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Challenges of Cross-Border Lesson Study for STEM Education on the APEC Project

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Abstract

A lesson was designed as part of the Asia-Pacific Economic Cooperation (*APEC) Cross-Border Lesson Study: Energy efficiency and Cross-Border Education* project. Two classes from different schools in Chile and one class from a school in the United States participated in a pilot Cross-Border Public Class in STEM. From one of the schools in Chile, a researcher taught the lesson that was transmitted to the other two schools via Skype. During the class, the researcher posted four open-ended questions, which the students were invited to answer using their computers or tablets. The disruptive innovative class demonstrated that the concept of Cross-Border Public Classes boosts student engagement and is a promising strategy for introducing a key 21st century skill: synchronous learning involving multiple teams across the world. The experience also revealed how lesson study and public classes can be greatly extended using social networking technology. Challenges of having Cross-Border Public Classes in STEM will be discussed as well as future plans for more successful cross-border classes.

Keywords: Challenges, Cross-Border Lesson Study, STEM Education, the APEC Project

Introduction

The Asia-Pacific Economic Cooperation (*APEC) Cross-Border Lesson Study: Energy efficiency and Cross-Border Education* project was accepted to develop a textbook for secondary students about energy efficiency and to implement these lessons with students of several countries at the same time. The idea of having a lesson taught by a teacher to mutltiple classes from different countries at the same time was to connect students to the relevance of the content not just in their own country but to other countries as well. The project's three step process for carrying out the objectives of the project will be discussed as

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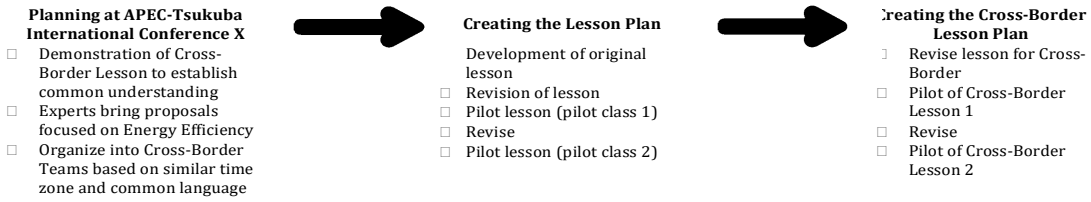

Fig. 1. Diagram of the lesson study cycle from the APEC-Tsukuba International Conference to the implementation of Cross-Border Lesson Plan.

it relates to the development and implementation of one of these lessons using lesson study as well as an account of the challenges (Figure 1).

The first step in the process for carrying out the objectives of the project was a meeting with all participating countries at the APEC-Tsukuba International Conference X. Three central questions were posed to stimulate discussion and activity:

1) What is the major issue facing Energy in your economy?
2) In relation to science, technology, engineering, and mathematics (STEM), what reforms are taking place in your economy?
3) In relation to Lesson Study for Cross-Border, what possibilities do you have?

A demonstration class of the possibilities for cross-border lessons occurred involving a 9th grade Japanese class connected using Skype with a 9th grade Malaysian class. More than a dozen APEC country representatives presented initial lesson ideas about Energy Efficiency and Cross-Border Education. For the purposes of this paper the teams from only the Americas is presented. The Mexican team proposed a lesson plan related to energy for middle school students, the Peruvian team proposed a lesson based on developing a generator for producing drinking water, the American team proposed a lesson plan where the cost of utilities were calculated, and the Chilean team proposed an energy lesson using a basic steam engine.

Cross-Border STEM Lesson

The second step was to form teams to plan and implement a lesson about Energy Efficiency and Cross-Border Education using lesson study. The specialists and experts from the Americas partnered because of similarity in time zone and some commonality of the language, English and Spanish. Based on the proposals from the American, Chilean, Mexican, and Peruvian representatives, lesson plan development and adjustments were discussed in Skype meetings together with a guest representative from Brazil. From the proposals three lesson ideas prevailed that included:

1) students calculating their daily energy intake of different food compared with the amount of energy consumed by different devices;

2) students estimating energy spent when they do a physical activity such as running and swimming; and

3) students integrating the concept of energy with social development as illustrated on the left graph of Figure 2, and realizing the need to be more energy efficient in the future as illustrated on the right graph of Figure 2

Some of the instructional decisions to be incorporated included teaching energy units, questions to promote reasoning, and specifying the amount of time spent doing the physical activity.

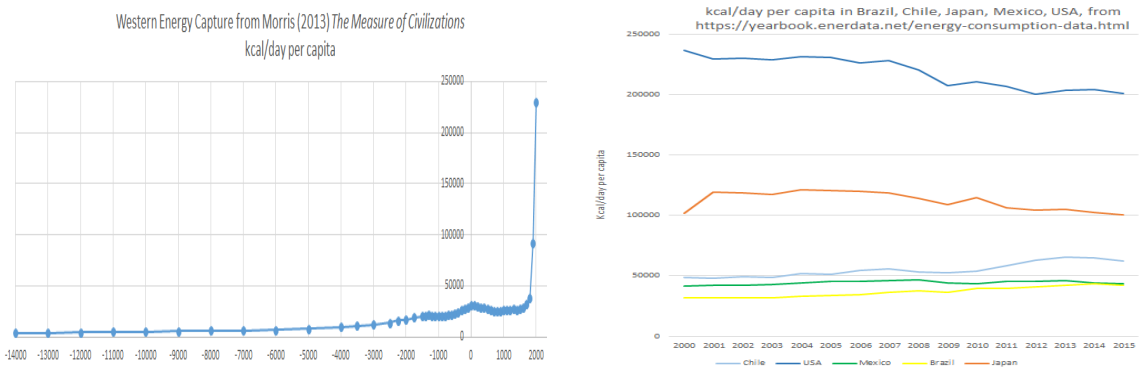

Fig. 2. Left: energy captured in the West in kcal per day per capita over the last 16,000 years, showing an explosive increase on the last years. [1] Right: Energy captured in kcal per day per capita in Brazil, Chile, Mexico, USA and Japan. It shows how developing countries (where most population lives) are approaching the energy captured per capita of developed countries. This trend will generate a huge demand for energy.

1. Pilots of Energy Lesson Plan

There were two pilots of the lesson with a single class. The first pilot (pilot class 1) with 7th grade students from a Chilean school had students using tablets to access the Internet to estimate the amount of energy spent during physical activities. Several local teachers suggested that the lesson would be more engaging if students actually did some physical activity themselves. This resulted in a change from searching for information about energy expenditure relating to different physical activities to students actually doing a physical activity such as jumping.

Following this, a second pilot of the lesson (pilot class 2) was then implemented with the lesson changes at another Chilean school of 7th grade students. The lesson began with the teacher asking students what variables have an impact on the temperature of the air inside the classroom. Next, the students did an experiment, measuring the temperature increase under two conditions: condition 1 was at rest for 10 minutes, condition 2 was jumping for 10 minutes. A subsequent lesson occurred where the students analyzed connections between energy and social development and made predictions for energy expenditure in the near future based on historical trends in the amount of energy captured per capita. The students then discussed the need to improve energy efficiency.

2. Pilots of Cross-Border Energy Lesson Plan

Based on these two pilot lessons, preparations were made to conduct the lesson cross-borders. Considerations were made for some of the challenges for implementing the lesson with students from several countries. This included the ability to increase the room temperature by jumping during. First, in a typical public class, held in a gym or theater, the increase in temperature is very slow because of the large volume of the room. Second, schools in the United States have central heating and air conditioning systems that cannot easily be turned off. As a result, data collected from the second pilot class was used.

The first pilot cross-border lesson was held using Skype between two Chilean schools that were more 100 km apart from each other. The lesson involved asking key questions to all of the students and having them respond online using Conectaldeas, an online platform that some of the researchers used previously for interclass tournaments (Araya, et al., 2014). A couple of key questions included:

- Question 1: Which variables impacted the temperature of the room during the session that was reviewed? Explain your answer.
- Question 2: What is the volume of your classroom? Did you use exact measurements or did you estimate?

Some of the challenges exposed during the initial cross-border implementation of the STEM lesson included the remote location not hearing or understanding the questions and instructions from the teacher and the lack of engagement by the students. As a result, suggestions were made to repeat instructions and questions by the teacher and to have students do the jumping activity. However, given time restrictions and the unpredictable conditions of the different rooms in which the Cross-Border Public Classes would be taking

place, the revised lesson plan did not contemplate having the students measure the temperature change. Instead, the jumping activity was going to be used in order to have a more active class, while synchronizing students from different schools, promoting social interaction, and encouraging students to think about the relationship between physical activity, heat, and energy.

The second pilot cross-border lesson was held using Skype between two Chilean (Santiago and La Pintana) schools and one school in the United States (Texas). The Public Class coordinator spent a day prior to the implementation of the lesson to test the technology and contrive any possibilities of challenges that could occur during the lesson. As a result, schools made plans in the placement of the furniture to be seen on camera, name cards for the students, creating an English version of the interactive online portion of the lesson, and signing on students to the online system.

Figure 3 shows a diagram with the three classes from the three schools, the Public Class coordinator and several remote observers of the Cross-Border Public Class. All of the students from each class participated by watching Skype and answering the teacher's open ended questions using the online platform, ConectaIdeas. The Public Class coordinator, located at another site, video streamed footage from the three classrooms using YouTube. The video stream was watched by teachers and observers at an APEC meeting in Lima, as well as other remote observers. This is the first Cross-Border Public Class that we know of where every student answered several questions simutaneously, where the responses were received instantly by the teacher who reviewed and provided comments.

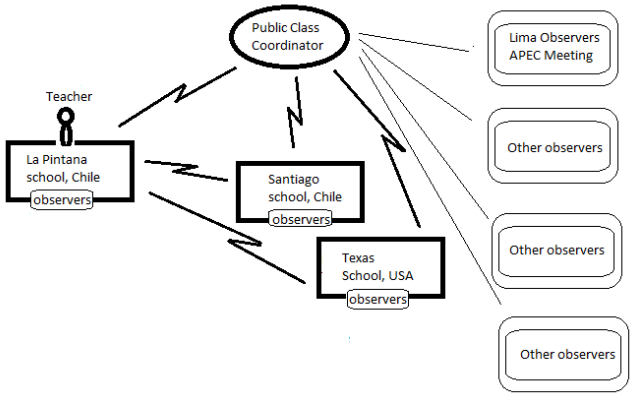

Fig. 3. Diagram of the Cross-Border Public Class on Energy Efficiency with 3 schools connected synchronously.

For this to be successful there is a dependence on the functioning of all technology tools and the Internet. Challenges were experienced with sound and Internet connection.

Several minutes were lost at the beginning as there were problems with the sound quality at the Santiago School at the beginning of the class where the teacher was teaching the lesson. Sound returned but the quality at Santiago was quite poor throughout the lesson. In this sense, the Public Class Coordinator, who managed the video streaming, helped by clarifying the main questions and giving instructions to the other schools. Once this was fixed there was engagement of the students from all the schools.

One of the sites, Texas, had difficulty with Internet service. Once the Internet briefly returned, the online side did not have the English version. This was not a huge challenge since the students were part of a dual language class of English and Spanish. A few of the students were native Spanish speakers. However, shortly after wireless Internet was down for the entire school. As a result students answered questions with paper and pencil. Students answered the following questions prior to total loss of Internet connection:

1. What is energy?
2. How much energy do you need per day?
3. How much did the temperature increase in the room?
4. What causes temperature to increase?
5. How do you find the volume of the classroom?

About 30 minutes into the lesson the Texas school lost all Internet connection that impacted the entire district and did not return until after the lesson was complete. A possibility for future implementation is to test out the use of a personal computer and personal Internet hotspot.

One of the challenges for this type of class is classroom management. The teacher needed to simultaneously manage several classes located in different parts of the world and to do so without losing personal contact with each individual student (Figure 4).

Fig. 4. Screenshot of the Cross-Border Public Class video streamed via a YouTube channel. Three classes synchronized and jumping simultaneously: Left, Santiago school; center, Texas school: right, La Pintana school.

The teacher maintains contact with each student with the use of ConectaIdeas, both those in their classroom, as well as the students in the remote classrooms. Even though the class can be classified as a "whole class" lesson, where the teacher is constantly asking key questions to all of the students, they also receive written answers from each individual student. These answers are reviewed by the teacher, selected and provide immediate comments.

During the class, a model of a classroom was used, as well as several small white cubes representing a cubic meter (Figure 5). This was a strategy to help understand and calculate the volume of the classroom.

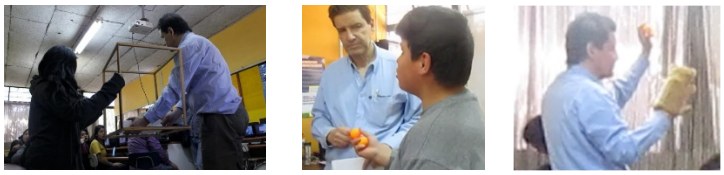

Fig. 5. On the left, the photo shows a wooden frame representing a classroom and two white cubes to represent two cubic meters of air. In the middle, the students show two ping pong balls representing two kilocalories. On the right, the teacher can be seen with an orange ping pong ball in his left hand, used to represent one kcal, and a puppet on his right hand, used to represent a student.

During the Cross-Border class, the teacher posted four questions on the ConectaIdeas platform.

- Question 1: What is energy and how much do you need per day?
- Question 2: What variables cause the room temperature to increase?
- Question 3: In one minute each student produces 2 Kcal. How many Kcal do they produce in a day? Explain.
- Question 4: From the graph (Figure 5) (Morris, I. 2013), explain why there is a huge difference in the energy captured per capita between 15,000 years ago and nowadays.

Discussion

A lesson study (Isoda, M., Arcavi, A., Mena-Lorca. A., 2012) was conducted by teachers and researchers based on the transcript of the Cross-Border Class. Suggestions received from these individuals included:

- Given that the concept of "energy" is central and transversal to many STEM disciplines, it is worth exploring alternative methods that will allow the students to have a deeper

understanding of the topic. One suggestion is to use the metaphor of money for energy. Money, like energy, is not created; it is simply transformed.

• When the teacher explained that the amount of heat required to increase the temperature of one cubic meter of air was one quarter of the amount required for heating water, he could have invited the students to conjecture instead of simply stating the fact.

• Spend more time explaining the notion of captured energy. This is something that requires a shift in thinking.

• The first part is about energy concepts in Physics, Chemistry and Biology, whereas the second is related to History and Social Development. There should be a smoother integration between the first part of the class and the second part.

Following this experience, we are able to make certain recommendations for future Cross-Border Public Classes. This includes making sure to have a good Internet connection. Consider other more reliable and better quality video-conferencing services other than Skype. There should be a good sound system in each class and it should be tested prior to the lesson. Consider including a robotic system to automatically control the camera that follows the teacher and picks up the voice of the teacher clearly such as Swivl. The teachers in the remote locations should act as teaching assistants and have a strong understanding of the lesson. This will require more coordination and a more detailed lesson plan. This has the potential to greatly improve the learning experience for the remote students. This includes having comparable objects available for all of the students in each of the participating classrooms.

What are the challenges of Cross-Border Lesson Study for STEM Education?

We imagine education will continue to develop where cross-border STEM classes we described in this paper are more common. Several questions emerge for continued development:

1) What is required to be ready for cross-border STEM classes?

Besides the technological and internet infrastructure, we can foresee challenges in coordination across schools and teachers with population of students, different priorities, different schedules, and different curricula. These challenges can all be worked out, but the effort is not small. Probably a university or an agency focused on Cross-Border Lesson Study can be very helpful at least on the initial phases.

2) What will be the impact on socio-emotional life of students?

We see a great opportunity to generate an innovative and disruptive transformation on classroom practices. This first pilots shows that Cross-Border Lesson Study and Public Classes

can have a enormous impact on students engagement and socio-emotional attitudes to STEM and schooling.

3) What will be the impact on student´s learning outcomes,

Interclass activities can boost intra class collaboration and learning (Araya, R., et al., 2014)., Araya, R., Aguirre, C., Bahamondez, M., Calfucura, P., Jaure, P. (2016). In interclass tournaments it is known that synchronous activities across school produced a phenomenon called "social facilitation" (Araya, R., Aguirre, C., Bahamondez, M., Calfucura, P., Jaure, P., 2016). that improves performance, particularly of academically weak students, reducing the gap with academically string students. This phenomenon was first found and studied by Trippet in a classic study from 1898 (Araya, R., et al., 2014). Triplett found that cyclists were faster when competing against others than when racing alone. This effect has subsequently been found in other tasks and other animals (Zajonc, R. B., 1965 , Zajonc, R. 1968) . Cross-Border Lesson Study and Public Classes should have a similar impact on learning. However, this is something that requires further research in order to be should be empirically measured.

4) What will be the impact on teacher professional development?

Cross- Border Lesson Study facilitates the connection between teachers and the constructions of powerful active networks for teacher professional development.

5) What will be the impact on changing teaching practices?

According to Cuban (Cuban, L., 2013) there is ample evidence that schools have not changed dramatically over the last few centuries and classroom practices are a black box. The network of teacher collaboration and working together with their own classes can increase the exploration of alternatives and accelerate transformation of teaching practices.

6) What will be the impact on reducing teacher isolation?

For centuries teachers have been working isolated with their classes. Labaree (Labaree, D., 2010) compares a school with a typical nuclear power facility. Since every component of a nuclear facility is causally interrelated with the others, it is much easier to trace the source of any deficiencies and fix them accordingly. Schools, conversely, are composed of completely independent units: isolated classrooms. If one classroom performs well, it does not immediately produce an effect on parallel classrooms. Cross-border connects classrooms and teachers. This should facilitate improvement, similarly to what happens on other sectors as in the nuclear facilities.

7) What will be the impact on building learning communities?

According to Avent (Avent, R., 2016), wealth has always been social, and one of the critical challenges of the digital era will be how to share social wealth. Cross-Border Lesson

Study and Public Classes are powerful tools for integrating students into a globalized world, as well as a promising strategy for introducing students from more underprivileged areas to networks of students with more resources and social connections. They are powerful mechanism for constructing and enhancing students´ social wealth.

This paper described some of the requirements and challenges for Cross-Border Lesson Study and Public Classes. With more students, teachers, and researchers participating in cross-border lessons, the challenges will become fewer and the requirements common to all.

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