Underwater Web Cameras as Tools for Motivating Students to Engage in Inquiry-Based Learning of Marine Science Topics.

by

Mike Irvine
BA, University of Victoria, 2011

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

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In an attempt to motivate students to engage in technology supported inquiry-based learning of marine science topics and ocean literacy. This M.Ed project proposes that underwater web cameras are effective tools for facilitating student learning in these areas. Through the use of underwater web cameras, students and teachers can connect to marine environments in real-time by observing and engaging in inquiry-based learning collectively. Underwater web cameras allows access to live video feeds from anywhere, any time of day and through all Internet capable devices, promoting further student engagement largely without spatial or temporal constraint. Real-time interactions with marine environments have the potential to improve engagement with marine science when compared to traditional pedagogical approaches. Research suggests that real-time underwater video feeds provide an engaging presentation of marine environments and encourages students to pursue marine science careers. In addition, online web streaming can facilitate real-time discussions between students and scientists. Students can hear and speak with researchers that are underwater instantaneously, inquiring about the various marine environments they are observing. The educational importance of these kinds of interactions, promote participatory science, STEM and ocean literacy. Underwater web cameras give students the opportunity to explore and discover the richness of the ocean, motivating students to potentially engage in ocean stewardship.
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Chapter 1

1.1 A Personal Journey

Four years ago, I decided to become a certified open water diver. This decision catalyzed an abrupt reformation of my life back to the path I was perhaps supposed to be on. I come from a family of divers, my grandfather was a diver and underwater engineer, my father was a scuba diving instructor and met my mother during her open water scuba certification. Growing up surrounded by the ocean and with parents that were divers was a unique experience. I came to love the ocean through my family; my older brother, sister and I would all go fishing, snorkeling and camping together on the Gulf Islands off the coast of British Columbia, Canada. I remember how excited I was when my father surprised us with our first snorkeling experience. It was the first time I had been able to see the amazing life and diversity we have off of Vancouver Island. Snorkeling allowed for my first real glimpse into the ocean, I remember feeling like an adventurer discovering a new world. The Salish sea territory surrounds much of lower Vancouver Island and is a nutrient rich marine ecosystem that provides for a diverse marine community. It has been said that the Jacques Cousteau society rated the waters off of Vancouver Island as one of the top scuba diving sites in the world and the divers in my family agree (Moore, 2011). These kinds of experiences have helped to shape my understanding of the importance of connecting with marine environments. However, roughly fourteen years ago there was a diving accident while my father was testing a new re-breather unit and he drowned.
Against difficult odds he survived and began a long road to recovery. Subsequently, this event severed my connection to the ocean for many years. Over ten years later, in October of 2010, I became a certified diver and began a new mission to engage, entertain and educate students about the ocean. Going diving brought back a flood of great memories, reconnected me with my family roots and reengaged my desire to explore and discover the marine world. During this adventure, I have been fortunate to meet and work with an amazing community of ocean enthusiasts who have influenced this research.

Since 2011, I have been providing live dive events, which are video and audio feeds that allow local students and the public to see, hear and communicate with divers, at Fisherman’s Wharf in Victoria, British Columbia. The core goal has been to engage, entertain and educate students about marine awareness and ocean literacy. On June 8th 2014 the Fish Eye Project, a non-for-profit that I co-founded in 2013, began streaming Live Dives globally which connected people from distant places and spaces to the ocean (fig 1). Fish Eye Project’s current system allows students to interact with marine environments on any Internet capable device where they can instant message their questions via Twitter, Facebook or on the Fish Eye Project’s YouTube Live channel.

Before each event, we weave a narrative about the history of the dive site, the technology used, scuba diving equipment and how we use these technologies to perform a live event. In addition, we setup streaming stations at different locations that provide extra hands-on activities such as touch-tank aquariums provided by World Fisheries Trust (World Fisheries Trust, 2014). Through informal instruction and inquiry based learning, people from around the world have been able to participate in the Live Dives. Their questions drive the experience and exploration of the underwater safari that Fish Eye Project
provides. In my study of live events, a marine expert utilizes an underwater camera and an intercom scuba mask that connects students personally to marine environments.

![Image of students interacting with a diver](image)

**Figure 1: Students Interacting With the Diver**

In my experience, a Live Dive has an encapsulating effect that facilitates students' interest in marine biology, and in multiple occurrences, parents have reported their child's continued engagement with marine science topics following a live event. This is a possible example of the motivational capacity of using an underwater web camera to engage students in science inquiry and marine topics. Technological challenges are constantly a factor with every event, but with adequate time before each Live Dive, there have been no technological issues that our team could not resolve.

Between 2013 and 2015, I co-founded a company called Subeye Technology to develop underwater cameras and innovative solutions for web streaming. In partnership
with Eagle Wing Tours, Subeye placed its first ‘seal cam’ to monitor harbour seals (Fig 2). Within the first week of web streaming, there were over one thousand viewers that tuned in nationally and internationally. These numbers were reached with minimal marketing of the web cameras to test public interest. There is a want and need for students of all ages to connect with marine life in real time. The seal cam has been streaming online daily for over a year now and the number of viewers has grown exponentially. After the first year, the seal cam has had over one hundred thousand views from over one hundred and thirty countries.

Figure 2: Live Seal Camera at Fisherman’s Wharf

1.2 Statement of the Problem and Rationale for the Study:

Current technologies developed and used for technology-supported inquiry learning (TSIL) focus primarily on modeling phenomena and processes, creating simulations of actual environmental conditions, support of visualizing and analyzing qualitative data as well as sharing this data and constructive ideas online (Littleton, Scanlon, & Sharples, 2012). TSIL can provide a means to structure and support argumentative discussions and
host relevant information online. Each program, mainly utilizes simulations and models created from pre-collected data as a means to structure the process of inquiry. A significant challenge with TSIL, as Edelson, Gordin and Pea (1999) mention, is motivating students to engage in inquiry meaningfully. Inquiry based learning requires a greater amount of motivation from students when compared to traditional educational activities (Edelson, et al., 1999). Motivation is the outcome of interest in the investigation, results and implications of a subject. As mentioned by Edelson et al. (1999), without a student’s interest in the subject they will not adequately engage in inquiry processes. Current TSIL studies have not adequately addressed this challenge. This research argues that underwater web cameras merged with TSIL can assist with overcoming the challenge of motivating students during inquiry processes.

With the addition of underwater web cameras, students can engage in inaccessible environments, such as the ocean, in real-time and potentially be motivated to engage with marine science topics. Research has shown the motivational impacts of real-time virtual interactions with divers to engage students in marine science topics. In light of marine degradation, it is imperative that students’ understanding of ocean literacy increases. In an effort to increase ocean literacy and stewardship, it is important to engage students in marine science topics through a new form of TSIL.

1.3 Context of the Project:

1.3.1 Ocean literacy

Dr. Sylvia Earle (2009) once said “knowing is the key to caring, and with caring there is hope that people will be motivated to take positive actions. They might not care even if they know, but they can’t care if they are unaware.” However, it is strikingly obvious
how unaware many people are of the major issues and impacts we are all having on our oceans. In this century alone, humanity has decimated and destroyed ocean systems that we now understand to be vital to the sustainability of all life on Earth (Earle, 2009). As Dr. Sylvia Earle points out in her book titled The Ocean is Blue, “the ocean drives our climate and weather, regulates temperature, absorbs much of the carbon dioxide from the atmosphere, holds 97 percent of Earth’s water, and embraces 97 percent of the biosphere” (Earle, 2009, p.17). Without a healthy ocean, there is a serious risk of compromising climates, weather, temperatures and breathable air.

Greenhouse gas effects are a major threat to marine ecosystems due to a chemical reaction that occurs when carbon dioxide mixes with the ocean. This reaction is called ocean acidification (Ocean Networks Canada, 2014). A recent study by O.Hoegh-Guldberg et al., (2007) measured carbon dioxide concentration in the atmosphere and analyzed the effects of increased temperatures on ocean environments. Results demonstrated that carbonic acid was being generated as a reaction to increasing carbon dioxide levels in the atmosphere. Increases in CO2 absorption noticeably affects the ph. levels of near shore environments, such as coral reefs, and decreases marine growth and recovery (Reyes-Nivia et al., 2013). For example, local waters off the coast of Vancouver Island, Canada, have also experienced impacts from ocean acidification. Island Scallops Hatchery has had devastating mortality rates on their oyster farms as a result of increased acidity (Picard, 2014). There are ample sources researching the effects of greenhouse gases as well as the exploitation of ocean resources, which demonstrate the massive repercussions to marine life (Ocean Networks Canada, 2014; Earle, 2009; Norse & Amos, 2010).
In addition to overfishing, pollution and deep sea trawling, the technological innovations of the 20th century, have allowed oil and mining industries to freely exploit marine sites. Ocean dredging is a relatively new industry that combs large areas of the sea floor in search for valuable minerals; however, this process also combs any and all marine species, which are grounded, sifted and disposed of as unusable waste material (Deep Sea Minerals Project, 2009; Earle, 2009). Ocean dredging has almost zero regard for the treatment and care of the marine sites that are combed; however, even more disturbing is the extraction of oil and the eventual accidents that occur. A recent example is the oil platform Deepwater Horizon, which erupted and sank in 2010 after a series of explosions (Norse & Amos, 2010). The result of the catastrophe caused a massive oil spill in the Gulf of Mexico and an estimated 205 million gallons (4.9 million barrels) of crude oil spread across 600 miles of beaches and wetlands (Norse & Amos, 2010). Researchers are still reporting the effects of this event on coastal communities and a number of species on land and at sea. The current treatment of ocean ecosystems gives rise to the need for an increase in ocean literacy.

1.3.2 Technology Supported Inquiry-based learning

Inquiry-based learning, as defined in this research, is a pedagogical approach that promotes the exploration of the natural and material world. From this exploration, students ask questions which leads to discovery and testing each discovery in order to further their understanding (The National Science Foundation, 2008; Power, 2012). Inquiry-based learning allows students to acquire new knowledge that will be
incorporated and compared with their existing knowledge, which is fundamental to the practice of science (Edelson et al., 1999).

Technology supported inquiry learning offers extensive support to multiple aspects of inquiry-based learning as mentioned by Blumenfeld et al. (1991). These include a potential of enhancing interest and motivation, providing access to information, allowing active manipulation of representations, structuring the process with tactical and strategic support, diagnosing and correcting errors, and managing complexity and aiding production (Blumenfeld et al., 1991). Underwater web cameras as part of TSIL, allows students to explore and discover marine environments in real time, providing students with the opportunity to apply existing knowledge to their observations. Viewing marine environments virtually in real-time has the potential to enhance interest and motivation to pursue deeper understandings of marine science topics. The ocean is still largely unexplored and grossly undervalued in curriculum; however, the unknown nature of the ocean uniquely presents itself as a perfect subject for an inquiry based learning model.
Chapter 2

2.1 Literature Review:

This section provides a review of previous and current technology supported inquiry based-learning examples, marine science education, and ocean literacy principals in an effort to map a landscape of blending marine science with TSIL. The final subsection includes the purpose and objectives of this research, focusing on the use of underwater web cameras as tools to motivate students to engage in marine science topics.

2.1.1 Examples of Technology Supported Inquiry Learning

There are many forms of technology supported inquiry learning, most of which focus on modeling phenomena and processes, visualising and analysing quantitative data, exchanging data and ideas online, structuring and supporting discussion, as well as cataloging online data bases (Littleton, Scanlon, Sharples 2012). Included in this section are three examples of TSIL that represent the diversity of what current TSIL projects offer. These projects will then be compared to the use of underwater web cameras as a potentially new form of TSIL.

2.1.1.1 Co-Lab

Co-Lab is an interactive virtual environment that supports collaborative discovery learning with a focus on the natural sciences. The four topics covered are: water management, greenhouse effects, mechanics and electricity (Van Joolingen et al., 2005). Utilizing a game-like design, using the structure of a building with corresponding rooms as a metaphor, Co-Lab assists high school and university students to explore and create
their own models of phenomena (Van Joolingen et al., 2005). Within the virtual environments, Co-Lab tools uniquely promote inquiry, modeling, and collaborative learning processes. During inquiry, students collect data from simulations, laboratories and databases supplied within the program. From the data supplied, students are required to explore the input and output variables through experimentation (Van Joolingen et al., 2005).

In this research there are five phases of inquiry: analysis, hypothesis, experiment design, data interpretation and conclusion; however, each phase has unique challenges including the correct formulation of hypotheses, poor experiment designs and difficulty extrapolating conclusions from data. Van Joolingen et al., (2005) argue that regulatory processes such as planning, monitoring and evaluating, will provide solutions to the challenges of inquiry processes. Furthermore, that using a model of progression with Co-Lab, students would begin with simplified simulated models that increase in complexity over the course of the topic.

Van Joolingen et al., (2005) argue that collaborative discovery learning is an important component for fostering student scientists. In addition, collaboration encourages higher achievement, increased success in discovering scientific mechanisms and promotes regulation of the learning task. The collaborative dynamic with Co-Lab expands the in-situ concept of distant partnerships between students in separate geographical locations. Using a chat tool, Co-Lab can facilitate virtual collaborations between students, allowing them to contribute to each other’s work.

Authors Edelson, Gordin and Pea (1999) note that a significant challenge many researchers of Inquiry-based learning face is motivation. Inquiry requires a greater
amount of motivation to engage students in science curriculum. Interest in the content of a subject is integral to affectively motivate a student to participate. Co-Lab’s level structure does show a degree of motivating students to participate in iterative processes of modeling; however, one third of the participating students required motivation from the teacher to engage in new cycles (Pinto & Couso, 2007). Although largely successful, one third is a significant portion of students that required motivation from teachers to engage in Co-Lab’s virtual environments. To reiterate Edelson et al. (1999), without adequate interest there is a serious risk of students participating in a disengaged manner or not at all (Edelson, Gordin, Pea 1999).

2.1.1.2 GLOBE

Global learning and observations to benefit the environment (GLOBE) is an international organization that focuses on student-teacher-scientist partnerships (STSP). GLOBE trains and provides teachers with materials to support their students to partake and contribute in earth science research. Students and teachers work together to collect data in their local environments, which is then shared with researchers via the GLOBE website (Wormstead et al. 2002). On the GLOBE website, quantitative data is entered into visualization tools such as maps, tables and graphs, which are accessible by other teachers and researchers for further analysis (GLOBE, 2015). Through this global initiative, students gain hands-on scientific experience and come to understand the importance of healthy environments and stewardship (Wormstead et al. 2002). In an article by Wormstead et al. (2002), the authors focus on GLOBE as an example of student-teacher-scientist partnerships, reviewing ways to improve the communication and collaborations between these groups. In 2001, there were over ten thousand schools from
over ninety six countries that joined with GLOBE to capture atmospheric, hydrology, land covered biology and soil data (Wormstead et al. 2002). This partnership provided an astounding collection of data that reported over five million measurements.

Globe is a form of TSIL that uses visualization tools, online archives for storing and analyzing quantitative data as well as exchanging data across distances (Littleton, Scanlon, & Sharples, 2012). GLOBE uniquely blends hands-on participatory inquiry-based learning in natural environments with online data and tools. Students and teachers are also encouraged to communicate through email with other global participants to collaboratively develop usable environmental data. A major benefit of GLOBE’s inquiry model is the physical interactions students have with their local environments. Teachers in Littleton, Scanlon, & Sharples, (2012) study reported high levels of student engagement due to the fun nature of the outdoor activities. As mentioned by Edelson et, al. (1999) interest in a science project is integral to the level of engagement and motivation required for the continued participation of a student.

2.1.1.3 Knowledge Integration Environment

The Knowledge Integration Environment (KIE) was designed to utilize online resources in an effort to promote student understanding of the nature of science (Bell, 2000). Knowledge integration is defined as “a dynamic process where students connect their conceptual ideas, link ideas to explain phenomena, add more experiences from the world to their mix of ideas and, restructure ideas with a more coherent view” (Bell, 2000, p.797). In Bell’s study (2000), 172 middle school students participated in a six-week experiment using KIE software tools. Using a debate project called ‘how far does light go,’ Bell examines argument building, use of evidence, addition of further ideas, claims
and measure process of students using the knowledge integration framework. The impact of an argument building software called SenseMaker and guidance software called Mildred were also examined as components of KIE. The process begins with a student stating their position on ‘how far light goes,’ from their statement a student would then explore and develop evidence to support their claim (Bell, 2000). Students are encouraged to infuse relevant knowledge from their own personal experiences and experiments previously performed to further refine their argument. Students are then grouped into teams to present their collective argument and discuss their claim with the class. Following the discussion, student groups reflect on the questions raised and restate their claim.

The KIE network uses a unique program labeled SenseMaker, to visually assist students in forming their argument in a graphical representation. Students are required to locate evidence they find on the internet that supports their argument (Bell, 2000). This data is then inputted into the SenseMaker software that displays all information as dots on a graph. After the information is collected, SenseMaker has a framing tool for students to group the different dots of evidence together to support the organization and structure of a student’s argument (Bell, 2002). In conjunction with SenseMaker, a program called Mildred prompts an explanation of why a student chose each piece of evidence and how it contributes to their argument. The combination of these two programs can benefit both the student in a supportive structure and the teacher for proper evaluation (Bell, 2002).

Bell (2000) concludes that KIE successfully achieved its primary goal of furthering knowledge integration utilizing both SenseMaker and Mildred. Bell (2000), notes that Mildred’s ‘hint’ option was a useful tool to promote autonomy. A student could request
multiple or minimal hints to assist with their evidence descriptions, allowing a student that does not want support to continue without interference. The final element of the scaffolded KIE framework was the importance of collaborative learning, especially the prompt to collaborate when using SenseMaker. In order to sustain the process of knowledge integration there needs to be activities that allow students to share their own knowledge and experiences collaboratively. These collaborations of shared knowledge enrich the claims made by each group of students, maximizing the goal of knowledge integration (Bell, 2002).

Technology Supported Inquiry Learning supports and promotes collaborative learning, knowledge integration, modeling of phenomenon, student-teacher-scientist-partnerships, global discussions and much more. However to reiterate Edelson et, al. (1999), a significant challenge that TSIL programs have is how to affectively motivate students to engage with science topics. Co-Lab and KIE’s programs do not adequately address the challenge of motivating students to engage in science topics. Co-Lab requires students to explore and analyze information about a virtual environment, during this exploration students are then required to provide a hypothesis about the input and output variables they discover in the simulated environment. In the Co-Lab study, teachers were required to motivate one third of the students to engage in the multi-level virtual environments (Pinto & Couso, 2007). Unlike Co-Lab, GLOBE’s approach utilizes local data collection from physical environments that are then input online to share with scientists and teachers around the world. Interviews from teachers participating in GLOBE’s in-situ model, mention that students were motivated to engage in the research they were conducting due to the fun nature of the outdoor activities. When implemented
appropriately technology can enrich inquiry processes and motivate students to engage in science topics (Littleton, Scanlon, Sharples 2012 ). In contrast to Co-Lab and GLOBE, KIE provides a question to illicit inquiry from students instead of encouraging students to discover and provide their own questions, there is also no mention of the motivation required by students participating. However as stated by Edelson et al., (1999), a significant challenge many researchers of Inquiry-based learning face is motivation. Inquiry requires a greater amount of motivation to engage students in science curriculum. Interest in the content of a subject is integral to affectively motivate a student to participate (Edelson et al., 1999). Underwater web cameras provide a possible hybrid between actual marine environments and virtual tools, improving upon the motivational benefits as seen in GLOBE and Co-Lab. In addition, underwater web cameras are the first step in engaging in knowledge integration, which would further students’ understanding of marine science.

2.1.2 Marine Science Education through Underwater Live Events

Underwater live events are the closest example to the powerful effects of using underwater web cameras to motivate and engage students in marine science topics. Live events allow students to connect with marine environments in a way that is typically reserved for scuba divers. Students can see, hear and communicate with divers through instant messaging or, directly. Both the JASON project and Bamfield Marine Science Centre provide positive data regarding the motivational impacts of using live events to connect students to marine science.
2.1.2.1 JASON Project

Currently there are two reputable organizations that use underwater web cameras that connect students and teachers to marine environments, this connection is called a live event. The first is the JASON Project: a non-for-profit outreach education program designed to engage middle school students in science, technology, engineering and math (Ba, Martine, Diaz, 2002). JASON situates its curriculum models on the use of multimedia applications such as web streaming video from research locations, online science based curriculum outlines, online educational games and online interactions with research experts (Ba, Martine, Diaz, 2002). A summative evaluation of the JASON Project in the State of West Virginia demonstrated the success of using live events to engage students in science topics (JASON, 2011).

The evaluation involved five teachers that received training from JASON, whom were initially interviewed to evaluate the curriculum quality, the training and support, the perceived impacts on students, and how to strengthen the JASON project (JASON, 2011). From these interviews four main themes were discovered and used to create a survey for the one hundred forty seven science teachers that were participating in the JASON project (JASON, 2011). Out of the one hundred forty seven science teachers participating, there were fifty-three fully completed surveys. In addition to interviews with teachers, four students participating in the JASON curriculum were interviewed for their perspective on JASON.

In more than one interview, teachers commented on how live events encapsulated their students’ attention, spurring questions and following interest into marine related topics. The report shows that live events motivated over sixty percent of students academically
to learn science and motivate students to consider science careers (JASON, 2011). Only five percent were reported as unengaged, while the other thirty-five percent had no response due to technical difficulties. The report mentions that teachers were challenged with technological issues, not having access to computers, poor internet connection or lack of computer literacy. Overall, the Jason Project demonstrates the motivational power of using visual interactions, with underwater sites, to encourage inquiry from students. The majority of the project’s success is also an indicator that an underwater web camera provides an effective bridge between the ocean and STEM subjects.

2.1.2.2 Bamfield Marine Science Centre

Live web streaming events are similarly used by the Bamfield Marine Science Centre to educate middle and high school students on marine science topics. The project Bridging the Gap with Ocean Sciences provides a combination of live dives and live labs that allow students to engage on site or at a distance, with marine science experts (Bamfield, 2010). A core principle of the project is ocean literacy, which focuses on students understanding that the ocean is relevant to everyone and to any geographic location in the world (Bamfield, 2010). In 2010, a summative evaluation of live events was carried out and made use of quantitative and qualitative data from the public education program educators at Bamfield Marine Science Centre, classroom teachers, organization educators and students from the province of British Columbia and Alberta. During each live dive, one of four topics was covered: coastal critter communities, acid waves, physics of diving, and species at risk. All live dives included pre-session learning activities to provide relevant background information for both teachers and students in preparation for a live dive lesson. Background resources were supplied in the form of
online multimedia such as YouTube, websites, photos, animations or other video sites. These resources promoted further in-depth learning and cross discipline discussions. After each live dive, post-learning activities using online multimedia were used to summarize the learning objectives. Each topic followed British Columbia’s Ministry of Education Prescribed Learning Outcomes and the Expected Learning Outcomes of Alberta’s Ministry of Education. The summarized evaluation demonstrated that live dives motivated students academically, showing a twenty six percent increase from pre to post testing on various marine science topics (Bamfield, 2010). Teachers also reported that their students retained the knowledge they had acquired during the live dives (Bamfield, 2010). An important connection made was between marine science and mathematical concepts, which supports the notion of integrating STEM subjects around the ocean. Similarly to the JASON Project, technological issues were factors, but overall the live events worked effectively in both projects. In both evaluations, academic motivation and interest in science were reported as a direct result of the live events.

2.1.3 Merging the Ocean with Science and Technology

In many ways, technology supported inquiry learning of science, technology, engineering and math (STEM) education lends itself as a potential solution to the current state and treatment of the ocean. In light of the global financial crisis, STEM education has been adopted by the United States to promote an innovation-based economy (Williams, 2011). The executive director for the national science teachers association, Francis Eberle, was quoted saying that “STEM education creates critical thinkers, increases science literacy, and enables the next generation of innovators. Innovation leads
to new products and processes that sustain [America’s] economy (Eberle, 2010)". An article from the National Research Council in 2011 outlined three reasons why STEM education is critical in the United States. Firstly, STEM fields in the past century have propelled the United States towards an innovation-based economy. Secondly, growing industries require workers with backgrounds in STEM making it crucial for students to prepare for related careers. Thirdly, many personal and societal decisions require scientific and technological understanding. Acquisition of STEM literacy "is vital for making informed decisions about health, environment and technology (National Research Council, 2011)." In relation to the ocean, this last point suggests that STEM literacy could yield an understanding of marine environmental issues and provide possible solutions to our current treatment of the ocean. In 2005, many reputable ocean science and educational organizations, created a document outlining the need for ocean literacy (Centers for Ocean Science Education Excellence et al., 2014). Ocean literacy is defined as an understanding of how the ocean influences an individual and of how that individual influences the ocean. In relation to STEM, an ocean literate person is able to make informed decisions about the treatment of the ocean and its resources. Ocean literacy and STEM literacy share the same fundamental concept that with understanding, students will be able to make informed decisions regarding human interactions with the environment.

My research focuses on the S and T of STEM, using technology to motivate students to engage in inquiry-based learning of marine science topics. Underwater web cameras connect students to marine science topics and provide a bridge into science and technology subjects. Both the JASON Project and Bamfield's Bridging the Gap with Ocean Sciences, mention the motivational impact of underwater web streaming on
students’ interest in science and science related careers. The JASON Project reported that sixty percent of students were motivated academically to learn science and pursue science careers. The test scores provided by Bamfield supported the motivational effect of live events, reporting a twenty six percent increase from pre to post test scores on marine science topics. In later interviews, teachers from Bridging the Gap with Marine Sciences reported that students retained the knowledge they had learned; however, other than teachers commenting on their students’ knowledge retention, there is no statistical information to support these claims. Bamfield did provide pre and post tests for live events, but did not provide follow up tests after the students finished the program. Multiple teachers participating in the JASON Project commented on the encapsulating effect of live events, which spurred questions and further interest into marine related topics.

Live events are not without their setbacks, they require proper Internet connection, Internet capable devices and technological understanding in order to engage participants. In each report from Bamfield (2010), JASON (2011) and Ba, Martine & Diaz (2002), technical difficulties were a main issue that had hindered the experience of live events. Close to thirty five percent of teachers using the Jason Project curriculum were unable to use the appropriate technology required to participate in the live events. Teachers of that thirty five percent commented on the lack of Internet connection in their schools or lack of computer access (JASON, 2011). Bridging the Gap with Marine Sciences also had technological difficulties, but managed to provide the tools required for live events and technical support for teachers (Bamfield, 2010). In my experience with live events, an
ample amount of time is required to set up each event and to prevent technical difficulties during a live dive event.

2.1.4 TSIL & Marine Science Projects

This section examines two marine science projects and reflects on the potential benefits TSIL can offer using underwater web cameras.

Baumgartner, Duncan, and Handler’s (2006) study focuses on student–scientist partnerships (SSPs) in two separate marine research projects that involve the assistance of middle and high school students. Using the SSPs model, researchers evaluate the educational benefits of students working with scientists on marine research projects as well as evaluate the benefits of having students as research assistants. The first research project involves forty-five, public and private high school students and six teachers that are required to attend a two-week summer program educating participants about shark biology and ecology. Following the program the teachers and students assisted researchers fishing for and tagging hammerhead sharks.

The field-based work required students to apply the knowledge they had acquired during the two-week workshop. The goal of the hammerhead research was to collect information about the growth, movements and population size of these sharks by using marking and recapturing techniques. With the assistance that students and teachers provided, researchers were able to collect the data required to estimate the survivorship and population size of hammerhead sharks. After two hundred eighty hours of fishing, students volunteered to provide a workshop and teach the information that they had acquired throughout the research.
The evaluation methods testing the knowledge acquisition and teachable knowledge of these students were determined by self-report surveys. Only twenty out of forty-five students participated in the surveys, which required students to rank their conceptual and teachable understanding of shark biology and ecology. The participating students were put into two separate groups that were supposed to fill out pre and post surveys. Group A completed the pre and post survey at the end of the study, whereas group B filled out pre and post surveys at the designated times as asked. The results demonstrated a significant increase in conceptual and teachable knowledge of shark biology and ecology (Baumgartner et al., 2006). Students had also created workshops that were assessed by the involved teachers to determine the student’s level of teachable knowledge. The teachers assessed students that were not in any of their classes to prevent bias; the results provided further support of the increase in the student’s teachable knowledge of shark biology and ecology (Baumgartner et al., 2006).

The second project Baumgartner et al. (2006) reviewed, involved one hundred forty high school students researching the habitat choice of mangrove blenny. The research was tailored specifically to blend with a unit on fish biology curriculum since all of the students participating were taking a marine science course. Mangroves were chosen because they are a local invasive species that are easy to study and preserve in high school labs. Most of the research conducted was classroom based with the exception of an optional field trip to see the lab of the head researcher, but not all students attended. In order to examine the habitat choice of the mangrove blenny, students designed, built and maintained aquariums. Within each aquarium, students placed empty oyster shells and other various types of habitats to determine if mangroves preferred oyster shells to
different habitats. Students’ responses were mainly qualitative and used presence and absence data to identify the habitat choice. In the end the researchers compared their findings with the students’ to affirm the result; however, due to observer bias the researcher did not use the data obtained by the students. The evaluation method of this research project was determined by the lab reports completed by the students. In the lab reports, students included explanations of their findings as to why mangrove blennies chose a particular environment. The important feature of this project was the opportunity for students to create and design their own experiments.

In conclusion, the shark tagging and mangrove blenny projects illustrated in their evaluation methods, that students acquired most of their knowledge through experimentation.

When applied to technology supported inquiry learning, the two marine science projects closely resemble GLOBE’s model of hands-on participatory research. Shark tagging involved outdoor activities, while the mangrove blenny project was carried out in a classroom. As noted by teachers participating in GLOBE, high levels of student engagement were due to the fun nature of the outdoor research activities (Wormstead et al. 2002). However, the shark tagging project require students to be able to access marine environments to practice hands-on research. This is problematic as most students do not have access to marine sites and will be unable to participate in hands-on data collection. Underwater web cameras would be a great first step and substitute for connecting students to these marine research projects. As an example, a camera could be placed in shark populated areas where students can get their first glimpse at the species they will be studying. Students would then be able to virtually connect in real-time to view these
sharks in their natural habitat and connect with researchers tagging the sharks. Although many students are unable to participate in the physical act of tagging sharks, they are still able to engage in real-time observations. This would act as an effective initiator to build interest in the marine science project, potentially motivating students to engage in further understanding of the importance of sharks and why they are being tagged.

The mangrove blenny project could have been enriched by underwater web cameras especially in comparing aquarium environments in the classroom to the actual marine environment the mangrove blennies were removed from. A significant benefit underwater web cameras provide for these projects are their ability to stream and record data that can be reviewed by students throughout the research projects. Web cameras also give students the ability to connect with marine environments that they are unlikely to see unless they scuba dive.

2.1.5 Purpose and Objectives of the Study

The purpose of my study is to examine if underwater web cameras motivate students to engage in ways that provoke questions and interest in marine science topics. The question driving this research is: Are underwater web cameras effective tools for motivating students to engage in inquiry-based learning of marine science topics. This study will contribute to a new form of technology-supported inquiry learning (TSIL), STEM literacy and ocean literacy. Some other questions of interest to this study (not limited to) include:

1) How can real-time video feeds motivate students’ interests and thought development?
2) Through observations, do students generate questions, discussion or explanation using prior knowledge?
Chapter 3

3.1 Methodology

This research fits within an exploratory case study model where the methodological framework of this research was roughly designed before the commencement of the research itself (Berg & Lune, 2012). This research is a pilot case study that hopes to increase the understanding and use of underwater web cameras as tools for initiating and motivating student engagement of marine science topics. In addition, this study will attempt to provide a new form of technology supported inquiry learning. This study observed a target group’s reactions of the phenomenon of viewing live underwater marine ecosystems in an effort to discover future theories. This exploratory approach, often negatively viewed as mentioned by Burg and Lune, is supported when in search of theory through the observations of natural phenomenon (Yin, 2003).

3.2 Methods

This study involved a single classroom of 15 students attending an elementary school in Victoria, B.C. The class represented a diverse group of learners in grades 4-6 and included students with special needs. Research was carried out during science classes over three separate days, each period lasted approximately one hour. The marine unit I facilitated was an introduction to modeling marine species’ interactions and interdependency, marine diversity, effects of ocean acidification and the interconnections between people and the ocean. This unit included three of the seven ocean literacy principals:
1) The ocean is a major influence on weather and climate.

2) The ocean supports a great diversity of life and ecosystems.

3) The ocean and humans are inextricably interconnected.

These three principals were chosen as they best fit this research project (Centers for Ocean Science Education Excellence et al., 2014). Weather and climate was the previous science unit before this study. The timely connection of the first principal acted as the perfect bridge into the marine unit.

This study used pre and post-surveys as the first method in an effort to measure each student’s interest in marine topics, if they enjoyed observing marine life and if they had begun to understand the interconnected relationship between people and marine species (Appendix B). The second method was the use of video recording to capture the reactions of students when the live feeds were first shown as well as their subsequent responses. At the beginning of each class two cameras were placed at opposite sides of the room to provide a clear view of each student and of the instructor. Key transcribed video clips were then coded using open and axial techniques suggest by Berg and Lune, to illuminate themes related to the research questions. Open coding in this research was the analysis of the transcript to preliminarily define key concepts and themes. From this initial analysis, axial coding was then applied to verify the accuracy of each concept and theme. Lastly, each concept and theme was then explored to find how each was related. Pre and post surveys were also used assist in identify the level of interest students had at the commencement and conclusion of this study. The pre and post surveys are discussed further in the results section of this paper.
3.2.1 Participants

The school that participated in this study is a private school is the first Science, Technology, Engineering, Arts and Math (STEAM) school in Canada. The school blends inquiry-based learning as a pedagogical approach to their science classes. Many of the students that participated in this study were already familiar with inquiry-based instruction. An article by Edelson, Gordin and Pea (1999) outline the need for adequate time and practice of inquiry techniques in order to overcome research challenges. As a research assistant to Dr. Mijung Kim, I observed and worked with these students for over eight months. A limitation of this pilot case study was that it only took place over three separate classroom session and may not be a substantial contribution to curriculum and teaching related research. However, already having access to these students and their affinity for inquiry techniques is the reason I chose this group for the study. With the support of the teacher, I also chose to lead the application of the marine unit. I have a diverse range of experience teaching in informal settings, but with only limited practice of inquiry instruction prior to this study. The choice to lead the unit was to better understand the practice of inquiry in comparison to the theory, but also because of my knowledge and experience with the technology and the curriculum design.

3.2.2 Lesson Design

This study adapted elements of lesson designs from Bamfield Marine Science Centre and the JASON Project. I began the lesson using a narrative approach, providing a brief history of Victoria’s inner harbor. I explained to students the implosion and explosion that occurred to the marine ecosystem due to the removal of a keystone predator, in this instance we were focusing on sea otters. I also included how human impacts on the
marine environment, through pollution, had additional effects that subsequently destroyed the majority of marine life in Victoria’s inner harbor; however, I concluded that Mother Nature is resilient and various marine species adapted to the changed environment. I then passed around marine booklets that I had created to help students identify species they observed during the live feed and important information about each one (Appendix A). The booklets were tailored for the marine life that would be seen on the two cameras being used for the activity. Students were required to work in groups of 2-3, sharing the marine booklets, to foster collaborative identification of species.

Following the conclusion of the narrative, a live feed from an underwater web camera at Fisherman’s Wharf located in the inner harbor of Victoria BC, was then shown to the class (Fig 3). I waited for student’s initial reactions to the live feed and from their observations, waited for questions related to what they were witnessing. After roughly 15 minutes of identifying species and key visual features of the Fisherman’s Wharf site, we then explored the Race Rocks camera feed, located in a marine protected area roughly 35 km away (Fig 4). Repeating the same process as before, I waited for student’s reactions and questions. After identifying species and key features of the Race Rocks site, the whole class worked together to create a food web of some of the species they had identified (Fig 5).
Figure 3: Live Underwater Web Camera at Fisherman’s Wharf
At the beginning of the second day, students were shown the live underwater web cameras again and asked to identify what they observed. Revisiting the cameras allowed
for more data collection of student’s reactions to viewing marine life live and assisted to remind students of what they had seen prior. The class as a whole completed the food web and using the marine booklet began to look at the interconnections between each of the species in the web. After a brief discussion, I asked students if they knew of something that most of these species shared in common. Most of the species in the marine booklet and on the cameras have a key feature to their composition that they all share. The main feature is calcium carbonate, which most marine species with any sort of structure require to form their body (Fauville et al. 2011). A student recognized this, which allowed for a transition into discovering what calcium carbonate is and why it is important for these species to absorb it.

Due to time constraints, two experiments were already setup to test the reaction of CO2 as it is absorbed by water and how the acidity of water can dissolve calcium. The idea for both of these activities was attributed to the teacher, Roberta McDonald, as a great fit for the lessons. The first step was showing students a PH scale referencing the change in colour from alkaline (blue) to acidic (red) (Fig 6). Before each experiment students recorded their claims and evidence to support what they thought would happen. The first experiment used a blue solution called bromothymol, a PH indicator that was mixed with a cup of water. Students were required to use a straw and blow into the water, effectively transferring their CO2 into the cup. Using a visual of the PH scale students could see the colour of the water change from blue to yellow as they continued to blow into the cup. Students then illustrated their observations during the whole experiment from beginning to end.
The second experiment involved a cup of water, chalk and vinegar. The chalk represented calcium carbonate and vinegar being highly acidic would cause a reaction to PH of the water in the cup. Using prior knowledge from the first experiment, students recorded their claims and supportive evidence. After observing the chalk dissolve in the water, once the vinegar was added, students made their conclusions of both experiments.

The final day focused on bridging what students had learned while forming the food web and performing the experiments. The whole class participated in a discussion about the effects of ocean acidification on the species within the food web and where CO2 comes from. I then showed students a video of a news story covering a business that harvests scallops in Qualicum, a short distance north of Victoria BC on Vancouver Island (CBC News, 2014). The video highlighted how the PH level had changed by one point, making the ocean in that area slightly more acidic, and how it had caused the deaths of all
scallop crops since 2010. Following this story I asked students if they think people are connected to the ocean and how might they be affecting and affected by it. I then reminded students that Mother Nature is resilient and how marine species adapted to the inner harbor of Victoria at Fisherman’s Wharf.
Chapter 4

4.1 Results

Drawing from my two sub-questions:

1) What are the initial reactions of the students and what do they notice when the live video feed is first shown?

2) Through observations, do students generate questions, discussion or explanation using prior knowledge?

I reviewed the video transcripts of day one and day two. Using open and axial coding techniques two main themes appeared, the first is motivation and engagement, the second is science inquiry.

4.1.1 Theme 1: Motivation and Engagement

Motivation and engagement were measured through the initial reactions and questions students had while viewing real-time marine environments. When the live video feed was first displayed on the screen it spurred immediate questions followed by dialogue from observations made by students. As seen in the fragment tables below, students were motivated by the underwater web cameras to participate in inquiry-based learning. There were some technical challenges with viewing the Race Rocks camera as it had frozen and skipped ahead more than once during the two sessions of observations. Subsequently students became frustrated while attempting to make observations, pulling focus from the marine environment to the camera technology.
Fragment 1: Students' initial reactions itemized by line number

Day One:
1-1  Aaron: What is that in front of the camera?
1-2  Theo: That’s a sea cucumber.
1-3  Chris: No, it’s a sea anemone
1-4  Matt: Ananmmnenenone
1-141 Sarah: That one looks weird
1-142 Matt: Is that an octopus?
1-144 Lukas: It’s really slow
1-145 Sarah: It’s really sleepy
1-147 Theo: A lot of flowing movement
1-148 Olive: Not a very good camera

Day Two:
1-2  Aaron: It’s a mystical cable
1-8  Theo: A cable and an anemone and what’s that green leafy thing?
1-9  Olive: And then there’s a stick
1-15 Sarah: This one’s not active
1-16 Olive: But it’s very glitch[y] – lagging

Fragment 2: Students’ overall reactions itemized by line number

Day One:
2-39 Theo: This is so cool!
2-96 Sarah: Aw, it’s cute
2-127 Carol: I can’t see a lot of fish going by
2-173 Theo: Oh, a jelly fish just went by
2-206 Luke: This one is a lot more glitch[y] (negative)
2-221 Theo: Oh my gosh!
2-222 Luke: Look at that!
2-223 Class: Whoa….
2-227 Sarah: Awesome!
2-296 Aaron: There’s a jellyfish that just went by!

Day Two:
2-38 Aaron: Come on! (negative)
2-92 Theo: Oh wow! Look at that!

Overall, reactions to the live feed initiated emotional responses linked to the actions happening on the screen. These responses were found throughout the first day as a direct result of viewing live marine sites, which demonstrates a constant level of engagement from participants. Marine environments are in constant motion, especially in the areas that these cameras were located. Throughout the first day the majority of student’s
reactions to the live feeds were positive with only one comment related to the technical
distractions of the Race Rocks camera. Many of the responses demonstrated the
excitement various students had while observing different marine species as they entered
the viewing area. In comparison with the second day, the amount of reactions from the
students decreased significantly from nine to only two responses. This suggests that the
students were less excited and less interested in viewing the live feeds on the second day.
It is important to note that the visibility on the second day was significantly decreased
due to a storm that stirred up large amounts of particulate in the water column. The live
feeds were also only displayed for a brief period of time when compared to the first day.

4.1.2 Theme 2: Evaluation of Science Inquiry

Science inquiry was measured by identifying students’ questioning and use of prior
knowledge. Indicators of these skills were noted by the kinds of questions students’ asked
through observations and how they used prior knowledge to inform their analysis. Most
questions asked by students were for the purpose of identification, the second highest
frequency were questions related to making decisions and a third type of question posed
for analysis of a specific marine invertebrate.

Fragment 3: Students' questions through observations itemized by line number

Day One:
3-1 Theo: What is that in front of the camera?
3-31 John: Do you think it’s a sea anemone or a sea cucumber?
3-45 John: How could it be an anemone?
3-77 Sarah: Do you think it’s orange?
3-90 Sarah: How long is it?
3-107 Sarah: It’s poisonous?
3-142 Matt: Is that an octopus?
3-187 Josh: Question. Are sea lemons poisonous?
3-197 Theo: So are there red sea lemons and sea lettuce?
3-204 Carol: Where’s the fish?
Fragment 4: Students' explanations and discussion using prior knowledge itemized by line number

Day One:
4-110  Aaron: When you touch the end of it, it sucks straight back into its hole.
4-112  Aaron: Because it thinks that it’s your prey and it is trying to get away from your reach?
4-114  Aaron: I remember I saw a hug one that was like this big and it went “whoosh”.
4-130  Aaron: And didn’t you say that sometimes on the bottom of them, when you – if you look, you could see the shrimp? Or something on the bottom of the…
4-238  Carol: Well, there was a little bit in the other camera

Day Two:
4-32   Theo: Underwater – there’s a lot of salt and it gets misty, kind of blurry.

The coding results illustrate that students were actively engaging in science inquiry and in providing explanations using prior knowledge. As mentioned by Edelson, Gordin, Pea (1999), the use of prior knowledge compared with newly acquired knowledge is fundamental to the practice of science. Fragment three highlights student engagement as they asked an array of questions to evaluate, acquire and analyze information from their observations. There is however a stark contrast between the amounts of inquiries made on the first day of fragment three compared to the second day. A possible explanation would be students’ lack of engagement due to the repetition of identifying marine species from the day before. Explanations using prior knowledge were useful for understanding if students were connecting relevant information previously learned or experienced before this study. On the first day of fragment four, Aaron discussed and explained that when a feather duster tube worm is touched ‘it sucks straight back into its hole.’ Other students participated in this discussion to share their own explanations of why the feather duster
tube worm reacts in this way. At no point prior to the lesson had students been given this information, meaning it was prior knowledge they had received from before this study.

4.1.3 Surveys

The pre and post surveys for this research were used, but of interest to this study, only question three from the post survey was used. Question three in the post survey provided details regarding students’ interest in using underwater web cameras to view marine life. Thirteen out of fifteen students participated in the post survey, eleven of which had positive responses, one was neutral and another was negative. The negative response, as stated from the student, was because they wanted more interactivity with the marine species they were viewing (Appendix B). Many students mentioned that they thought the experience was ‘cool’, “it was so cool to see natural environments (Appendix B).” Other students found the experience ‘neat’ mentioning that “[their] habitat is so neat and I hardly know much about them (Appendix B).” Another student commented on how the experience was better than looking at a picture, “you get to see it [in] real life. [It’s better than a picture. You can see their habitat and their habits] (Appendix B).”

Table 5: Pre marine survey

| Question 1 | Do you have any interest in learning about the ocean? Why? |
| Question 2 | What is your favourite marine animal? Why? |

Table 6: Post marine survey

| Question 1 | Do you have any interest in learning more about the ocean? Why |
| Question 2 | What is your favourite marine animal? Why? What marine animal would you like to see on camera? |
| Question 3 | Did you like seeing real live underwater environments on the smart board? Why? |
| Question 4 | Do you think marine animals in the video are connected and depend on each other? If so, what connections might they share? |
| Question 5 | How might people be connected to and dependent on the ocean? |
Chapter 5

5.1 Discussion

Results conclude that underwater web cameras initiated students’ questions and motivated students to engage in marine science topics. Themes one and two, with the support of the post surveys, illustrated how students were prompted to ask questions during the live observations of the marine environments. Students asked an array of questions to evaluate, acquire and analyze information from their observations. Some students used prior knowledge to inform their observations and actively participated in discussing their experiences with other classmates to answer their questions. These results prove that underwater web cameras are motivational tools for TSIL programs and have the potential to support engagement and interest in marine science. With an increase of meaningful engagement with marine science topics, students will become informed and thus aware of their impacts on the health of marine environments.

5.1.1 New Technology for TSIL

The ocean covers over seventy percent of the Earth’s surface, yet is still largely ‘alien’ to people everywhere in the world (Earle, 2009). This is mainly due to the inaccessible nature of marine environments. As mentioned previously by the National Science Foundation (2008) and Power (2012), inquiry-based learning is fundamentally centered on the exploration and discovery of the natural and material world. The ocean is thus a perfect candidate for inquiry-based learning as it is a place that is unknown and unexplored by the majority of the planet’s human population. Underwater web cameras are powerful tools to connect students to the ocean in real-time, providing a captivating
and motivating medium for discovering marine science topics. As noted in the literature, motivation is a challenge for technology supported inquiry learning programs.

In the Co-Lab study, teacher interviews revealed that one third of students required the teacher to motivate them to engage in the multi-level virtual environments (Pinto & Couso, 2007). This is indicative of a lack of engagement from a large portion of the participating students. Many TSIL projects focus on simulated environments which can be restrictive and potentially disengage learners (Littleton, Scanlong, Sharples 2012). In contrast, GLOBE offers a supportive model of in-situ data collection and online collaborations with scientists; however, when related to the ocean, many students do not have the ability to access marine sites. Results from the use of underwater web cameras indicate a high frequency of student engagement and general interest in learning about marine environments. If merged with TSIL, underwater web cameras provide a possible hybrid between actual marine environments and virtual tools, improving upon the motivational benefits as seen in GLOBE and Co-Lab.

The first day of student’s observations of the Fisherman’s Wharf camera and the Race Rocks camera demonstrate a high frequency of positive reactions and excitement. The first initial reactions were inquiries of phenomena students were observing. Students’ questions then spurred discussion and further questions from other students. Many students were actively sharing prior knowledge with classmates in an attempt to determine and explain the species they were discovering, fundamental to the practice of science (Edelson, Gordin, Pea 1999).

Results from students’ reactions affirm their immediate interest and engagement when the live underwater feeds were first shown. Interest did begin to decrease during the
second day of viewing but this could be attributed to the repetition of observing the same marine environment, visibility, or other unknown factors. In conjunction, post marine survey question three provided further indication of students’ interest and engagement in viewing marine life via underwater web cameras. Students associated the experience as being ‘cool’ and ‘neat’ to see natural environments, but more importantly there was expressed wonder by students wanting to observe more marine environments.

“[their] habitat is so neat and I hardly know much about them.”

The study on KIE focuses on argument building, use of evidence, addition of further ideas, and claims. Within this framework students are given a question to illicit inquiry to engage students to learn science concepts. However, when merged with the use of underwater web cameras, KIE would benefit from having students discover and provide their own questions. As the use of underwater web cameras have proven, students became engaged and interested in learning more about marine science. The use of underwater web cameras further support Bell’s definition and practice of knowledge integration. To reiterate, knowledge integration is defined as “a dynamic process where students connect their conceptual ideas, link ideas to explain phenomena, add more experiences from the world to their mix of ideas and, restructure ideas with a more coherent view (Bell, 2000, p.797).” Students in my research observed marine environments and linked their knowledge to explain phenomena.

Overall the results of the first day reveals correlations that underwater web cameras are a substantial asset in motivating students to engage in inquiry-based learning of marine
science topics. Students’ observations of marine environments in real-time, fostered interest and engaged them in technology supported inquiry learning of marine science topics and ocean literacy. Underwater web cameras combined with other TSIL projects will affectively provide a strong starting point for engaging and motivating students to learn science concepts.

5.1.2 The Implications for Marine Science Curriculum

There is a substantial need for students to engage in marine science curriculum as outlined in chapter one; however, engaging students in marine science can be difficult. A major issue is the lack of physical access to marine environments. As mentioned in the example of GLOBE, teachers reported the excitement and engagement of students collecting data at physical sites (Wormstead et. al. 2002). In the literature review, the shark tagging and mangrove blenny projects in the Baumgartner et al. (2006) study illustrated in their evaluation methods that students acquired most of their knowledge through experimentation. When applied to technology supported inquiry learning, the two marine science projects closely resemble GLOBE’s model of hands-on participatory research.

The challenge is that many students do not have access to marine environments and will be unable to participate in certain hands-on research projects like shark tagging. Underwater web cameras would be a great first step and substitute for connecting students to different marine research projects. Cameras could be placed in various marine sites where students can get their first glimpse at the species they will be studying. Students would virtually connect in real-time to view marine species in their natural habitat as well as connect with marine researchers as seen in the JASON project and
Bamfield. Although many students will be unable to participate in certain hands-on research such as tagging sharks, they are still able to participate in real-time observations, which will motivate students to engage in increasing ocean literacy. Lower risk and more accessible ocean projects such as the mangrove blenny project can provide a means for hand-on research. In addition, when combined with underwater web cameras, students could compare aquarium environments in the classroom to the actual marine environment the mangrove blennies were removed from. This would act as an affective initiator to build interest in marine science project, potentially motivating students to engage in further understanding of the importance of marine research and conservation efforts.

JASON project and Bamfield Marine Science Center indicated the motivating effects of using live underwater interactions with marine researchers. Results from my research build upon the foundations of the JASON project and Bamfield, further validating that stationary underwater web cameras are also effective at motivating students to engage in marine science topics.

**5.1.3 The Potential and Limitations of Underwater Web Cameras**

Live events provided by the JASON project and Bamfield Marine Science Centre require a great amount of preparation and planning; they are also restricted to schedules. Live events are accessible for only a short period of time and are weather dependent, which means that these events can be cancelled if the waters are unsafe for the divers. The JASON project and Bamfield also noted the technological challenges that teachers encountered while attempting to participate in live events. Some classrooms did not have access to laptops or computers and in some instances did not have a sufficient internet connection. My research had similar technical challenges especially related to the quality
of the live video feed. As seen in student reactions, the Race Rocks camera would freeze and then skip ahead. Students’ attention was subsequently affected as they would begin to focus more on the functionality of the camera instead of observing the marine environment.

A significant benefit underwater web cameras provide for marine science projects are their ability to stream and record data. This data can then be reviewed by students for further observation and discovery of marine science topics. Underwater web cameras can also be viewed anytime of the day and on any internet capable device. This allows engaged students an opportunity for further discovery on their own time.

5.1.4 Increasing Marine Awareness

Sylvia Earle (2009) stated that “knowing is the key to caring, and with caring there is hope that people will be motivated to take positive actions. They might not care even if they know but they can’t care if they are unaware” (p.248). As my research has proven, underwater web cameras motivate students to explore and engage in marine science topics. The ocean is a vital organ to our planet that has begun to show serious signs of degradation and mistreatment. Ocean literacy and STEM literacy share the same fundamental concept that with understanding, students will be able to make informed decisions regarding human interactions with the environment. Students only require the opportunity to participate in TSIL to discover aspects of the ocean that might interest them. This pilot case study demonstrates that underwater web cameras are catalytic for motivating students to engage in marine science. Furthermore, it confirms the motivational results of real-time marine interactions as provided by the JASON project and Bamfield Marine Research Centre. It is time to engage students in marine science
and ocean literacy to assist students in making informed decisions regarding the treatment of marine environments.

5.1.5 Future Research

Building upon this pilot case study, future research should include a larger and more diverse sample of participants from coastal and landlocked communities in an effort to identify if underwater web cameras can motivate students from different geographical locations. In addition, researchers should highlight multiple marine sites to increase the diversity of marine species and combine live dive events to further student engagement.

An important topic at the last International Marine Conservation Congress (2014) was how to connect marine science research to the public at large. There is a vast wealth of information specifically focused on important marine conservation topics yet often researchers commented on the difficulty of reaching students. This study suggests that the placement of underwater web cameras at marine research sites would connect students to important marine science research. Following the SSP and STSP models, students could engage in research with local or distant marine research and scientists.

Responses from question three on the post survey illustrated a surprise from some students about what they thought the local marine environments looked like. Future research could look into what significant influences shape students’ perceptions of what they think specific marine sites look like.

The ocean is in constant motion, underwater web cameras simply provide an uninhibited means for students to explore and discover, engage and be entertained. The ocean interacts with the camera as we interact with the ocean, bridging a substantial gap between above and below.
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Appendix

Appendix A: Marine Booklet
(Photos Removed for Copyright Purposes).

Zooplankton

Zooplankton is a group of different kinds of larval species, newly born, that travel with the current. Zooplankton is a very important food source for many species and is also made up of the babies of many species.

- Zooplankton feeds on: other zooplankton, marine waste, phytoplankton and bacterioplankton.
- Predators include: anemones, orange cup corals, feather duster worms, barnacles, mussels and crabs.

Plumose Anemone

Plumose Anemones are tubular with extending tentacles that prefer to grow in places that are sheltered from waves. Similar to the feather duster tube worms, plumose anemones will hide themselves inside their tubes as a defense against predators.

- Plumose Anemones feed on zooplankton.
- Predators include: nudibranchs and leather sea stars.

Proliferating anemone

Proliferating anemones come in many different colours and are very common between Alaska and California.

- Proliferating anemones feed on: urchins, detached mussels, small fish and crabs.
- Main predators include: the leather sea star, nudibranch, and snails (most species feed on the tentacles), but the snails feed on the base.

Strawberry Anemones

The Strawberry Anemone resembles sea anemones, but is not a true Anemone.

- Feed on zooplankton.
- Predators include brine shrimp & leather star.
- Strawberry Anemones also have few known predators.

Orange Cup Coral
Orange Cup Coral: have stony, cuplike, calcareous bodies. They are typically found in areas exposed to moderately strong surf/current. This coral catches prey primarily by using its tentacles or through its mouth at the center of its body.

- Feeds on zooplankton.
- There are no known predators of orange cup coral.
- A possible predator may be the leather sea star.
- *They have calcareous bodies.

**Kelp**

Kelp is like the forests of the ocean, kelp provide important habitat and shelter to many fish species, in particular rockfish.

- Like plants, kelp uses the energy from sunlight to create their own food.
- The main predators are urchins.

**Red Algae**

Red Algae are leafy like plants that provide food and shelter to small species.

- Red Algae use the energy from sunlight to produce their own food (photosynthesis).
- Predators include snails, gunnels, and leather sea stars.

**Leather Star**

The Leather Star has a large central disc and five plump arms with a smooth velvety surface. Starfish are keystone species in tidal environments; they are responsible for maintaining the diversity of many species.

- Leather Stars feed on a diverse group of species including: algae, sea urchins, sea cucumbers, barnacles, muscles, anemones and many other species.
- Main predator is the morning sun star, a much larger starfish that moves like a vacuum across the ocean floor.
- *Leather Stars have calcareous bodies.

**Sunflower Star**

Sunflower Stars are large and quick moving (for a starfish!), they move at a speed of 1 meter per minute. They are predators to many species, but when attacked themselves they
have a unique defense to shed their arms to escape. These arms will gradually grow back within a few weeks.

- Sunflower Stars feed on: Urchins, clams, snails, sea cucumbers, starfish and abalone fish.
- Predators include: King Crab, Morning Sun Star, and various large fish.
- *They have calcareous bodies.

**Feather Duster Worms**

Feather Duster Worms have a tube-like shell that protects them from most predators. They have “feathery” branches that collect food and alert them of predators.

- Feather Duster Worms feed on: bacteria, marine waste, phytoplankton, and zooplankton.
- The main predators are: crabs, starfish and various types of fish.
- *Their tube is made of calcareous, shells, sand and detritus.

**Mussels**

Mussels are filter feeders found in shallow and deep portions of the ocean. Mussels reproduce quickly, this is important because they are food to many species. Leather Starfish are the major predator of mussels and are responsible for keeping the number of mussels down.

- Mussels feed mainly on zooplankton, phytoplankton and marine waste.
- Predators include: humans, starfish, snails, seabirds, otters and many other species.
- *Mussels have calcareous shells.

**Barnacles**

Barnacles are also filter feeders that use feathery legs to collect food as it passes by. Barnacles have two plates that they use to slide open and closed for feeding and for protection. Barnacles also have a unique ability to grab onto almost any surface in their larval form and begin to grow their calcareous shells.

- Barnacles feed on plankton and marine waste.
- Predators include: Sea snails, starfish and mussels.
- *Barnacles have calcareous shells.
**Decorator crabs**

Decorator Crabs can be found in kelp forests, red algae and other rocky habitats. Decorator crabs uniquely camouflage their body by attaching pieces of their environment to their shells.

- Decorator crabs feed on: dead marine species and plankton.
- Predators include: halibut, salmon, otters and humans.

**Nudibranch**

Nudibranchs are slug like species that can have many different colours, body structures and defenses against predators. They are able to eat harmful poison from other species and use it as a defense against predators trying to eat them.

Nudibranchs feed on: Anemones, sponges, barnacles, sea slugs, zooplankton and other nudibranchs.

Predators include: nudibranchs have very few predators because of their poisonous nature, but the main predator is other nudibranchs.
Appendix B: Post Survey Question Three

3) Did you like seeing real live underwater environments on the smart board? Why

No. Because we need to be more interactive.

3) Did you like seeing real live underwater environments on the smart board? Why

It was ok. It was very different.

3) Did you like seeing real live underwater environments on the smart board? Why

Yes! It is so cool to see natural environments!
3) Did you like seeing real live underwater environments on the smart board? Why

you get to see it. Really life is so much better than a picture. You can see there habitat and there habits.

3) Did you like seeing real live underwater environments on the smart board? Why

yes because there habitat is so neat and I hardly knew much about them

3) Did you like seeing real live underwater environments on the smart board? Why

yes I did. Because it was cool and fun. I love it!

3) Did you like seeing real live underwater environments on the smart board? Why

Yes it gives us a chance to see a real underwater without actually diving
Appendix C: Transcript Day One

June 10 – A – abbreviated – live cam reaction (17:17:8)

M - So right now, we are looking at the bottom of a float home. And what I’m going to do is I’m going to pass around these sheets –

- That’s a sea cucumber
- No, it’s a sea anemone
- Ananmmmenenone.
- We know.
T - There’s not enough for everybody to have one.

M - So what are we observing right now? Does anybody know what we are observing right now?

- Sea anemones?

- It is a sea cucumber?

M - So what I’m going to do is I’m going to get you guys into groups –

T - I think these guys need one.

M - Ok – these are identification sheets – these are going to help you to understand what you’re looking at under the water here. So would anybody be able to tell me what this looks like? (18:37:0).

- It looks like a spaghetti worm a bit
- A red sea urchin
- A sea cucumber?

M - So what are some of the unique features that this has? Spikes? It does kind of have like a spikey kind of look to it.
- It looks like a sea cucumber.

M - Yes?

- Maybe it’s one of those things that ground fish live in like the...Nemo?

M - Do you remember what Nemo lives in? What did Nemo live in? What did it...

- A sea anemone

M - A sea anemone, okay. So does everybody think this is a sea anemone?

- I think it’s a California cucumber

M - You think it’s a cucumber?

- A red sea urchin

M - It’s a sea urchin?

- A red sea urchin

(Lots of chatter)

M - OK – so what I’d like you to do is, if you could circle the species that you think it is. So we are going to start looking at some of the species here and if you can circle on the first two pages, if you can circle which species you think you are looking at. What can you see?

- You can circle this and the anemone.

- I found the actual sea anemone

- Do you think it’s a sea anemone or a sea cucumber?

M - So you guys are in a group – do you agree on that?

(Lots of chatter)

M - There are two pages –

- Two of us are saying anemone...
- That means we’re right
M - So have you guys agreed on that?
- Just from looking at it, it’s... a
M - It is a bit of a mystery.
- This is so cool!

BREAK

M - So does everybody kind of agree that it’s a feather duster tube worm?
- Yea
M- Then you are right! You guys got it!
- Yay!
M - So, I’d like to ask you a quick question – can anybody tell me what happens if you were to touch the tips of the feather duster? What would it do?
- I know – I saw this
M - I’m going to see if I can ask somebody who hasn’t seen this yet.
- Oh ,darn it!
- Maybe it’s like a sea anemone and it attaches to your finger and tries to eat it?
M - Close - so what do you think it would do as a
- It’s poisonous?
- Can I just say it?
M - Yeah –
- When you touch the end of it, it sucks straight back into its hole
M - And why do you think it would do that?
- Because it thinks that it’s your prey and it is trying to get away from your reach?
M - Right – there you go – that’s exactly it – it’s a defense mechanism.

- I remember I saw a huge one that was like this big and it went “whoosh”.

M - Oh yeah, they can get really large. Definitely. Ok. Cool. Yes, Matt?

- I found it in here – it’s the same.

M - Could you talk about what do you think some of the predators would be?

- Crabs, starfish and various types of fish.

M - So why do you think crabs would be a predator.

- Maybe they can – because their hard claws they can whack the base of it.

M - They’d whack it? Yeah. Yes?

- Their claws can get into the little hole and try and pull it out?

M - Yeah, that’s part of what they definitely like to do. Now, I’ll mention one thing as it’s hard to know this one – crabs actually do something really interesting with tube worms when they want to eat them. They actually pinch them while they are in the tube – because the worm – the worm head itself is actually further down in the tube – that’s where its main body is. So it’s – the tube worm is on the second page –

- Oh, the red tube worm? Huh –

BREAK

M - Alright, so I just want to ask you guys a quick question – what does it look like – what’s kind of the environment that we’re looking at in this area?

- Murky water

M - Murky water.

- I can’t see a lot of fish going by

M - Not a lot of fish going by
And didn’t you say that sometimes on the bottom of them, when you – if you
look, you could see the shrimp? Or something on the bottom of the...

M – Shrimp can be there on the float homes, yes, definitely. So what does it look like
is happening right now? (31:03:4).

- It looks like the – well, it looks like – everything is kind of moving –
- The house is moving

M – yes, yes

- Rocking a little

M - Ok – I’m going to show you another camera. This is another camera – now this
camera is in a different location –

- It’s really slow because it’s...
- It’s really sleepy

M - It is – what are some of the things that we are observing here?

- A lot of flowing movement
- Not a very good camera

M - No, this one’s a – yeah –so it looks like there’s a lot of flow coming through here,
right? Race Rocks, to give you a bit of a description – Race Rocks is not in the inner
harbour. Race Rocks is actually outside, heading more towards the west coast of the
island so what is really cool about Race Rocks is that it is an ecological reserve. And
there’s not a lot of traffic that’s allowed to go through this particular area. So, Race
Rocks is probably about a 20 minute boat ride from the inner harbour.

M - So can anybody tell me some of the species that we’re looking at? How about
this one here? (33:02:4).
- It’s white.
- It looks like some sort of a – worm? Maybe it’s a pacific oyster – they’re white.

M - So what it is – I will explain a little bit because it looks like something has affected it – it’s curled in on itself.

- So maybe it’s a

M - Which one? The plumis anemone? What does everybody think?

- The plumous anemone?

M - Think it’s the plumous anemone? Okay? So there is a unique feature about this type of species – it does have similar types of tentacles. Almost. At the very end. So almost like you saw the tube worm. Very similar.

(Lots of chatter)

M - And then once you have figured that out, what do you think this red kind of stuff is here? (35:01:5) what do you think this is?

- The red stuff?

M - Yeah.

- Oh the red stuff.

M - So if you actually go through the booklet, you will be able to find it, not just on the first two pages but if you go into the booklet itself, we have here.

- The booklet itself.

T - Use the scroll bar – scroll to a different part of the image.

M - Ah, yes. Okay?

- Oh, a jelly fish just went by

T - What?
M - Oh, there it goes! Back up. So sometimes people control the cameras, yes.

- I think I know what it is.
- Control the cameras or ...

M - Control it, yeah. So we want to know what this one is, we want to know what this one is and this is like – this is a tricky one for you - see all these really neat kind of colourful almost – what do they look like?

- Sponges.
- Oh, are they the...

M - You will see it in the booklet.

- It’s a sea lemon
- What’s a....
- There’s such a thing as sea lemons.
- I want those

M - So what we want to do is circle the ones that we think they are. Yes?

- Question. Are sea lemons poisonous?

M - Are sea lemons poisonous?

- You’re going too fast, I haven’t even found the red one or the white one.

M - Ok, we’re taking our time. We are going to see what this one is here –

- Sea lemons!
- You haven’t told us the right one

M - I will in a second. We’re just going to find more than one object and then we are going to talk about all of them.

(Lots of chatter)
- It’s the orange..

M - You will actually find it in the booklet
- I knew it!
- So are there red sea lemons and sea lettuce?
- I want an underwater salad!
- Is the red stuff???

M - The red stuff is food – what did we just see there?
- A jelly fish

M - There it goes.
- Fishy
- I don’t see the fish – where’s the fish?

M - I have a question for you guys – just before we talk about the species that we are looking at, what have you noticed about the difference between – what have you noticed the difference between this camera and the other camera?
- This one is a lot more glitch

M - Aside from the physical features of the camera.....yes, Matt?
- It covers more space...

M - It covers more space. What do we notice about some of the things in the frame itself?
- It has actual fish.

M - There’s fish there
- There’s more rocks and stuff
- We know what the red thing is!
M - OK so what I’ll do right now is we’re going to talk about some of the species that we just saw. So what does everybody think the white one is?

- Plumous anemone

M - It’s a plumous anemone?

- Yes!

M - Alright! You guys are right.

- Yay!

M - It’s tricky because it’s folded in on itself. Now, plumous anemones – so when there’s a lot of activity going on, sometimes the very sensitive little fingers almost – they’ve got little tentacles that go out and they are little feelers – they collect a lot of food that way –

- Oh my gosh!

- Look at that!

- Whoa....(39:06:8)

M - Look at it go!

- Are those bass?

M - They are rock fish. Yeah.

- Awesome!