

# Developing Global Awareness and Twenty-First Century Skills Using PBL on Ocean Pollution\*

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This paper discusses a global collaboration on ocean pollution between two science classrooms: One is in the Southeastern China and the other is in the Southwestern United States (US). The primary goal of this project-based learning (PBL) collaboration was for students to explore the content-related concepts of ocean pollution and to conduct research on oceanic water quality when polluted with trash. The project was designed to provide participants a cross-cultural environment for understanding a diffuse global environmental issue by developing students' global learning (i.e., global awareness and global competencies) and sustainability. Students reported they valued global collaboration and gained skills of critical thinking, and teachers reported that language and technology were premier tools for global collaboration which provide students an opportunity to get a sense of worldwide ecological community. This collaboration provides insight to how cross-cultural PBL experiences may be a successful strategy for promoting high school students' awareness and consequences of global environmental issues.

*Keywords:* 21st century skills, environmental science, global collaboration, ocean pollution, project-based learning

## Introduction

Pollution is no longer a local or even regional issue. Non-point pollutants can travel across long distances from their point of origin, across environmental boundaries and international borders. This is particularly true of marine (ocean) pollution, where marine debris (trash), 4.8 to 12.7 million metric tons worth, are deposited and dispersed in the world's oceans per year and projected to increase tenfold by 2025 (Jambeck et al., 2015). Since 80% of the ocean trash derives from human behavior on land (National Oceanic and Atmospheric Association, 2015), it is important for individuals who live inland understand how their actions of waste disposal and stewardship impact the ocean and the people who live alongside it globally. As the human population grows, ocean pollution falls within the purview of the United Nations Educational, Scientific, and Cultural Organization's (UNESCO, n.d.) aim for education for sustainable development (ESD). A key

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component of ESD is that individuals should act responsibly by taking an active and culturally responsive role in fostering a sustainable world.

For decades, ocean currents have been porting more than 4.8 million metric tons of plastic waste into the world's oceanic gyres from land-based sources, negatively impacting more than 660 marine species (Jambeck et al., 2015). The *Nanfang Daily* newspaper reported in 2017 on a stranded whale died in the South of China. From its mouth, trash such as plastics and foams, poured out. In the article, experts warned that ocean trash has become the major threat to sea creatures and called for join the movement of protect our ocean (Wang, 2017). Yet, ocean pollution is a too a human concern, as ocean pollution may seriously harm human health, regardless if they live near an ocean (Burns, 2007). Individuals from all over the world voluntarily participate in trash cleanup (Ocean Conservancy, 2016), yet are not preventing the real problem of trash entering into the oceans. This would require fundamental shifts in individuals' global awareness by understanding of the science of trash on ocean and impacts on planet-wide human health, which can foster the systemic and long-term changes in human behavior to end the problem. This paper provides a classroom vignette of a global collaboration on ocean pollution between two schools: One is a coastal high school geography classroom located in the Southeastern China and the other is a landlocked high school environmental science classroom located in the Southwestern United States (US). In an international project-based learning (PBL) format, secondary students explored the content-related concepts of ocean pollution and conducted collaborative research on oceanic water quality by taking samples from a polluted oceanic source in China. The aim of such classroom-based interventions is to develop the global awareness and competencies needed among students (across the world) to foster long-term sustainable behaviors and practices, that is a ESD goal for a more sustainable world (UNESCO, n.d.).

### **Issues Addressing Global Oceanic Trash**

The Ocean Conservancy (2017) launched the organisation of the *International Coastal Cleanup* nearly 30 years ago. Since then, approximately 12 million people from all over the world have rallied to participate in the campaign to protect ocean by collecting and documenting the trash along coastline. From their efforts, they have cleaned up more than 210 million pounds of trash in recent 30 years. However, few students participate in this movement, begging the question of why are students no engaged in this campaign? Across the world, students sit in classrooms, learning environmental science, yet have little access to first-hand experiences to explore oceanic pollution to not only appreciate the scope of this issue, but also empower them to action. According to the research by Wong (2003), Chinese students acknowledged the importance of and urgency for preserving the environment, but reported that they felt powerless to help. Wong concluded that "rising environmental awareness among these young intellectuals would ultimately spark increased environmental activism in China" (p. 536). Research by Hausbeck, Milbrath, and Enright (1992) found that students wanted more experiences to engage in environmental education, so they could develop their knowledge to act on their environmental concerns. This paper posits that through internationally focused classroom activities, students may develop an in-depth knowledge and understanding of an international issue (global awareness) and skills in working with individuals from different linguistic and cultural heritages (global competencies) (Hunter, 2004; Van Roekel, 2010). It is this student-centered activity in where learners of different cultures through technology improve their global perspectives while remaining in their home countries that facilitates global learning (Gibson, Rimmington, & Landwehr-Brown, 2008) that "empowers people to change the way they think and work towards a sustainable future" (UNESCO, n.d., Para. 1).

### **Global Standards in Environmental Science Education**

In China, oceanic geography is an elective course in high school. In Grade 11, students learn about various concepts related to the ocean: coastal line and oceanic equity, economic-based oceanic development, and understanding oceanic environmental problems and protection. Regarding to the part of oceanic protection, per China's National Geography Standards, students should be able to:

- (1) analyze research papers;
- (2) identify the main source of oceanic pollution and its dangers to an oceanic environment;
- (3) explain common strategies to protect the ocean.

These standards reflect the Chinese national policies of sustainable development and the implementation of ESD into high school geography curricula (Wang & Wei, 2007).

In the US, earth and environment science is course mandated for high school graduation whose standards vary from state to state, but has similar content to the Next Generation Science Standards (NGSS Lead States, 2013) and Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; Laboratory, 2013). The NGSS focuses on the disciplinary core ideas, practices in a real world and cross-cutting concepts. Whereas the Common Core State Standards engages students with activities, such as reading, writing, research, and making real-life data have driven connections to build up deep understanding and skills. For example, using scientific investigations seeks the cause and effect of impacts on ocean pollution, students may be asked to identify solutions by using a systematic model. However, oceanic content and literacy is not explicit within the NGSS (Strang, 2012).

### **Project-Based Learning**

Project-based learning or PBL helps address large, real, and complex problems that related to the curriculum (Savoie & Hughes, 1994). Therefore, this global collaboration on ocean pollution was designed as a PBL where students were expected to collaborate, explore, analyze, and communicate their findings by using an authentic problem (Siemens, 2005). PBL has evidenced success in motivating to students (Bell, 2010), as PBL allows students to work in group to enact something locally through real and immediate action from their classroom activities. This global collaboration used a PBL format as it requires consideration of "task structure" for solving a real problem (Gibson, Watters, Alagic, Rogers, & Haack, 2003). Task-structure is defined as planning what to do and how to do, and is important because it helps complete task in an effective way. In doing so, students can be guided to take responsibility for their interests (Larmer & Mergendoller, 2010).

### **Global Collaboration**

Global collaboration is defined as a set of interactions, with diverse levels of complexity, based on shared task goals and activities engaged internationally (Lee & Tsai, 2011). Global collaboration is a valuable pedagogy for 21st century education (Neal, Mullins, Reynolds, & Angle, 2013), ascribed to fostering global-mindedness (Zahn, Sandell, & Lindsay, 2007) and global citizenship, where individuals take personal and social responsibilities for life and career planning and for a better world (Neal et al., 2013). Global collaboration can enable teachers and students to connect people globally without leaving their country or losing their identity (Lindsay & Davis, 2012) as well as improve people's understanding about diversity and appreciation of it (Lock & Redmond, 2006).

As online technology increases (Chang, 2005), there is new access for classroom based global collaborations. Through technology, collaboration can be delivered synchronously (real-time interaction) or

asynchronously. Asynchronous online formats have shown that they students understand the task structure in PBL activities, benefiting class discussion and individual reflection (Nelson, 2010). As the issue of time difference exists in global collaboration, asynchronous communication is needed. Through the use of technology, discussion forums that allows students' to interact at their convenience expand a traditional classroom beyond bricks and mortals to a flattened classroom (Lindsay & Davis, 2012). Since all materials used and discussion discourse can be readily documented (e.g., written correspondence), it may help students to develop reflective skills and practices (Nelson, 2010).

### **Educational Outcomes of Using Global PBL on Ocean Pollution**

**Content/Cognitive skills.** The outcomes of this global PBL collaboration included content understanding and global learning. By reviewing literature, collecting data from water sample in Local Ocean, sharing and communicating, students developed knowledge, scientific research skills and understanding about ocean pollution. Through international collaboration, students fostered the habits of authentic learning: working in collaborative groups; asking questions; engaging in on-going group negotiation of task structure; and active participation in discussion forums to co-construct knowledge of this complex and global problem.

**Twenty-first century/non-cognitive skills.** Twenty-first century skills are defined in a variety of ways, but largely concern the skills, students must cultivate to be effective users of technology, communicators, problem solvers, and global citizens (Dede, 2010). The *Assessment and Teaching of Twenty-first Century Skills* (Griffin, McGaw, & Care, 2015, Partnership for Twenty-first Century Learning [P21], 2007) has produced a framework for 21st century skill development with standards that fall into four categories: ways of thinking, ways of working, tools for working, and living in global world (Neal et al., 2013). As PBL engages students in intellectually challenging problems and focuses on research, brainstorming, discussion, and presentation (Larmer, Ross, & Mergendonner, 2009), it too develops students' skills of critical thinking, creativity, collaboration, and communication that are needed in 21st century (Larmer, Mergendonner, & Boss, 2013). PBL has been advocated for a strategy for developing 21st century skills and competencies (Bell, 2010). Gibson et al. (2008) described that, "Global learning is a social constructivist learning activity that involves experiential and project-based learning" (p. 13).

**Cultural exchange and awareness.** Information and communication technologies like learning management systems may be a useful tool that facilitates cultural exchange and knowledge sharing in English among students who are geographically scattered and culturally diverse (Zakaria, Amelinckx, & Wilemon, 2004). Positive cultural sharing depends on the construction of intra-team's respect and cultural diversity understanding. Without an understanding of cultural differences, technology could foster conflict rather than facilitate a learning environment (Zakaria et al., 2004). To smoothly facilitate cross-cultural collaboration, it is necessary to introduce interaction norms prior to global collaboration. Moreover, in cultural exchanges, commonly used languages (i.e., English) plays an essential role in individual's cultural understanding (Ayyash-Abdo, 2001).

### **Classroom Intervention**

Two classrooms were observed, one is in China and the other is in the US, to explore how a global PBL collaboration aided students' understanding of global ocean pollution and the development global learning (i.e., global awareness and global competencies). Data were collected through interaction observations and online surveys to examine four categories of global learning: ways of thinking, ways of working, tools for working,

and living in the world.

### **Participants**

**The American teacher-partner was located in a suburban area located in the Southwestern US.** There are approximately 90,000 residents in this city, which has too experienced rapid growth in recent years. Participants selected were nine American students and their teacher in a high school Advanced Placement (AP<sup>®</sup>) Environmental Science course from a school within this area.

**The American teacher-partner is a seven-year veteran environmental science teacher.** In this class, he utilized student-centered instructional strategies including video-producing and PBL. For example, he taught his students environmental science by investigating air pollution caused by various kinds of vehicles. This teacher volunteered to participate in this project because of his interest in global collaborative activities.

**The Chinese teacher-partner was located in Southern of China, a large metropolitan area of 20 million day-time residents.** Participants selected were six Chinese students and their teacher in a secondary geography course from a school within this area. This school is academically competitive and students are encouraged to engage in all kinds of academic activities both nationally and internationally. Hence, global projects are welcome.

**The Chinese teacher-partner is a 15-year veteran geography teacher.** In his class, he utilized student-centered instruction including hands-on activities and emphasized students learning with the local context (environment). For example, he taught his students not only how to use Google Earth as a tool to investigate a local quarry about pollution, but also how to interview nearby residents about how badly pollution has influenced their health and impacted their daily life. This teacher volunteered for this study based upon his expressed desire to meet international colleagues and learn novel pedagogies.

### **Planning the Global Collaboration PBL**

The eight-week collaboration began in September of 2016 and ended in November of 2016. The global collaboration had these goals: developing content understanding (ocean pollution), 21st century skills (problem-solving), and global learning (global awareness and global competencies through multicultural understanding). Both Chinese geography and American science standards guided the content presented during the PBL unit, which is important to link the shared classroom activity to shared goals and curriculum of both schools (Gibson et al., 2003). The following were the driving questions that guided the PBL structure and implementation:

1. What causes ocean pollution?
2. How does ocean pollution impact human health and how can we measure this?
3. What can we do to protect our oceans?

To measure the desired goals, an assessment system was planned. It included formative assessment (discussion and observations) that allowed students and teachers to give feedback to help guide the learning process. Global learning is a “student-centered activity rooted in dialogic co-construction of meaning between learners of different cultures”. Therefore, peer-to-peer discourse was a critical feature of student interaction in the PBL (Gibson et al., 2008, p. 13). The summative assessments, a lab report on water quality and a research paper, evaluated students’ understanding and mastery of the content (Dixson & Worrell, 2016). Scoring rubrics were implemented to assess students’ abilities upon participating in the global PBL in the four categories of 21st century skill development: ways of thinking, ways of working, tools for working, and living in the world.

Students participated in the assessment process by conducting peer-reviews and reflections for self-evaluation.

The nine American students and six Chinese students who were placed into three small groups. This decision was based upon literature describing that PBL facilitated knowledge building through social interaction (Glaserfeld, 2011), to help acknowledge individuals' diverse perspectives (Siemens, 2005).

Because technology was vital to connect the American and Chinese students, video conferencing (WeChat), Web-based tools (Wiki pages or Wikis), and a learning management system (Canvas) were used for students to asynchronously interact (e.g., collect, share data, and converse) and track learning process.

**Addressing 21st century skill development.** A critical feature of this global collaboration PBL is not only addressing science content, but also 21st century skills. These skills include ways of thinking and working, using the tools that foster collaboration, and an appreciation of an interconnected world (P21, 2007).

**Ways of thinking.** This global collaboration aimed to develop global awareness and global competency through PBL. This not only enriches school-based curriculum (Iwamoto, Hargis, & Vuong, 2016), but also fosters the 21st century critical thinking skills (Thomas, 2000). In this global collaboration, students developed their critical thinking skills by determining in what materials they were interested, cited specific references when writing, and used evidences to support their claims.

**Ways of working.** Through this project, participants were to gain a better understanding of multiple cultures and about effective communication, vital for a successful global collaboration (Lindsay & Davis, 2012). Through small-group discussions (starting with their favorite festivals and into the PBL itself), participants understood and developed an appreciation the uniqueness culture and individuals in the respective international classrooms. They helped each other build on ideas, co-constructing science and international understanding.

**Tools for working.** Students garnered learned skills in using various technology tools for successful communication and collaboration. Although the Chinese participants performed the collaboration during the school day, the American partners implemented the project informally, outside of classroom as a part of an existing environmental science club. Collaborative activity was performed on Canvas, a cost-free Learning Management System where student work could be tracked and archived. In addition to Canvas, participants communicated synchronously and asynchronously via the social media platform WeChat and the Webpage development software Wikis. This tool allowed for free-of-charge group video conference services for group communication and group data sharing respectively, both important to the success of collaborative projects (Lindsay & Davis, 2012). These tools aided in scaffolding communication in attempts to overcome language barriers and stem miscommunication issues (Vonderwell, 2003). In this case, technology was not a tacked-on component to the curriculum, rather a vital vehicle for facilitating students' learning.

**Living in global world.** The global collaboration integrated multicultural, global awareness, and civic perspectives into a school-based curriculum (Camicia & Zhu, 2012). An environmental problem requires next generation to think globally and to act locally. The collaboration was intended to provide students an opportunity to get a sense of a larger or worldwide ecological community. It is through efforts like these that empower students to make positive changes (changing behavior and mitigating pollution) for a better world (UNESCO, n.d.).

**Teachers' role.** To smoothly implement the PBL, it was vital for the teachers to provide on-going support for their students through:

- (a) facilitating introductions to schools and instructional facilitators involved;
- (b) justification of the global science collaboration and timeline;

(c) outlining the tasks of each week, including orientation, understanding the ocean pollution problem, sample collection, sample testing and analysis and project conclusion and reflection;

(d) communicating the means of formal communication and informal communication which help students learn to learning (Ackermann, 2001) are introduced;

(e) enforcing rules of etiquette related to cultural awareness (Negy, Shreve, Jensen, & Uddin, 2003), social awareness (Gutiérrez, 2008), and global awareness (Hanvey, 1982).

### **Enacting the Global Collaboration PBL**

In the initial implementation of the global PBL, there were designated activities (tasks) for each week of the eight-week collaboration. The task for week one was a digital handshake. The global collaboration began with a digital hand-shake, a type of personal or narrative storytelling (Robin, 2008) where students share a bit about one another and gain low-stakes experience communicating with technology (Lindsay & Davis, 2012). To develop relationships with each other and their peers' country, students are instructed to introduce the following details:

1. Personal information including age, ethnicity, grade level, favorite activity and languages spoken;
2. Future goals;
3. What they knew about one another other's respective countries;
4. Their favorite holiday with an explanation of why;
5. A question and answer session.

This interaction, although agnostic of science content, is important as social identity theory posited by Negy, Shreve, Jensen, and Uddin (2003) who suggest as individuals embrace their own ethnic (national) identity, the more positive views they hold or develop toward people of other foreign groups. Students were encouraged to ask one question to their global partners to develop their cross-culture understanding during digital handshake, which aims to make positive first impressions for global interactions and raise students' global awareness (Lindsay & Davis, 2012).

In the second stage, from the second week to fourth week of the global PBL, Chinese students visited local government department offices, such as Urban Planning, Land, and Resources Commission of Municipality to obtain relevant information on ocean pollution, while US partners conducted online research on existing problem of ocean pollution worldwide. As defined in this paper, skill development was scaffolded for students through the following pedagogical processes: navigating inquiry, structure tasks, support communication, and foster reflection (Y. S. Hsu, Lai, & W. H. Hsu, 2014). Advised by teacher, Chinese students visited local government agency and American students' online reviewed problems caused by ocean pollution worldwide, especially in China. Based on Wikis initially created by the teachers in Canvas, each group synthesized points of view of the findings from sources they chose. They were explained why citation was needed and instructed how to use MLA format to cite the sources of their findings. In addition, students reflected their concern on the problem of global ocean pollution, especially in China. In peer-review, students made suggestions on any needed improvement groups' Wikis.

Students presented their ideas and responded to their group members on weekly discussion board. Through reviewing students' discussion discourses, teacher commented on student's scientific literacy, such as writing technique and scientific argumentation that includes claim, evidence, and conclusion, and reminded them of cultural difference. One comment from an American student was:

The findings in the following sources are great, but they are all in Chinese. Some of the students cannot read Chinese. To our Chinese partners, could you summarize the content and importance of the following sources? You can create section title to organize the following information. Please note that you are not trying to translate these WebPages into English. You are trying to bring out the most important information from each of the webpage that is relevant to our collaboration here.

In the final stages of the PBL, after the students performed their background research, students investigated the water quality of the Chinese ocean to compare data, in which they were tutored by teacher and expert invited from outside of school to analyze data. Their final task for students was to make connections to local environmental protection organizations to call for ocean protection.

### **Reflection**

Overall, students and teachers held positive attitudes towards the global collaboration. In surveying students, overall they valued having multiple perspectives in global collaboration (Tichnor-Wagner, Glazier, Parkhouse, & Cain, 2016). Yet, they reported that the interaction level among students was low resulting in a lag in the planned timeline. Even though this project was not completed in the allotted time frame, students expressed a desire to continue. After the winter holiday, students independently collected data and analyzed the quality of water of the ocean. Both groups eventually created their proposals to advocate people to protect the world's oceans. From the teachers' perspective the Chinese teacher partner reported how important language tool were for facilitating global PBL (Hunter, 2004). He used Google Translate to translate the students' discussion, although he himself did not understand the translation well. He felt that negatively impacted his ability to help guide and scaffold the PBL for his students.

Student's reflections online (Wiki and Canvas) were assessed through analyzing written and spoken communication, or discourses. There are five hierarchical reflection levels: reporting, technical, descriptive, dialogic, and critical used to explore the data (Gibson et al., 2003):

1. Reporting is just telling without reflection;
2. Technical describes reflection based on experience;
3. Descriptive is defined as analysis-based reflection;
4. Dialogic was self-discussion and reflective;
5. Critical presented multiple perspectives.

Based upon the researcher's observations, the level of both American and Chinese students' discourse was at technical level.

### **Discussion**

This global PBL collaboration had strong beginnings, but it did not finish in the time allotted. Response delays were common due to interruptions from classroom tasks and the school schedule, resulting in inefficient communication. Considering both Chinese and American students have heavy load in school courses, the timeline of this activity should have been designed to half a year, even longer. In addition, it is crucial for a successful implementation of a global collaboration to use technology in a meaningful way. To better facilitate collaboration, technology tools require careful scaffolding and used for both asynchronous and synchronous communication. Video and audio may have been differently to engage students for more effective communication (Herbsleb et al., 2000). If video-conferencings were used throughout the collaboration, it would



likely help global partners know and interact with each other. Challenges in the teachers' executing their roles played a role in the global PBL to successfully implement the global academic research, it is crucial for teacher to be an instructional leader in guiding students in higher level thinking skills (Lock & Redmond, 2006).

Positive outcomes of the collaboration indicated that students were reflective in their work evidenced by the predominately technical peer-to-peer discourse. This suggests that students were engaging in self-reflection, an often neglected component of critical thinking (King & Kitchener, 1994), which is a hallmark of 21st century skill development. Despite the inability to complete the PBL task in eight weeks, students continued in their collaboration outside of the prescribed class time. This helps support the research that PBL is motivating (Bell, 2010), even in a global context. Positive reports from students suggest the global PBL aided in their global awareness and global action, where they advocated locally for stemming oceanic pollution. This is encouraging for the landlocked American students to demonstrate action for oceanic pollution, as people are less likely to act on environmental concerns that do not immediately affect them (Schultz et al., 2005). Research has shown that students develop a robust global awareness by studying abroad (Marion, 1980), but few students have access to those experiences due to the issues of access. Further research is needed regarding global PBL experiences, that if they may provide (even if modest) increases in students' global awareness, students in their own classrooms may too reap the benefits of having a global, 21st century mindset with sustainable behaviors.

### Conclusion

True collaboration requires participants think together although being (geographically, temporally, culturally, and linguistically) apart. Due to distance and cultural difference, the challenge for supporting true collaboration rather than only sharing information existed. Distance matters, although we are able to bridge to make richer communication for people apart than before (Törlind, Larsson, Löfstrand, & Karlsson, 2005). The call for global learning is paramount in a globalizing world, students (Hausbeck et al., 1992; Wong, 2003), and nations (UNESCO, n.d.) alike want to grow knowledge in global understanding and sustainability. Therefore, it is imperative to develop learners with global mindsets can create individuals who perceive themselves as connected to the world community and develop an awareness of their responsibility for its members (Hett, 1993). By providing students with global, PBL-based, learning experiences like this, we hope to provide educators actionable tools to implement the UNESCO ESD mission in empowering the current generation to create a sustainable future.

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