

THE IMPACT OF INTEGRATING NEXT GENERATION SCIENCE STANDARDS  
AND ENVIRONMENTAL LITERACY CURRICULUM

by

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## DEDICATION

I would like to dedicate my paper to my family, Melissa, Joan, Allison, Scott and Nick who inspired me to pursue a graduate degree. Their encouragement and support throughout the process gave me the confidence to keep moving forward. I'm grateful for my parents and their support in this lifelong journey. For my grandchildren, Devi, Rowan, Amelia and Fraser, who already demonstrate a love of the natural world, I know they will do their part to take care of our earth. They are the future and I hope the environment and love of nature will always be a part of their lives.

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## ABSTRACT

Next Generation Science Standards provide a framework to develop students' understandings of science ideas, using scientific practices to make sense of natural phenomena. The environment offers a meaningful context to develop these important ideas. However, there are few resources that effectively integrate both the science and environmental standards. This study was part of an ongoing initiative to develop lesson sequences that could be used K-12, created by teacher leaders and informal science educators. The research question focused on the impact of integrating curriculum on students' science understandings and attitudes about nature and environmental stewardship. During Spring 2021 the lessons were taught as part of a pilot. For this study, students participated in a pre and post survey. A sample of student work as well as student interviews were part of the data collected. Results indicated that the lessons supported students' science understandings and affected their attitude towards caring for the environment. Local environments can provide meaningful contexts for important science ideas and bring science alive for students. Increasingly, the environment and human activity will be an important issue to understand better.

## INTRODUCTION AND BACKGROUND

### Context of the Study

Since California adopted the Next Generation Science Standards (NGSS) seven years ago, I have been providing K-12 professional development with classroom teachers and teaching courses with pre-service teachers. I have explored how to design effective lessons for deeper student learning and opportunities for students to develop their science and engineering practices. This is because students may participate in NGSS lessons, but the lessons often lack meaningful connections with environmental awareness. Other than a one-time outdoor school experience, learning first-hand about the environment, most students are disconnected from science and real world connections. Now that the curriculum for NGSS is published and widely available for use, the environmental literacy connection is still missing. Outdoor educators in our area, during a one-week experience with students, are expected to develop students' understanding and appreciation of nature. The 2016 Science Framework for California Public Schools recognized this problem and integrated the Environmental Principles and Concepts (EP&C) with the NGSS and included snapshot descriptions of possible integrated lesson sequences that address both. While this is a valuable resource for teachers, that illustrate the integration of standards, it does not provide units of instruction with field experiences for students. I have observed that science curriculum often lacks contextualization and authentic experiences connected to the environment that can provide students with real-world connections. For that reason, I researched the impact of lessons that integrate NGSS and Environmental Literacy (EL). The lessons were designed by teachers and informal science educators to support students' science understanding, watershed awareness and stewardship.

### Background Information

The Santa Cruz County Office of Education (SCCOE) County Science Initiative (CSI) in conjunction with the Environmental Literacy for All Initiative provides leadership for all school districts countywide to connect learning and local environments to inspire all students to develop the vision, skills, and motivation to create healthy communities and a healthy planet. Achieving environmental literacy for all requires taking action in a variety of areas, from policy-making to providing student access to connect with nature. NOAA's California Bay Watershed Education and Training Program (BWET) is providing funding to implement the Relevant Environmental Action and Learning for Science (REAL Science) Project. REAL Science will incorporate all the elements of Meaningful Watershed Education Experiences (MWEE) and will increase the scientific and environmental literacy of teachers and students by integrating classroom curriculum with outdoor science and stewardship activities. This has been achieved by providing high quality professional learning opportunities to prepare teacher leaders throughout Santa Cruz County school districts to implement MWEEs with students and share resulting programs with teacher teams at all school sites in the county. My role as the director of the Monterey Bay Science Project is to facilitate the professional development and ongoing support for this project. REAL Science will advance NGSS and the California Environmental Literacy Standards by engaging students and teachers in outdoor field experiences and classroom activities that will increase understanding and stewardship of these local watersheds, the ocean, and the Monterey Bay National Marine Sanctuary. Currently, there are evaluation tools for assessing teacher changes, however instruments for evaluating student progress are not tailored for integrated curriculum. In

California, an NGSS-aligned statewide assessment has been implemented for two years, however due to the pandemic over the past year has been put on hold for 2021.

### Focus Question

My focus questions are based on my work with the REAL Science Project and the impact it will have on students. This is an area I have been curious about since I have been working with grade level teams to develop new curriculum for several years now. After a review of related literature and research in this area, I realized the importance of this project, as there is little information about the integration of NGSS and environmental literacy standards.

My focus question was, What affect does curriculum that integrates NGSS and environmental literacy have on students?

My sub-questions included the following:

1. What is the impact on their scientific understanding of local watershed, ocean and climate issues?
2. What is the impact on their science and engineering practices?
3. What is the impact on their attitudes about their connection to nature?
4. What effect does it have on their attitudes and beliefs about environmental stewardship?

### Support Team

The support team that I selected was comprised of colleagues who have expertise in a variety of areas. Julie and I met weekly to plan and discuss both teacher and student

evaluation instruments. I kept in touch with Will and Heather as needed. I had been in Zoom meetings with each of them for different project events, so we were accustomed to meeting virtually.

Julie Shattuck was the Project Evaluator for REAL. Julie is an experienced researcher/evaluator working with several NSF grants, B-Wet grants and past work with Horizons Research. We met multiple times as we collaborated on developing instruments for both the teacher and student surveys. I included Julie in my support team because of her experience in evaluation, data collection and analysis. She had developed survey instruments in her past work and was open to my input and collaboration. We discovered that we've worked with many of the same colleagues over the years.

Heather Murphy is a Soquel High School Chemistry/AP Chemistry teacher and former Science TOSA (Co-facilitated institutes for teacher leaders to develop lesson sequences) She also taught Biology and AP Biology for 16 years prior. Heather and I worked together to further NGSS implementation in Santa Cruz County for the last 8 years. She is a statewide NGSS trainer and helped to develop and facilitate the professional development the teacher leaders participated in the summers of 2018 and 2019. She is a master practitioner and professional developer. She is also a good friend and gave constructive feedback.

Will Franzell is the Science Coordinator for Monterey County Office of Education. Will is part of our California regional science collaborative team that meets three times during the year, with other regional teams statewide, to develop plans for implementation of NGSS. Will has a school administrative credential and elementary teaching background. He supports NGSS for all of Monterey County. He has a wealth of

knowledge and is a great resource. He's also a good friend that I counted on for feedback and constructive suggestions. He offered several suggestions for instruments to measure student learning.

## CONCEPTUAL FRAMEWORK

### Introduction and Background

My action research project centers on the integration of Next Generation Science Standards (NGSS) and Environmental Literacy (EL) standards, development of lesson sequences and the affect the lessons have on students' knowledge and attitude about the environment. The themes I focused on are the importance of environmental literacy, the need for merging NGSS and EL standards and how the lessons impact students.

### Research Studies

It was difficult to stop researching, as it seemed to keep opening more doors and windows about areas I hadn't considered. One study examined changes to a field course by including a socio-scientific issue (Kinslow et al., 2019). While environmental education programs immerse students in learning, they described the lack of critical thinking and reasoning as problematic. In order to better engage students and provide a context, they introduced a socio-scientific issue. In our NGSS planning, we tend to focus on a phenomenon as a starting point. After reviewing this and another research study, I thought a local issue could be based on the anchoring phenomena or at least connected. In this study they looked at the effectiveness of The Confluence Approach (TCA), curriculum that was based on NGSS and integrated with problem-based learning and place-based learning, with rural high school students. After a year-long curriculum study, the pre and post survey results among 207 high school students showed that it had a positive impact on them seeing the importance of science, in particular when it was based in a local context and students had a chance to be actively engaged in solving a problem

(Engels et al., 2019). Students' comments on the survey referred to feeling very engaged, when the science was something they could apply to real life.

Another theme came up as I reviewed various studies, which I think will demonstrate a need for my research study. The fact is that environmental education has been recognized nationally as so important that it was enacted in 1970 by congress. Yet, environmental education is very fragmented without any consistent or formal setting for it to be taught (Walker et al., 2017). Outdoor schools or residential camps are short-term experiences and not all students participate. On the other hand, NGSS could benefit from an actual field experience and connection to local real world issues for more meaningful science learning.

### Theoretical Article

Over the years, I've realized through my teaching experiences that my beliefs about how people learn are based on a couple of learning theories. The constructivist model is the basis for the work of my research, though the sociocultural model is essential for students to engage in learning by talking. Students need to discover and build on their prior knowledge, constructing new ideas and making meaning through experiences (Bada & Olusegun, 2015). The ideas about how students learn are the foundation for the lesson sequences that teachers developed. Not only is it critical that teachers have a deep understanding of the nature of constructivism, they also need to experience this approach themselves. This study illustrates the differences between a traditional and constructivist approach, which supported teachers in their lesson development.

### Research Methodology

Over the last twenty years, there have been a few large-scale studies assessing environmental literacy implementation. In 2010, a baseline study of middle school students' environmental literacy was conducted (McBeth & Volk, 2010). They measured ecological awareness, environmental affect, cognitive skills and behavior of students in 6<sup>th</sup> and 8<sup>th</sup> grade. However, there are a few more recent studies that focused on students' and teachers' attitudes, knowledge and beliefs. One study is about the development and validation of the Environmental Literacy Instrument for Adolescents (ELI-A) that is short enough for use in field and measures four domains of environmental literacy (ecological knowledge, hope, cognitive skills, behavior) (Szczytko et al., 2019).

### Research Reports

There are some additional resources I found, which will be valuable in providing some direction for my research. In 2015, our state school superintendent in California oversaw the development of A Blueprint for Environmental Literacy. This document lays out a vision and plan for implementing the state-adopted environmental principles and concepts, now integrated into all of our content standards. In addition, a recent evaluation report from the Early Implementers Initiative describes how teachers in the project are finding the added benefits of using environmental education with NGSS (Nilsen et al., 2019). Both of these reports are current and provide a context for local efforts in this area.

## Conclusion

In my research and review of current and past studies, I found that the additional research provided insight for my study. Each paper contributed a piece or an idea that was useful in developing the focus for my study. From data collection instruments and methods of evaluation to the research design, it was very helpful to refine even more my focus questions. When we first reviewed the capstone papers, it began to open the door to what was out there. But the literature review process revealed even more possibilities. What I discovered is that there has been a lot of research in environmental education that I wasn't aware of. In a couple studies, the authors described the NGSS as an improvement, but didn't feel as though it did enough to address the domains of environmental literacy.

One study did an item analysis of NGSS and looked for connections to the EL (Hufnagel et al., 2018). Areas that they identified as lacking were an appreciation for the environment and a call to action. The studies that actually researched the connection of NGSS and EL are few. In one case, the focus of the research was on the professional development of teachers to integrate NGSS and EL (Hayes et al., 2017), which had some useful tools for surveying teachers about their professional development experience. I didn't find any case studies looking at actual classroom application of NGSS and EL, which would have been useful.

## METHODOLOGY

Demographics

My study involved two classes from Santa Cruz County, from a larger evaluation project for K-12 classes countywide. While I recruited upper elementary and middle school teachers to participate in the study, they were reluctant to take on another commitment as they tried to engage students in distance learning. After reviewing the lessons that had been finalized in late January, I reached out to the Coastal Watershed Council (CWC) education director to seek their help in recruiting classes that might participate. They enthusiastically reached out to two teachers they were about to begin work with. The education coordinator actually co-taught the series of lessons with the classroom teachers and walked students through the pre and post survey through the first session together. The two classes are from a small K-12 school district in the Santa Cruz Mountains. San Lorenzo Valley Unified School District has over 2500 students with a student population that is 1% Black, 2% Asian, 11% Hispanic and 82% White. Most students are English speakers with 87% reporting only English is spoken at home. About 9% of the students are considered fluent English speakers, since another language is spoken at home. There are 3.9% of the students in the district whose English language proficiency is less than well. Families that receive Food Stamps/SNAP benefits are 10% of the school population. The two third grade classes at the school were made up of 41 students, 19 boys and 22 girls. There were 39 students that indicated that English is the only language spoken at home and two students that speak Spanish at home. The research

methodology for my study received an exemption from Montana State University's Institutional Review Board (Appendix A).

### Treatment

The treatment for my study took place in stages over two summers prior to the pilot implementation of the lessons. Over that time, adjustments to the schedule were necessary due to a move to distance learning, wildfire and evacuations. The process involved multiple teachers and environmental educators working collaboratively.

Table 1. Timeline of the stages to complete the study.

Stage of Study	Timeline	Notes
Developed lesson sequences over two years	Summer 2018 and Summer 2019	85 K-12 teachers and informal science educators each summer participated in five day institute
Reviewed lesson sequences for alignment with NGSS and EL, converted to a HyperDoc format to accommodate for distance learning	Fall 2020	45 teachers and informal science educators- postponed from summer to fall 2020
Developed survey instruments for K-2, 3, 4-12 in English and Spanish	November 2020	Reviewed with leaders in December for approval- revised by grade level
Recruited teachers to participate in the study	December-January 2021	SCCOE offers \$300 stipend for teacher participation in study
Finalized lesson sequences- revisions completed after review with Equip rubric	January 25, 2021	Website with lessons made available.
Classes for study identified	February 2021	Teachers sent special link for survey (pre-survey) responses
Students engage in CWC lesson series- Can steelhead trout migrate on the San Lorenzo River?	February-March 2021	Two classes participate in lessons and complete the post survey.
Student sample artifacts of drawings, final projects. Student interviews complete	April 2021	Only one class completed the post survey.

Approximately 45 teacher leaders and informal science educators from the 2018 and 2019 summer institutes participated in a curriculum revision phase of the project during fall 2020. The goal was to review the sequences for clarity, accuracy and alignment with NGSS, formative assessments and possible connections to the adopted curriculum materials for the school districts within Santa Cruz County. The lessons also had to be converted to a distance-learning format through HyperDoc, due to the lack of

in-person instruction this school year. The group of teachers who participated in the development of the modified sequences implemented the lessons from January to April 2021 to test them out. Students engaged in lesson sequences that included a field experience and integrated NGSS and environmental literacy, designed by select teacher leaders and informal science educators.

During the REAL Science summer institutes in 2018 and 2019, each grade level K-12 developed two lesson sequences that addressed their NGSS standards. During the summer development they collaborated with a local environmental educator to integrate the EP&C that aligned with their science standards. The sequence included a field experience with the organization associated. During the institutes we used the Biological Science Curriculum Study (BSCS) model of professional development, using planning strategies learned during the Professional Development Provider Institutes the TLI team attended.

### Sampling Strategy

I used multiple sampling strategies for my study. For the 45 teacher participants, including both formal and informal science educators, I proposed the follow-up study during the school year to determine the impact of the lessons on students thinking. My goal was to study three classes, ideally upper grade or middle school. I needed to coordinate with the informal science educators as well to determine which teachers might be involved. Although there were teachers from grades K-12 in the project, I wanted to focus on three elementary or middle school classes. Since teachers volunteered to

participate, my sampling needed to adjust. By April, over one thousand students had participated in the lessons, so the classes I worked with represented a small sample. As far as analyzing student work samples, I collected three different examples from one teacher that participated in this part of the study. Due to a change back to in-person instruction in April, one class was dispersed into other classes and the teacher re-assigned to online instruction. I focused the pre and post survey analysis on only one class for that reason.

### Timeline

Despite the delays caused by the change in classroom instruction and natural disasters, my study concluded in time for the final paper. Ideally, the classroom implementation would have taken place in the fall so there would be more time for analysis. Although teachers were invited to participate in the study with the county office of education offering teachers an additional stipend to participate the student study, they reported feeling overwhelmed as they navigated teaching in a new format. Fortunately, the Coastal Watershed Council's involvement helped to meet deadlines and supported the collection of student artifacts for the qualitative data. In addition, the education coordinator joined the student interview session on Zoom to be sure students felt comfortable in the talk.

### Data Collection and Analysis Strategies

As a part of the REAL Science evaluation teachers were surveyed before and after the three-day professional development experience about their ideas, attitudes and knowledge related to both NGSS and EL. For my action research study, I employed both qualitative and quantitative data collection methods. Students were given a survey before and after experiencing the lessons in order to measure their attitudes and beliefs. Students' final projects and student interviews provided qualitative information about the impact of the lessons.

Table 2. Triangulation matrix.

Data Collection Matrix	Pre and Post Survey	Student Work Samples	Student Interview
Focus Question What affect does curriculum that integrates NGSS and environmental literacy have on students?	X	X	X
Sub-question 1 What is the impact on their scientific understanding of local watershed, ocean and climate issues?	X	X	X
Sub-question 2 What is the effect on their science and engineering practices?	X	X	X
Sub-question 3 What is the impact on students' attitudes about their connection to nature?	X		X
Sub-question 4 What affect does it have on students' attitudes and beliefs about environmental stewardship?	X	X	

The table includes the focus question, sub-questions and the data collection methods. Validity and reliability were considered in this study through a triangulation of the instruments, with both peer and professor input, in addition to using published instruments from NOAA. The student data includes a pre and post questionnaire, which collected insight about ideas, attitudes and beliefs regarding trout habitat and life cycle, connection to nature and stewardship (Appendix B). The survey was built using banks of questions provided by the California BWET website. Questions were developed by a group at University of Michigan for grant-funded projects to use. The content questions

about steelhead trout were used for measuring content outcomes and were developed by the Coastal Watershed Council for their curriculum. As part of the survey, there were questions to collect demographic information such as gender and home language. The student interviews provided insight into their thinking about what they learned and how they felt about nature and the environment. Interview questions (Appendix C) were modified based on the age of the students from teacher feedback. The samples of student work included final projects that explained their ideas about steelhead trout migration, and offered another perspective into the impact of the lessons. A rubric used to assess student explanations and developed by the University of California (Appendix D) was utilized to understand their science practices and content understanding.

## DATA ANALYSIS

Results

Quantitative and qualitative data were collected to learn more about the effect the NGSS environmental lessons might have on students. So often, we don't have the time or opportunity to find out if what we are trying to change actually works. The sample for this study started out with two third grade classes, a total of 42 students. However, one class was disrupted by the transition from distance to in-person learning and did not complete the post survey. Ideally, they would have been able to complete the final survey to be included in the study. I worked with teachers at the school San Lorenzo Elementary in California two years ago as part of a yearlong professional development initiative on science and literacy. I was mostly interested if the lessons were able to reach the NGSS standards as well as the environmental literacy goals. Students completed a pre and post survey, and submitted final projects to summarize their understandings of the content. In addition, I was able to interview a small group to learn more about their thinking. There were primarily three findings I will share about their science understandings, connection with nature and attitudes about environmental stewardship.

The Coastal Watershed Council lesson sequence, titled "Can Steelhead Trout Migrate in the San Lorenzo River?" found in Appendix E. was the third grade lesson sequence the students participated in. The lessons were based on NGSS 3-LS1-1: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. Analyzing survey responses, interview transcripts and drawings with videotaped explanations, the data indicated that

students were able to explain the six stages of the life cycle and habitat needs of steelhead trout in relation to the water level of the local San Lorenzo River. They used drawings to explain the life cycle, as well as the migration pattern for the trout. Appendix F is an example of the students' drawings with labels.

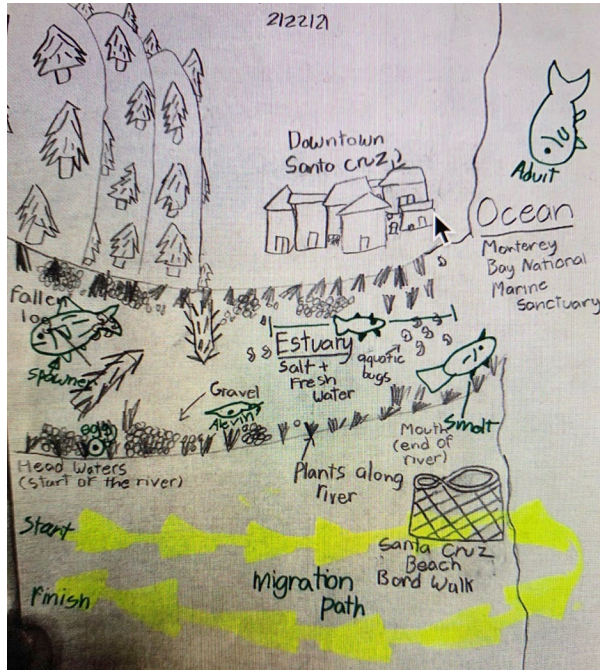


Figure 1. Example of a student model of the steelhead trout life cycle and migration pattern in the San Lorenzo River.

Integrating NGSS with environmental literacy became more challenging in an online format. The lessons were originally designed so that students would engage in an actual field experience, using observations and interacting with other students. The informal science educators were creative in designing activities to give students the virtual field experience, using video footage of trout.

Table 3. Survey results for science and engineering practices.

Do you know how to do these things?	Pre Survey (N=22)	Post Survey (N=20)
a. Ask questions about things I notice.		
No	0%	5%
Not Sure	23%	25%
Yes	77%	70%
b. Make a plan to answer my questions.		
No	9%	0%
Not Sure	45%	55%
Yes	45%	45%
c. Explain what I find out using words or pictures.		
No	0%	10%
Not Sure	41%	20%
Yes	59%	70%

Given that the lessons were taught in an online format, the results confirm that there was not a noticeable change from the pre and post survey for the science practice of asking questions about what they notice. For the practice of making a plan to answer a question, 9% said no in the pre survey, but were not sure (Pre- 45% to Post 55%). The ability to explain what they know using words and pictures, showed a slight increase from 59% to 70%. The fact that they were asked to draw the migration pattern and explain the life cycle with drawings, gave students an opportunity to use this practice.

Table 4. Results from survey question about connection to nature, Pre  $N=22$ , Post  $N=20$ .

Q3. Mark the response that best matches how you feel now.	Pre	Pre	Pre	Post	Post	Post
	No	Some-times	Always	No	Some-times	Always
a. Spending time in nature is important to me.	0	7	15	1	7	12
b. Learning about nature is important to me.	4	7	11	4	9	7
c. I like learning about nature.	3	10	9	1	10	9
d. I like learning things outside of school.	1	7	14	2	11	7
e. Nature makes me happy.	1	9	12	0	7	13
f. I like nature.	0	8	11	0	4	15
g. I like to be outside.	1	9	12	0	7	13
	6%	37%	55%	6%	39%	54%

To learn more about students' connection to nature, they responded to questions about nature and learning, as well as just being in nature in the pre and post survey. An average of pre and post survey responses showed few changes generally about feeling more connected with nature overall. Questions about learning in nature, spending time in nature, learning outside and being outside indicated only a slight or no change from pre to post. The question about liking nature however did see an increase in yes responses, as illustrated in the figure below.

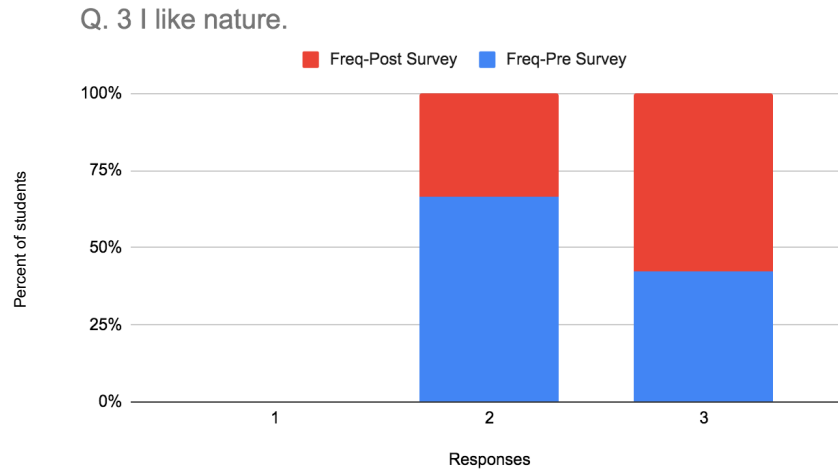


Figure 2. I like nature responses, represented by the percent of students ( $N=22$ ) (1=No, 2=Sometimes, 3= Always).

The area of the study that indicated the most change from the survey responses related to the idea of environmental stewardship and students' role in protecting nature. These questions were connected directly to the lessons that students experienced.

Table 5. What is the effect on students' attitudes and beliefs about environmental stewardship? (Pre Survey  $N=41$ , Post Survey  $N=37$ ).

Q.4 I can help protect steelhead trout in the San Lorenzo River.	Pre survey	Post survey
No	5%	0
Don't Know	49%	30%
Yes	46%	70%
Q.5 I want to help protect steelhead trout in the San Lorenzo River.	Pre survey	Post survey
No	10%	0%
Don't Know	32%	16%
Yes	58%	84%
Q.6 The amount of water we all use at home and school can change how much water is in the San Lorenzo River.	Pre survey	Post survey
No	0%	3%
Don't Know	37%	8%
Yes	63%	89%

Students' attitudes and beliefs about environmental stewardship, as the survey data collected indicated, positively impacted students' awareness of their role to help the migration of steelhead. Initially, students didn't know if they could protect steelhead with 5% saying no and 49% not sure. Following the lesson series, 30% reported that they weren't sure, while 70% reported that they could. They also understood the cause and effect of water use and its impact on the survival of the trout. On question six, 63% of students thought their water use affected the water level of the river before instruction. Following the lessons, 89% reported they thought it affected the river.

## CLAIMS, EVIDENCE, AND REASONING

Claims From the Study

The primary goal of the REAL Science project was to find ways to integrate science with local environmental contexts so that we can begin to educate students about their role in the environment around them, while using NGSS as a driving force. After analyzing survey results and interview transcripts as well as sample student explanations, there seems to be two major findings from this study. Students' science understandings about the concepts of life cycles and habitats, as indicated through their explanations, discourse and drawings, show that the lessons had a positive affect for reaching the content goals, (See Figure 2 and Table 3). Students' attitudes and beliefs about the role of environmental stewardship shifted to be more concerned and aware of how they can help, (See Table 5).

The survey provided some evidence for evaluating students' science ideas and practices, but the interview and scientific drawings with their video explanations clearly demonstrated an understanding of the steelheads' life cycle and needs at each stage of development. In the student drawings, they were able to label the life cycle of the steelhead, from egg, fry, alevin, fry, smolt to ocean adult and spawner. In the small group interview, students expressed their understanding of the migration pattern and the effect the water level in the river had on its survival at each stage. The education coordinator asked them if they could choose one stage to be in the steelhead's life, what would it be and why. One student shared, "an egg, because it would be safe and I'd have everything I

need.” They realized the risks of water level and also predators at different stages of development. One survey question asked students about their science practices and which ones they felt they could accomplish. They showed an increase from pre to post in feeling able to explain their ideas through science drawings and words, (see Table 3), compared with not much change in asking questions or making a plan. Given that the lessons were taught online and they didn’t have an opportunity to use those science practices, this seems logical. These findings helped to address my first two research questions about how the lessons impacted students’ science understandings and practices.

The second finding is that the lessons had a positive impact on students’ environmental stewardship in protecting the survival of the trout. The San Lorenzo River is used as a local water source, so their role in protecting the water source as well as the steelhead trout, was clearly illustrated in the results of the survey. The shift from not knowing for sure if they even could help protect the fish, to yes they want to protect them, was quite significant. In both the survey response and their final assignment about how humans can help the steelhead, they were clear that their use of water, littering and fishing all impacted their survival.

#### Value of the Study and Consideration for Future Research

This study has contributed to the REAL Science project next steps. In addition to having a chance to pilot the online post survey, we have collected feedback for making some improvements, before it is made available for all schools in the county during the 2021-22 school year. Following the pilot, one suggestion is to have a standard

introduction about the purpose of the survey and how the information will be used. I also realized that the content question and science and engineering practices should not be separated. In NGSS, the three dimensions need to be integrated and accordingly the survey question should also. As a post survey, it also would be helpful to have open-ended questions for students to respond in their own words, especially in constructing an explanation.

As we continue to refine the K-12 lessons developed that will be shared with teachers, we need to ensure they are high quality lessons that effectively integrate NGSS with EL. It will be essential that the final lessons clearly address grade level science standards. The original lessons were designed for in-person instruction, so the merging of the online and in-person material will need to be reviewed. I will prepare a summary of the research findings that will be shared with district and site level leaders in order to gain their support of teachers implementing the lessons.

When there is evidence to support why we do what we do, there is a better chance people will take the idea more seriously. We currently have a large portion of our society that does not believe the science behind climate change and its impact on our lives. The environment is becoming more relevant for people as we experience weather extremes, drought, wildfire and other natural disasters more frequently. I think our best chance is to have an impact on youth about the importance of their local environment and what they can do to have a positive impact.

I originally planned to research both teachers and students, studying the professional development impacts on teachers and how that might in turn impact students. Since I had a more direct role in working with teachers and informal science educators, it would have been much easier for me to collect data. Evaluating the work we do with teachers is something I am used to, and over time I have realized that even though there may be great professional development, what actually gets carried out in the classroom is what matters. I would like to research what takes place in the professional development that gets carried out in the classroom and has a positive impact on students. Of all the various informal science programs K-12 that we worked with, which programs were most effective in impacting students? There are currently twelve programs, from The Bird School Project, Elkhorn Slough and Groundswell to Monterey Bay Sanctuary, they vary greatly in their resources and connections with NGSS. For my own students, which are science undergraduates thinking about science teaching, I want to know what experiences, readings or assignments that I provide in class impact their attitudes and beliefs about the environment. I will continue to apply what I learned from this project in my own teaching.

#### Impact of Action Research on the Author

The impact of this project for my own professional growth, which has been a life long journey, has been tremendous. I have been involved with research studies in some capacity over the last twenty-five years, but this was the first time I had control over the questions, instruments, treatment and results. It also helped that it was a smaller study, since I worked alone. Other projects that I have worked with had over twenty-seven

schools in three counties. I think the advantage of an action research project is the process itself, for teachers to identify a problem, test an intervention, collect evidence and analyze if the change made a difference. It is really a process for thinking about how we teach everyday.

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APPENDICES

APPENDIX A

IRB EXEMPTION CERTIFICATE



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
 FWA 00000165

2155 Analysis Drive  
 c/o Microbiology & Immunology  
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*Chair:* Mark Quinn  
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**MEMORANDUM**

**TO:** Joyce Margaret Hill and Walter Woolbaugh

**FROM:** Mark Quinn *Mark Quinn*  
 Chair, Institutional Review Board for the Protection of Human Subjects

**DATE:** November 20, 2020

**RE:** *"Impacts of Integrated Next Generation Science and Environmental Literacy Curriculum for Students [JH112020-EX]"*

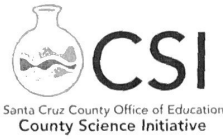
The above research, described in your submission of November 19, 2020, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

STUDENT SURVEY INSTRUMENT



**Relevant Environmental Action and Learning for Science Student Post Survey  
KF – Grade 3**

**In this survey, you will be asked about your feelings about nature and what you do in nature.**

**Your teacher and family may help you. Please be completely honest when you answer the questions. We don't ask for your name and your answers will not affect your grade. Participation in this research is voluntary. Participation or non-participation will not affect your grades or class standing in any way.**

**In the past year, how often have you...**

	Never	Sometimes	Often
a. Gone outside in nature?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Spent time in the outdoors with your family?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Gone hiking or walking in nature?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Spent time in the outdoors with your friends?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Watched wildlife?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Gone camping?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

In the past month, how often have you...			
	Never	Sometimes	Often
a. Read a book about nature?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Read about nature on the internet?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Talked about nature with your friends or family?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Volunteered to help nature with your school, church, community club, or scout troop?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>3. Mark the response that best matches how you feel now.</b>			
	No	Sometimes	Always
a. Spending time in nature is important to me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Learning about nature is important to me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. I like learning about nature.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. I like learning things outside of school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Nature makes me happy.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. I like nature.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. I like to be outside.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>4. I can help protect steelhead trout in the San Lorenzo River.</b>			
	<input type="radio"/> No		
	<input type="radio"/> I don't know		
	<input type="radio"/> Yes		
<b>5. I want to help protect steelhead trout in the San Lorenzo River.</b>			
	<input type="radio"/> No		
	<input type="radio"/> I don't know		
	<input type="radio"/> Yes		

6. The amount of water we all use at home and at school can change how much water is in the San Lorenzo River.

- No
- I don't know
- Yes

7. Do you know how to do these things?

	No	Not Sure	Yes
a. Ask questions about things I notice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Make a plan to answer my questions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Explain what I find out using words or pictures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. What is your gender?

- Girl
- Boy
- Other

9. What language do you speak at home?

- Spanish
- English
- Other language

10. Write your teacher's LAST NAME.

11. Mark your school name.

12. Mark your school district.

APPENDIX C

STUDENT INTERVIEW QUESTIONS

## **Student Interview Questions**

**(Third Grade-San Lorenzo Elementary)**

**Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

1. What did you learn about the environment from the lessons Sam and your teacher taught? What were some of the things that helped you to learn?
2. Watershed Probe. (Read and record responses)

**Which friend do you agree with? Explain your thinking.**

3. What can humans do to help the steelhead trout migrate successfully in the San Lorenzo River?
4. What are your thoughts about nature and your connection to it?
5. What do you think environmental stewardship means? What might it look like in action?
6. What science practices do you feel confident with?

For example:

Asking questions (for science) and defining problems (for engineering)

Planning and carrying out investigations

Constructing an explanation (for science) and designing a solution (for engineering)

APPENDIX D

SCIENCE RUBRIC

## Explanation Tool Rubric

Component	Level 3 Proficient	Level 2 Developing	Level 1 Emerging	Level 0 Not Evident
Claim	Claim answers the question, is accurate, and is complete. Completely describes the trend in the relationship between two variables.	Claim does answer the question but it is inaccurate or incomplete.	Claim does not answer the question.	Does not make a claim.
Evidence	Provides appropriate and sufficient evidence to support the claim.	Provides appropriate, but insufficient evidence to support the claim. May include some inappropriate evidence.	Evidence does not support the claim; only provides inappropriate evidence.	Does not provide evidence.
Science Concepts	Includes explanation of science concepts that link evidence to the claim (concepts are appropriate), and science concepts are sufficient (no omission of key concepts) and are clearly stated and accurate.	Includes explanation of some science concepts that link evidence to the claim, but are insufficient (one or more concepts that should have been included are not included) or some are inappropriate.	Restates evidence and does not include explanation of science concepts.	Does not include science concepts.
Scientific Reasoning	Includes logic statements that link the claim, evidence and science concepts (including words such as "because..." "therefore...") that clearly demonstrates logical reasoning.	Attempts to include a logic statement that links the evidence to the claim but does not adequately link the evidence to the claim.	Restates evidence or claim and does not include a logic statement that links the evidence to the claim.	Does not include scientific reasoning.


APPENDIX E

“CAN STEELHEAD TROUT MIGRATE IN THE SAN LORENZO RIVER?”

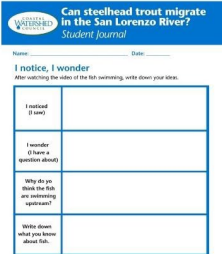
LESSON

## Can Steelhead Trout Migrate in the San Lorenzo River? Teacher's Guide

<b>Guiding Question</b>	How does water level affect steelhead trout's ability to migrate?
<b>Students will be able to:</b>	<ul style="list-style-type: none"> <li>● Describe the life cycle and migration of a steelhead trout.</li> <li>● Demonstrate typical water levels in the San Lorenzo River based on seasonal weather patterns.</li> <li>● Articulate how low water levels affect steelhead trout migration and reproduction.</li> <li>● Communicate about water conservation solutions and protecting steelhead trout.</li> </ul>
<b>Supports Content Standards</b>	<p><b>Next Generation Science Standards</b></p> <ul style="list-style-type: none"> <li>● <a href="#">3-LS1-1</a>: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death</li> <li>● <a href="#">3-ESS2-1</a>: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.</li> </ul> <p><b>Common Core Standards/ELA/Literacy</b></p> <ul style="list-style-type: none"> <li>● Language: <a href="#">CCSS.ELA-LITERACY.RI.3.1</a>, <a href="#">CCSS.ELA-LITERACY.RI.3.2</a>, <a href="#">CCSS.ELA-LITERACY.RI.3.3</a>, <a href="#">CCSS.ELA-LITERACY.W.3.1</a>, <a href="#">CCSS.ELA-LITERACY.W.3.2</a>.</li> </ul>
<b><u>Vocabulary</u></b>	Migration, life cycle, habitat, estuary, hydrograph, life stage
<b>Social and Emotional Learning support</b>	Each lesson starts with a 2-3 minute mindfulness activity guided by CWC staff based at the San Lorenzo River.
<b>Registration</b>	To register, please fill out this <a href="#">registration form</a>
<b>Decide how students will write their thoughts</b>	




**Option 1: print out journal**



**Option 2: download and use on computer**

[Click here for the student journal](#)



**Option 3: use class journal**

**Suggested Pacing Guide (see overview of each lesson below)**  
**It is recommended that you [make a copy of the Google Docs](#) to share with your students.**  
**This will ensure that students will have access to this in Google Classroom.**

Week	Lesson #	Format
1	1	Live Virtual Visit with CWC Educator
1	2	Asynchronous <a href="#">Google Doc Student Guide</a> (make a copy, then share) <a href="#">Seesaw</a>
2	3	Live Virtual Visit with CWC Educator
2	4	Asynchronous <a href="#">Google Doc Student Guide</a> (make a copy, then share) <a href="#">Seesaw</a>
3	5	Live Virtual Visit with CWC Educator
3	6	Asynchronous <a href="#">Google Doc Student Guide</a> (make a copy, then share) <a href="#">Seesaw</a>
4	7	Asynchronous <a href="#">Google Doc Student Guide</a> (make a copy, then share) <a href="#">Seesaw</a>
4 or 5	Optional	Live Virtual Visit: Watershed Rangers Ceremony

### Lesson #1 ENGAGE (week one)

**Live Virtual Visit**  
**30 minutes**  
[Live Virtual Visit](#)  
[Educator Guide](#)

1. Answer a few questions about what you already know.
2. Watch a video of steelhead and salmon swimming upstream.
3. Share what they notice and wonder.
4. Create a KWL chart for what they know about steelhead trout.

### Lesson #2 EXPLORE 1 (week one)

**Asynchronous**  
**30 minutes**  
*Make a copy then share*  
[Google Student Guide](#)  
[Seesaw](#)

1. Scavenger hunt! Explore the San Lorenzo River either virtually or in-person to observe where fish live.
2. Draw a picture of where fish live

### Lesson# 3 EXPLORE (week two)

**Live Virtual Visit**  
**30 minutes**  
[Live Virtual Visit](#)  
[Educator Guide](#)

1. Listen to a story to visualize how steelhead trout migrate to and from the ocean as they grow older.
2. Rewatch video of fish swimming upstream. Reflect on/update their answer to “why are the steelhead trout going upstream?”
3. Expand upon their model to draw direction arrows for the direction steelhead trout migrate.

### Lesson# 4 EXPLORE (week two)

**Asynchronous**  
**30 minutes- 1 hour**  
*Make a copy then share*  
[Google Student Guide](#)  
[Seesaw](#)

1. Observe steelhead trout in different life stages in a brief video.
2. Read about the different life stages.
3. Add life stages and facts to their life stage model.

### Lesson# 5 EXPLORE (week three)

**Live Virtual Visit**  
**30 minutes**  
[Live Virtual Visit](#)  
[Educator Guide](#)

1. Build a model to explore how water level affects migration.
2. Use a hydrograph to learn about changing water levels.
3. Identify which seasons and river levels are best for the migration of steelhead trout.

- |  |                            |
|--|----------------------------|
|  | 4. Review lesson #6 and 7. |
|--|----------------------------|

<b>Lesson# 6 EXPLAIN (week three)</b>	
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<p><b>Asynchronous</b>  <b>30 minutes</b>  <i>Make a copy then share</i>  <a href="#">Google Student Guide</a>  <a href="#">Seesaw</a></p>	<ol style="list-style-type: none"> <li>1. Answer the guiding question.</li> <li>2. View a video explaining migration and water levels.</li> <li>3. Identify water saving tips.</li> </ol>
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<b>Lesson# 7 ELABORATE/EVALUATE (week four)</b>	
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<p><b>Asynchronous</b>  <b>30 minutes- 1 hour</b>  <i>Make a copy then share</i>  <a href="#">Google Student Guide</a></p>	<ol style="list-style-type: none"> <li>1. Do an action project to save water.  <b>Option 1:</b> Teacher others to save water (comic strip or video)  <b>Option 2:</b> Do a home water use survey and pledge to save water.</li> </ol>
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<b>OPTIONAL: WATERSHED RANGER CEREMONY (week four or five)</b>	
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<p><b>Live Virtual Visit</b>  <b>15 minutes</b></p>	<ol style="list-style-type: none"> <li>1. Take a post-survey to share what they know.</li> <li>2. Celebrate and get sworn in as Watershed Rangers.</li> </ol>
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<b>EVALUATION</b>	
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<b>Teacher Evaluation</b>	<p>To help us improve the materials and also assess our impact on science and environmental education in our count, please complete the following two feedback forms. Your input is very much valued!</p> <p><a href="#">CWC Feedback form</a>  <a href="#">SCCOE Feedback form</a></p>
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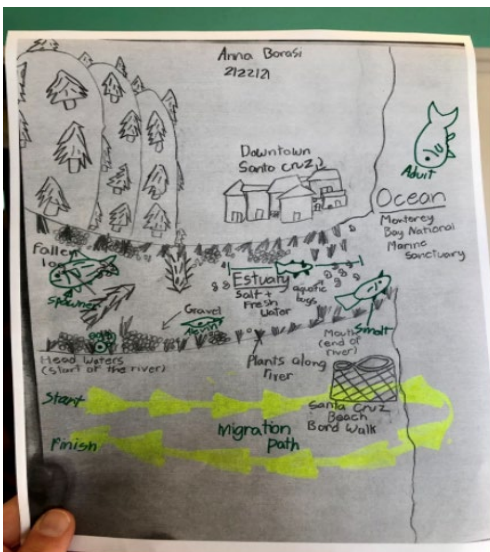
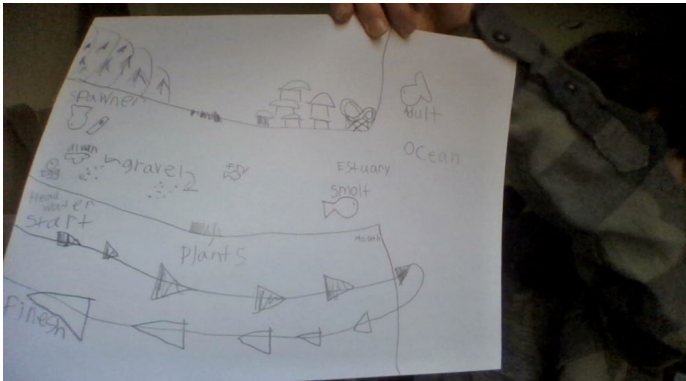
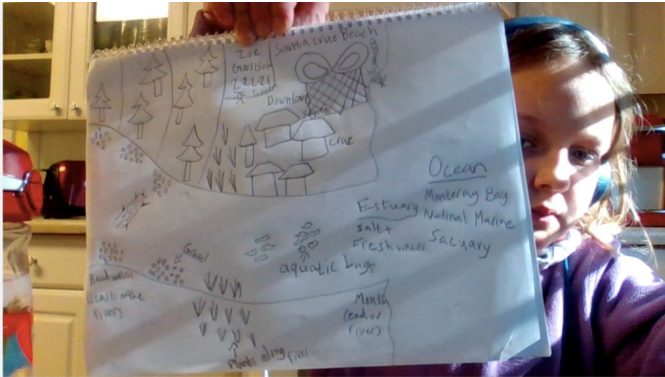
<b>Student Evaluation</b>	<p>The Coastal Watershed Council and Santa Cruz County Office of Education is seeking to learn about students' experiences and perspectives of nature. Please share the two below forms for students to complete with their families:</p> <p><a href="#">CWC Student Survey</a>  <a href="#">SCCOE Student Survey</a> (<a href="#">English</a> or <a href="#">Español</a>)</p>
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<b>Links from Hyperdoc</b>	<p><a href="#"><u>Lesson #1 Live Virtual Visit Educator Guide</u></a> <a href="#"><u>Lesson #3 Live Virtual Visit Educator Guide</u></a> <a href="#"><u>Lesson #5 Live Virtual Visit Educator Guide</u></a></p> <p><a href="#"><u>Pre-survey Google form</u></a> <a href="#"><u>Post-survey Google form</u></a> <a href="#"><u>Student Journal</u></a> <a href="#"><u>Steelhead trout swimming upstream video</u></a> <a href="#"><u>Visiting the San Lorenzo River Instructions</u></a> <a href="#"><u>Steelhead trout habitat in the San Lorenzo River video</u></a> <a href="#"><u>Steelhead trout life cycle video</u></a> <a href="#"><u>Steelhead trout migration obstacle course instructions</u></a> <a href="#"><u>Migration visualization story</u></a> <a href="#"><u>River Model Instructions</u></a> <a href="#"><u>Hydrograph Guidance</u></a> <a href="#"><u>Steelhead trout migration and water level video</u></a> <a href="#"><u>Final Steelhead trout habitat drawing example</u></a> <a href="#"><u>Guiding question answer/explain video</u></a> <a href="#"><u>Watershed Ranger Pledge Recitation</u></a> <a href="#"><u>Watershed Ranger Certificate</u></a></p>
<b>Questions?</b>	<p><a href="#"><u>Click here for the Frequently Asked Questions</u></a> Email Mollie Behn at <a href="mailto:mbehn@coastal-waterhsed.org">mbehn@coastal-waterhsed.org</a></p>

APPENDIX F

STUDENT EXPLANATION ARTIFACTS

Sample Student Artifacts



**Step 1: Answer to our focus question**

How does water level affect steelhead trout's ability to migrate?

Type your answer below

The way the water level effects the migration is if its high the water will be too fast for the fry and spawner. If the water was to low there would not be enough water for them to survive.

**Step 3: Brainstorm ways to save water**

In order to help keep more water in the San Lorenzo River, humans can save water.

Type your ideas of how people can save water.

Some of the ways to conserve the water is: 1. Make sure to turn the foseet when your done 2. Only drink what you need 3. Don't throw trash in the water 4. Don't spit in the water and 5. Don't waste water.

Using the student journal? Go to page 4 of your journal.

**Step 1: Answer to our focus question**

How does water level affect steelhead trout's ability to migrate?

Type your answer below

The way the water level effects the migration is if its high the water will be too fast for the fry and spawner. If the water was to low there would not be enough water for them to survive.

**Step 3: Brainstorm ways to save water**

In order to help keep more water in the San Lorenzo River, humans can save water.

Type your ideas of how people can save water. We can save water by not using a lot of water at once.

2: We can always turn of the foseet when brushing our teeth.

Using the student journal? Go to page 4 of your journal.

**Step 1: Answer to our focus question**

How does water level affect steelhead trout's ability to migrate?

Type your answer below

When steelhead are smolt they need lower water levels because if the water levels are too high they will not be able to swim. But when they are spawners they need higher levels to help them swim back to where they were born.

