from the website of the Census and Statistics Department: "Power supply and use in Hong Kong" How to analyse data To choose the right chart and to express the data Data misuse Attitudes To train students to examine the accuracy of different data analysis	To design a Statistical Poster with the theme "Electricity in Hong Kong"
Dec - Mar	Integrated Science	Subject knowledge To understand the basic knowledge of circuits and drawing circuit diagrams To learn circuit connection To recognize current, voltage, resistance and measurement methods Attitudes To cultivate curiosity and interest in science To cultivate the ability of recognizing safety issues in daily life	To create their own solar chargers To prepare the Experimental report
		Group experiment (Make a solar charger) Explore the content: To understand the principles of solar cells To compare the effects of different assemblies (series, parallel) To explore the power generation under different conditions, such as light intensity, length of sunshine, shade, number of solar panels, etc. To measure the time required to charge a solar charger	
Apr	Integration	To exhibit students' work	To Combine their work from different subjects so as to setup a booth for their projects.

After the completion of the project, all the students were invited to do a questionnaire. The questionnaire included three parts: (1) demography information (2) five-scale

Likert questions and (3) open-end questions. The students' questionnaire included Likert questions. They were about their attitudes towards the overall project and the 4 subjects namely Mathematics, Geography and Integrated Science. In addition, it comprised the 4 different dimensions: A. To forge connections to students' prior knowledge and experience. B. To assist students to develop complex understanding in particular subject areas. C. To promote students' development of sophistical views of knowledge and learning. D. To engage students' interest and to enhance their motivation. The Open-end questions which were about the examples and the suggestions for the improvement of the above 4 dimensions were included. The project ended in Mar 2019. However, due to the schedule's problem, the project was delayed to May 2019. Therefore, the results and discussion will present it later.

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