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"Introducing the Duality Nature of Light": A Lesson Plan Developed from SSTELLA

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Abstract: *This paper is introducing the framework of a lesson activity in teaching duality nature of light in secondary level. The lesson activity is a sample developed of SSTELLA*[1] *(Secondary Science Teaching with English Language and Literacy Acquisition) project, that reflects the reciprocal and synergistic relationships among science, language, and literacy. The study was started by analyzing the project during my opportunity as a scholar visiting at the University of California, Santa Cruz, USA. It takes two months of study by reading the resources, participating in teacher training classes, interviewing with experts and teacher-students and meeting with project researchers and leader. The lesson activity is trying to obey the project framework and it can help teachers and curriculum developer to investigate the main parameter to plan activities for an active teaching, depending on purpose of developer of educational projects.*

Keywords: *SSTELLA, Secondary Science Teaching, Lesson Plan, Duality Nature of Light*

1. Introduction

A significant body of research on second-language acquisition has demonstrated that contextualized, content-based instruction in students' second language can enhance the language proficiency of English learners with no detriment to their academic learning[1]. The subject matter content provides a meaningful context for the learning of language structure and functions, and the language processes provide the medium for analysis and communication of subject matter knowledge. Inquiry science, therefore, is an excellent context for learning language and literacy.

Integrating the teaching of science content with the development of English language and literacy through contextualized science inquiry has been consistently shown to increase English learners' achievement in both science and in the development of academic language and literacy[2],[3]. These advances in the knowledge base on teaching science and English language and literacy to English learners are consonant with the discourse about the development of NGSS. Similarly, the NGSS represents a major shift from the focus of scientific literacy as decontextualized content and process knowledge toward scientific literacy as the productive and integrated use of science language with science content while simulating what scientists do (e.g., plan investigations, develop models, argue from evidence). The NGSS, based upon the National Research Council [4] report, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, identifies core science ideas and cross-cutting themes that students could learn in more rigorous and relevant ways as they progress through their K-12 science education. Further, the Science Framework provides a description of eight scientific and engineering practices that promote not only investigative competence, such as asking questions, planning investigations, and analyzing data, but also representational thinking through the use of models and mathematical relationships. Four of these science and engineering practices are particularly language intensive: developing and using models; constructing explanations (science) and designing solutions (engineering);arguing from evidence; and obtaining, evaluating, and communicating information[5].

Few models of science teaching have been articulated in terms of how preservice secondary science teachers can learn to (a) promote authentic scientific discourse practices[6], and (b) engage students in rigorous, contextualized learning experiences in linguistically diverse science classrooms[7]. Secondary science teachers generally consider themselves to be teachers of content rather than teachers of language, despite the fact that scientific argumentation, reasoning, and communication require a multitude of specialized written and oral literacy practices[8].The prominent focus of NGSS on

[1]http://sstella.sites.ucsc.edu

productive language use via the identification of language-intensive science and engineering practices has opened up new possibilities for all science teachers to consider the role of language in science and engineering instruction. This change represents a major shift in the way science teachers will be asked to teach in secondary classrooms, particularly in science classrooms with English Learners.

2. The SSTELLA Framework: Synergistic and Reciprocal Relationship between Language and Science for Secondary Teachers

The SSTELLA framework provides a much-needed response in science education to the many challenges that secondary school English Learners (ELs) face. SSTELLA is a framework for addressing inadequate teacher capacity for improving ELs' science achievement by advancing research-based instructional practices in the classroom. One reason cited is that attention to language instruction has often been fore grounded over content learning for ELs[9].SSTELLA reflects principles from the Science Framework and is designed to prepare teachers to effectively integrate science, language, and literacy instruction for ELs by promoting the productive use of science language in authentic contexts, whereby "students are supported in using multiple resources and strategies for learning science and developing English"[10]. The SSTELLA framework is represented visually in Figure 1 to highlight the relationships among the four SSTELLA practices and anticipated student learning outcomes. The framework views contextualized science activity as the gateway through which ELs can come to understand relationships between school science learning and their lived experiences outside of schools. Teachers promote scientific sense-making, scientific discourse, and English language and literacy development through these contextualized learning experiences. Science content and language then intersect as students, for example, construct oral and written explanations and engage in argument from evidence. Thus, the relationship between science learning and English language and literacy development can be viewed as reciprocal and synergistic. Through the *contextualized* and *authentic* use of language in scientific practices, students develop and practice complex language forms and functions. Simultaneously, through the use of language functions such as explanations and arguments in science investigations, students make sense of abstract core science ideas and enhance their conceptual understanding as well as understanding of the nature of science[11].The four interrelated SSTELLA practices mediate two primary student learning outcomes. First, students use core science ideas (e.g.,Light as an Electromagnetic Radiation can be described either by a wave model or a particle model) while engaging in authentic scientific practices and texts. They may be carrying out and reporting on an investigation related to Electromagnetic Radiation or using journals[12]as a reading-to-learn strategy in an online article that provides a description of the wave model or particle model of light. Second, students will productively use language while engaging in authentic scientific practices and texts: Instead of just paying attention to the science "content" while carrying out an investigation and reading an online article, the students also communicate a well-structured explanation for their investigation and identify, with supporting evidence, the tone and primary audience of the online article.

3. SSTELLA Instructional Practices

Secondary Science Teaching with English Language and Literacy Acquisition (SSTELLA) is submitted to the NSF DR K-12 program for consideration for a full research and development project in the Teaching Strand to develop, implement, and conduct an evidence-based investigation on an innovative model of secondary science pre-service teacher education. This project focuses on a critical challenge in STEM education: preparing novice secondary school teachers to provide effective science instruction to the rapidly growing population of students from language minority groups who have traditionally been underserved in STEM education and are underrepresented in STEM degrees and careers. SSTELLA aims to contribute to the knowledge base on preparing secondary teacher to teach science to ELLs (*English Language Learners)*.The SSTELLA instructional practices are followed:

a) *Scientific Sense-Making Through Scientific/Engineering Practices*

Scientific sense-making refers to how students negotiate everyday and scientific ways of knowing, while developing increased awareness of the nature and practices of science via engagement in scientific/engineering practices. Scientific sense-making is enhanced when teachers make explicit to students what they are to learn (i.e., a "big idea"), make connections between the big idea and classroom activity and prior knowledge or experiences[13]and make students aware of how they will demonstrate mastery of the big idea (i.e., the learning objective)[14]Students can better relate to the big idea when it is couched within a puzzling question, defined problem, and/or model-based inquiry (e.g., student development, refinement, and/or use of models[15]). Expectations and classroom rigor for ELs are maintained through deliberate and sustained scaffolding[16], which may include modeling of instruction, graphic organizers, visual representations and use of technology.

b) Scientific Discourse Through Scientific/Engineering Practices

Developing a coherent understanding of science requires that students learn how science knowledge is constructed, presented, and shared through specialized scientific *oral* and *written* language forms, i.e., the discourse of science[17],[18].This can occur through students' use of scientific/engineering practices, whereby students are exposed to and encouraged to engage with disciplinary specific uses of language (e.g., scientific discourse), such as communicating scientific explanations and arguments, and engineering solutions. These forms of oral discourse promote conceptual understanding, investigative competence, and an understanding of the epistemology and social nature of science. Scientific disco-urse is, in itself, a social and collaborative practice that can help students make sense of both science concepts and develop language[19].

c) English Language and Literacy Development

Scientific genres are characterized by dense clauses, technical and general academic vocabulary, and the use of the passive voice[20].To become independent consumers and producers of science knowledge, students need to be able to both comprehend and use scientific discourses, with attention not only to technical science vocabulary but also to general academic words and English language structures commonly used in science[21]. In secondary schools, however, all students, particularly ELs, face both (a) an increase in complexity of language genres and registers associated with disciplinary reading, writing, speaking, and listening[22]; and (b) a decrease in authentic content learning opportunities[23]. English learners can engage in authentic literacy practices that promote both content learning (e.g., core science ideas) and language and literacy development[24]. Targeted comprehension, composition, and vocabulary development strategies can support ELs in understanding and communicating complex science concepts[25]. Some of these strategies include reciprocal teaching[26], annotation and summarization[27], and interactive science notebooks and writing heuristics as well as non-traditional writing activities (e.g.,blog entries, letters; [28]and a focus on process-oriented writing skills[29]. Vocabulary development can be supported through the use of word walls, facilitating word consciousness/analysis, and providing repeated exposure to and multiple opportunities to use new words[30].

d) Contextualized Science Activity

Finally, a key aspect of supporting ELs in learning academic content is the incorporation of their cultural and linguistic background into classroom learning experiences; these experiences should be not only rigorous but also meaningful and relevant. Teachers and schools often have positioned underserved ELs as deficient and in need of remediation prior to engaging in rigorous course work, which essentially sets students up for failure before they even step foot into a secondary science classroom[31].Teachers must understand that ELs are quite capable of grappling with authentic and contextualized real-world problems that enhance both language development and conceptual understandings, and they should provide opportunities for them to do so[32]. By engaging students in science investigations and engineering design problems in authentic, real-world problems, teachers can leverage students' funds of knowledge from their homes and communities, the local physical (e.g., school building, community center) or ecological environment (e.g., local stream, watershed issues), and/or socio-scientific issues (e.g., stem cell research, sustainability science) as a way to engage ELs in meaningful and rigorous science learning experiences. To summarize, the four interrelated instructional practices just described highlight the reciprocal and synergistic relationship between science learning and English language and literacy development. The challenge for teacher educators is to infuse these practices into teacher education programs in ways that support secondary science pre service teachers in learning how to effectively teach science to all students, including ELs.

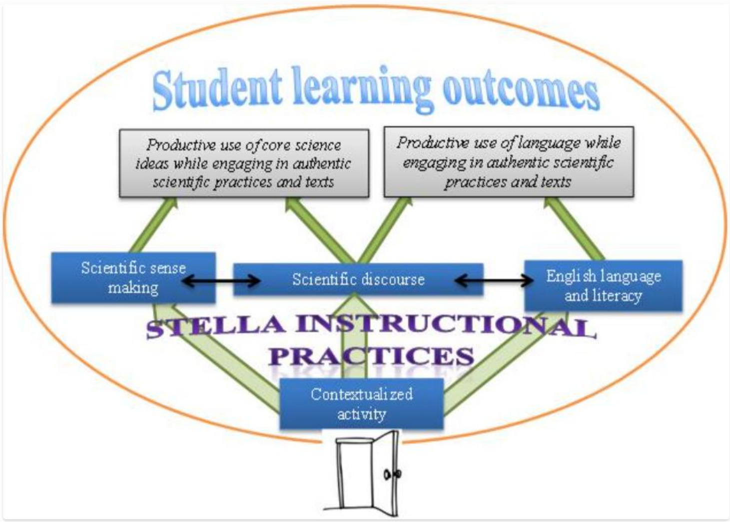

Figure1. *SSTELLA Instructional Practices*

4. SSTELLA SCIENCE METHODS COURSE

The SSTELLA science methods course addresses the core content of science methods instruction, i.e., theory and research on secondary science teaching, as well as appropriate state science standards and NGSS. In addition, the course addresses language and literacy integration for ELs. SSTELLA practi - ces are presented through multiple vehicles: video cases, instructor modeled science-language-literacy integrated units, and pre service teacher-developed and -implemented science-language literacy-integrated lessons. The use of video cases is effective in developing novice and experienced teachers' ability to identify, analyze, and use new teaching strategies through focusing their attention on specific classroom events, in this case, the SSTELLA practices[33] . Video cases from the classrooms of experienced secondary science-ELL teachers include the detailed footage needed to provide visual exemplars of the four SSTELLA instructional practices. The video cases contain both successful and failed episodes so that novice teachers can discern more-effective from less-effective strategies and transform their own conceptions and practices to approximate those of expert teachers[34]. The prese-nted vignette could be an example of episodes shared with pre service teachers and used to promote productive discourse for both individual and collaborative reflection. Throughout the lesson, instructors can engage in "metatalk" to discuss SSTELLA practices and ways to enhance learning for linguistically diverse students. For instance, after the lesson, the instructor might prompt students to reflect on how literacy was integrated throughout, as part of the focal science activities, and consider ways to support language development that would especially benefit ELs. Pre service teachers draw on the modeled video cases and instructional units to develop their own SSTELLA-infused science and engineering activities to be taught in the course and in their student teaching (to be videotaped) (See Table(a)).

Table(a). *Instructional Practices: SSTELLA Rubric*[35]

Not present(Rule based, inflexible)	**Introducing**(global understanding)	**Implemention**(organized plan)	**Elaborating**(Flexible, responsive to context)	**Instructional Practices: SSTELLA Rubric**[36]
Limited sense-making (recall science concepts; no "big idea")	Incorporates some S&E practices, but heavily T led; implicit "big idea"	Incorporates S&E practices through scaffolded, open-ended inquiry; explicit "big idea"	Development and use of scientific models w/ scaffolding, feedback, and reflection on learning goals	**Scientific Sense-making (SS)**[37]
Limited student talk and scientific discourse	Student talk and scientific discourse w/o probing and support	Student talk and scientific discourse w/ probing and scaffolding	Collaborative student talk and scientific discourse w/ probing, scaffolding, and feedback	**Scientific Discourse (SD)**[38]
Limited	Inauthentic	Authentic use of	Authentic use of	**English**

vocabulary and literacy in science	instruction on vocabulary and literacy in science	vocabulary and literacy in science w/ scaffolding	vocabulary and literacy in science w/ scaffolding and feedback	**Language and Literacy Development (LL)** [39]
Limited contextualized science activity	Momentarily relates activities to students' home/culture or local/ global environment	Makes clear connections between activities and students' home/culture or local/global environment	Makes sustained connections between activities and students' home/culture or local/ global environment	**Contextualized Science Activity (CX)**[40]

5. THE SAMPLE OF LESSON ACTIVITY BASED ON SECONDARY SCIENCE TEACHING WITH ENGLISH LANGUAGE AND LITERACY ACQUISITION PROJECT (SSTELLA)

Introducing the Duality Nature of Light

Developed by: Azita Seyed Fadaei

Class(Grade Level): High school Physical Science(grade12)

TimeLength: Two90 minute classes

"BIG IDEA" FOR LEARNERS

Light as an Electromagnetic Radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

LESSON OVERVIEW

This lesson allows students to focus on the necessity of study the nature of light in an article selection in **contextualized** real life example (Harnessing light in the life) to show how effects of light in our life can obey the investigating of the nature of light. This study can help students **develop disciplinary literacy** by historical study about the nature of light and its theories and by analyzing, constructing, and revising written explanations. In each model by analyzing each idea by **modeling** and **simulating** they with the help of **hands on activities** they put practical and theoretical aspects of light together, as scientists do to explore the physical world by **5E strategy**.

Students **use language in a variety of interactive modes** to explain two models of the nature of light, and to analyze each aspect of new **technologies** of light depending duality the nature of light.

The lesson begins with students activating prior knowledge about light and its effects on matter: Students observe and do the light experiments about wave or particle nature of light through direct interaction with real life experiments. They learn how to interpret them carefully; no preference will come to the each nature of light theories. They analyzes ome evidence in new technologies to the nature of light.

During teaching process next contents of SSTELLA are considered.

1: Remembering the Effects of Light on matter (**develop disciplinary literacy and language)**

2: The particle nature of light an its experiments (**contextualized** real life example)

3: The wave nature of light and its experiments (**contextualized** real life example)

4: Harnessing Light! To show the importance of the subject (**develop disciplinary literacy and language)**

5: Duality of Light and History (**develop disciplinary literacy and the nature of science)**

6: New Technology and duality of light (**develop disciplinary literacy)**

7: Academic language of Duality of light (**develop disciplinary literacy and language)**

During teaching process language and literacy activities are included in each activity and students will receive feedback from peers and revise their explanations.

STANDARDS

Next Generation Science Standards (NGSS)

HS-PS4-3. The Wave or Particle Nature of Electromagnetic Radiation

Students who demonstrate understanding can:

Evaluate the **claims, evidence, and reasoning**[2] behind the idea that (core idea): electromagnetic radiation (crosscutting): can be described either by a wave model or a particle model[3], and that for some situations one model is more useful than the other[4]. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [*Assessment Boundary: Assessment does not include using quantum theory.*][41]

Common Core State Standards Connections:

ELA/Literacy -

RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics -

MP.2	Reason abstractly and quantitatively.

Connections to other DCIs in this grade-band:
HS.PS1.C (HS-PS4-4); **HS.PS3.A** (HS-PS4-4),(HS-PS4-5); **HS.PS3.D** (HS-PS4-3),(HS-PS4-

[2] **Science and Engineering practices:**

-Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.

-Calculate the claims, evidence and reasoning behind currently accepted explanations to determine the merits of arguments.--- -Connections to Nature of Science:

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

[3]**Disciplinary Core Ideas:**

Wave properties

-[From the 3-5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other,(Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up)

PS4.B: Electromagnetic Radiation

-Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electronic and magnetic fields or as particles called photons. The wave is useful for explaining many features of electromagnetic radiations and particle model explains other features.

[4] **Crosscutting Concepts:**

Systems and System Models

-Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions-including energy, matter, and information flows- within and between systems at different scales.

4); **HS.LS1.C** (HS-PS4-4); **HS.ESS1.A** (HS-PS4-3); **HS.ESS2.A** (HS-PS4-1);**HS.ESS2.D** (HS-PS4-3)
Articulation of DCIs across grade-bands: **MS.PS3.D** (HS-PS4-4); **MS.PS4.A** (HS-PS4-1),(HS-PS4-2),(HS-PS4-5); **MS.PS4.B** (HS-PS4-1),(HS-PS4-2),(HS-PS4-3),(HS-PS4-4),(HS-PS4-5); **MS.PS4.C** (HS-PS4-2),(HS-PS4-5); **MS.LS1.C** (HS-PS4-4); **MS.ESS2.D** (HS-PS4-4

LESSON LEARNING OBJECTIVES AND ASSESSMENT

Scientific Objectives:

1. Students will investigate the duality nature of light. (NGSS, **HS-PS4-3)**

2. Students will identify the evidences related to wave and particle model of light. (NGSS, HS-PS4-A)

3-Students will identify the reasons behind the new technologies based on duality of light.

(NGSS, HS-PS4-B)

4- Students will identify with discovering new evidence in nature of light while old theory does not accommodate, the theory is generally modified in light of this new evidence.(NGSS, Nature of Science)

Language Learning Objectives:

1. Students will be able to assess the extent to which the reasoning and evidence in a text support the author's claim about each model of nature of light.

. (**RST.9-10.8**) (See Artifact D)

2. Students will be able to integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question about the duality nature of light. (**RST.11-12.7**) (See Artifact E)

3. Students will be able to evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (**RST.11-12.8**) (See Artifact H, NASA activities)

4. Students will be able to write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (**WHST.9-12.2**) (Final assessing, steps 13, 14)

SCIENTIFIC PRACTICES AND ASSOCIATED LANGUAGE FUNCTIONS

Table1. *Abstract of scientific and language functions*

SCEINTIFIC PRACTICE(S)	**5E(Engage, Explore, Explain, Elaborate, Evaluate)**
RECEPTIVE LANGUAGE FUNCTIONS	Analyze, Compare, Focus on written explanations in terms of structure
PRODUCTIVE LANGUAGE FUNCTIONS	Communicate Ideas(oral and in writings), Scientific writing, definition of academic keywords
KEY VOCABULARY	• Energy • Particle • Wave . Interference . Diffraction . Polarization . Photoelectric • Duality Nature of Light (DNL)

MATERIALS

For each student, copies of…

Artifact A: Light is energy;

Artifact B: New technologies and particle nature of light (NASA);

Artifact C: Polarization and contextualized hands-on;

Artifact D: Investigating scientific experiments based on 5E part 1;

Artifact E: Investigating scientific experiments based on 5E part 2;

Artifact F: Photoelectric effect;

Artifact G: Harnessing Light!

Highlighter (to highlight text);

Poster paper or white board (and markers) for each group: For groups to list evidence;

Index cards numbered 1-4 (enough for whole class) to use for participation (or other means of selecting students);

Experimental materials for each groups.

RESOURCES

http://www.nextgenscience.org/hsps-wer-waves-electromagnetic-radiation

http://www.nextgenscience.org/hsps4-waves-applications-technologies-information-transfer

https://www.youtube.com/watch?v=kgUnDeED9MM

http://www.nuffieldfoundation.org/practical-physics/viewing-sharp-shadows

http://www.bscs.org/sites/default/files/_legacy/BSCS_5E_Instructional_Model-Executive_Summary_0.pdf

https://www.youtube.com/watch?v=v-1zjdUTu0o

PREREQUISITE KNOWLEDGE

- Students will have already gone through five categorized concepts that define how two models about nature of light change over time

(1) Light is energy, (2) light and reflection, refraction (3) light polarization and interference, diffraction, photoelectric effect, (4) the nature of light based on each effect, 5) Duality of light.

TEACHING PROCEDURES AND ANNOTATED SSTELLA PRACTICES

Day 1

PART I: FRAME LESSON AND ACTIVATE PRIOR KNOWLEDGE
1. Activating prior knowledge about light. “Light is transferring energy in the space”. The teacher begins the lesson by displaying a photo of sunlight: “What do you already know about light? Light is Energy or matter? ”. Pictures of some light effects on matter in case of remembering the name of each effect. In the photo with the focus on sun light energy, “students’ misconceptions” about the transferring sunlight will investigate. By writing the all keywords regarding this discussion student concentration on keywords will improve. In the next step by watching video1(https://www.youtube.com/watch?v=kgUnDeED9MM):The power of the light to destroy a rocket. by discussing about the power of light to destroy objects, focusing is on the energy of light. Teacher: By watching this video think about the effects of light, what other cases like this subject in the video could you explain about the power of light, actually guess what is the light? Is that energy or matter? Why? Share your evidence in the group. Give students time to write, and then share with partner. Ask for a volunteer who said “energy” and one who said, “matter” and probe for their evidence and reasoning. Use this as an opportunity to draw out student conceptions, funds of knowledge. Teacher: “ Light is energy and with studying about different effects of it on matter we will investigate its nature, by investigating the nature of light we will be powerful to suggest its behavior in the matter and for future discoveries. In this part we want to remember what we have been learning over the last levels, so we need to review some aspects of light we’ve learned so far to address it”. Writing some keywords to response to this question. For each aspects of energy or matter putting them in the Table2,class discussion on the whiteboard. Discussing about evidence with group members. Table 2. Comparing matter and energy

Matter	Energy

-Watching video 2 (https://www.youtube.com/watch?v=0-Sf8ohG2aY): The power of the laser light to painting on a metal. (Contextualizing by asking questions about the usage of laser in every day life, beauty,

medical, industry, …)
-Discussing about evidence of light transferring based on video1and 2: Does it need physical substance?
-Discussing with evidence(light in the nature: reflection, refraction) in each case (Using slideshow 1, photos, hands-on experiments and contextualizing by asking about a glass of water and a spoon in it and…): the effects of light on objects depends on:
The objects:
The light:
(Instructional conversation)

2-Introduction to particle nature of light
-Teacher: In some old scientific books, light reflection has considered as a ball bouncing from ground surface.(A photo, hands-on with a small ball). Could light be considered as a ball, particles of energy?
(Instructional conversation)

-Teacher shows a short video 3(https://www.youtube.com/watch?v=DR-8ZRCHCXI, line marker:3:39-7:17).Have you ever heard about these particles name? Could refraction be considered with these high-speed particles movement?
-Teacher shows a short video 4(https://www.youtube.com/watch?v=J1yIApZtLos
, Line marker: 1:45-2:49) about old ideas about the particle nature of light. Teacher ask students about the idea of particle nature of light and scientists who believe it in the science history)
-Teacher's talk: *Light as a particle: Before the 19th century the popular belief among most scientists, notably Snell, Descartes, and Newton, was that light consisted of massless particles. Believed light moved faster in dense medium just like sound. These laws did seem logical at the time because light always seemed to move in a straight line, reflection was predictable and seemed elastic, and Snell's Law accurately predicted there fraction of light through a medium. Sir Isaac Newton was an advocate of the theory that light consisted of massless particles. He printed several works on the subject, most notably Opticks in 1704. Newton had two main sources of evidence to prove his theory of light consisting of particles: Sharp Shadow- When you observe any shadow it appears to have sharp edges. Sharp edges on shadows would be a result of particle light.(teacher can show it by demonstration). Waves would diffract around objects, resulting in fuzzy edges. Light Travels in a Vacuum- At this time it was thought impossible for a wave to travel in a vacuum. But everyone agreed that a particle would have no difficulty traveling in a vacuum.*

-Teacher demonstrates the **Newton's Refraction experiment:**
In this experiment you must observe the refraction of white light through a prism or diffraction grating resulting in the separation of light into the visible spectrum. This experiment was one of many found in Newton's Opticks printed in 1704. He describes the stronger red rays having less difficulty passing through the prism, thus being refracted less. While weaker blue rays have a much more difficult time passing through the prism, thus being refracted more. Then ask further questions to discuss in groups and write evidence on the whiteboard. What is the evidence that supports Newton's interpretation?
Is there enough evidence to support Newton's interpretation?
(Instructional conversation)

3- Particle model of light and new technologies
Discussing about the particle nature of light in the new technologies (Artifact B), finding new words and discussing about them in groups and in class discussion. Highlighting new words. Teacher adds explanation about the new technologies and particle nature of light depending on old scientists ideas about the light.

4-Teacher instructs students to take out the "light is energy and for transmission does not need matter, light has different effects on matter depending the light and matter, light effects with particle nature of light explanation" review sheet (see Artifact A) and give them time to write down notes to draw each of concepts. While they do that, circulate and assigned each person a number (1-4) [can be done through index cards, writing on their review sheet or orally]
- The teacher explains that "our goal is to investigate depending on light effects in real life and in our everyday life how could nature of light be considered? Particle model or something else?"

PART II: WAVE MODEL OF LIGHT
5- Teacher reviews key points from part I and figures out the light is a part of electromagnetic waves which you have been learning in last studies (Light is a wave of changing electric and magnetic fields. Light waves are caused by disturbances in the electromagnetic field, for example, the acceleration of charged particles (such as electrons)) and continues "We want to investigate the wave nature claim about the light and it starts

by a simple hands-on experiment in class(with a polarized sunglass in front of a cell phone) in the class".
Teacher: **Light as a wave:** In the 18th century, during the time that particle light theory was generally accepted, there was an alternate option presented by a minority of scientists. This alternative theory was that light consisted of waves, not particles. Most scientists did not believe this theory because of they observed shadow's to have sharp edges and they thought it impossible for waves to travel in a vacuum.
Teacher encourages students by asking some questions about the wave and important concepts about it to read the Artifact C and to summarize concepts and keywords in a concept map to start the study of wave nature of light. Then asks some questions about the reason of behavior of sunglass in front of cell phone light. Discussing in groups.

6-Introduction to wave nature of light

-Teacher starts students' instruction by some effects of light; which could not be explained by particle model:

(Light interference) The teacher asks students to see interference effect on the water surface (hands-on, demonstration, video 5, drawing what they observe on the video 5 about light interference, doing simulation about light interference (Simulation of light in interference effect, group working, analyzing, bridging between real life and virtual experiments). Answering the question about light passing through 2 splits, prediction, in worksheet, drawing, name the details of experiment and write their prediction. Focus questions are written on the Content Chart. (Artifact D, third row, not 5 and 6 columns)
Wrap up: particle model of light is not enough to define some effects of light.

(Light diffraction);The teacher asks students to see light diffraction between two fingers, and then asks students to observe a demonstration based on 5E strategy. (Demonstration 1) and then Video 6about the diffraction effect of light. Discussing about particle model of light is not enough to define some effects of light and the wave nature of light works.(Artifact D, another rows except end one, not 5 and 6 columns)
Then, ask small groups for explanation about claim (assertion) and evidence (use to support claim), reason (statements that elaborate on the importance of the evidence and link evidence and scientific principles to claim) about how could it be explained with the particle nature of light. Students get familiar with past scientists confliction about particle nature of light. Wrap up: the wave nature of light is appropriate to analyze this effect.

(Light polarization);the teacher asks students to see polarization of light in the video 7, drawing what they observe on the video 7 about light polarization and passing wave through sun glass. Wrap up: the wave nature of light is appropriate to analyze this effect.(Artifact D, end row, not 5 and 6 columns)

7-End class by displaying the task they will have tomorrow, to explain - "How particle model of light is not enough to define some effects of light and how it could be explained by the wave nature of light". Assign them the following homework:
a) Fill blank columns in Artifact D. For each effect, list any of the two ideas about the nature of light (particle or wave nature of light) that might help explain investigated phenomena.
b) Read through rubric (Artifact E) used to assess explanations you will work on tomorrow -will be discussed in the next class (Purpose: investigating scientists activities to explore the mystery behavior of light).

DAY 2

PART III: FURTHER UNDERSTANDING OF WAVEMODEL ABOUT LIGHT

8- Teacher reviews wave nature of light and encourages students to work on the review of meaning of wave that they have studies in the Artifact C, then discussing about the analyzing light interference and diffraction and polarization based on wave model of light in the Artifact D. Introducing them that analyzing the concept based on 5E are a way that scientists observe something they're wondering about, using as many senses as possible. They watch, notice, or even record exactly what happens.

Have students discuss questions with their partner, one-by-one about the results of each effect and what they had predicted , class discussion.
Teacher: Watching Video 4: History of light (line marker: 0 to 6:48) ;
In 1803 a scientist named Thomas Young (Young's Double Slit Experiment)changed the particle versus wave debate forever.
At the second part of the Video 4 (line marker 6:48-end) introduces them the scientific reasoning and exploring the world is possible by accepting facts by observing and analyzing them while new facts will welcome the scientific method is exploring the new idea and accepting them.
Students have to make a decision on which theory is correct and give evidence to support their decision before discussing the correct theory.

9-Photoelectric effect: The necessity of particle model of light! (Artifact F)
Video 8 (https://www.youtube.com/watch?v=v-1zjdUTu0o)
To review the photoelectric concept of light teacher asks students to read the Artifact F and discuss about the nature of light. In this part with the quantitative study about energy of photon, particle nature of light is emphasized. In this level of study students confused about the correctness of each theory, and it is exactly the same thing that scientists are thinking about the duality nature of light. Teacher encourages students to follow the latest news about the theories in this part. One of amazing scientific news is about a method of photography that could help researchers to see both nature of light in a ray.(News: The first ever photograph of light as both a particle and wave (2015, March 2) retrieved 17, September 2015 from http://phys.org /news/2015-03-particle.html)

PART IV: UNDERSTANDING THE DUALITY NATURE OF LIGHT
10- Teacher: Discuss of which theory is correct? Students have to make a decision on which theory is correct and give evidence to support their decision before discussing the correct theory.
Teacher writes the definition of duality of light from Science Dictionary to attract students' activities to use scientific resources and academic words. Today idea about nature of light: wave-particle duality: *The exhibition of both wavelike and particle like properties by a single entity. (The American Heritage® Science Dictionary, Copyright © 2002. Published by Houghton Mifflin. All rights reserved.)*
Then encourages students to state the meaning of the duality nature of light in their groups and then each group state their idea to the class.

11- (Contextualizing). The International Year of Light and Light-based Technologies, 2015 (IYL 2015) is a United Nations observance that aims to raise awareness of the achievements of light science and its applications, and its importance to humankind. To be informed about the benefits of studying about the nature of light helps students to achieve to the goals of this lesson.(Artifact G: Harnessing Light!). Asking students to think about the necessity of studying light to control it to achieve to the future researches. Group discussion.

12- The teacher asks students to discuss about Table 3 in their groups and mark each part with Yes or No. Group discussion.
Table3. Investigating duality of light in optical phenomena

Phenomenon	Can be explained in terms of waves	Can be explained in terms of particles
Reflection		
Refraction		
Interference		
Diffraction		
Polarization		
Photoelectric effect		

13-Final Summarizing; Ask students to:

- Write new conceptual key words intheir notebooks pages for assessing;
- Order them in the historical timeline;
- Draw concepts related them;
- Find definition of each word by the help of their textbook.
- Use a scientific framework to write their interpretation of each conceptual key word.

14- Assessment:
Write a letter to Newton and inform him about the evidences about wave nature of light (including evidences, an experiment, explanation with scientific words), then highlight the conceptual key words in this letter. Try to explain each key word to one of your family member in easy way.

6. CONCLUSION

Although the SSTELLA framework is grounded in empirical research, researchers still must determine the impact that it could have on pre service science teachers and their future students. The researcher team are currently using the SSTELLA framework in a quasi-experimental longitudinal study at four university teacher preparation programs across the western and southwestern United States. The design calls for them to track two secondary science cohorts at each program (~180 teachers), one during the 2013- 2014 academic year and one during the 2014-2015 academic year. Their theory of change states that *Science Method* instructors' increased implementation (and modeling) of SSTELLA practices will lead to positive changes in pre service secondary teachers' knowledge of SSTELLA practices and beliefs about teaching science to ELs. This, in turn, will lead to increased implementation of SSTELLA practices as student and novice teachers, which will ultimately improve student learning[42].

In this article, we propose a lesson activity and SSTELLA framework, for developing a pre service teacher education program designed to prepare secondary teachers to integrate the teaching of academic language and literacy with rigorous science content instruction for the rapidly growing population of English learners. Novice teachers benefit from explicit models of integrated instructional practices that use exemplar instructional units and video cases that link the models used in teaching science methods with those in teaching practicum activities. Coherence would be achieved, as pre service teachers receive coaching and feedback while developing integrated teaching practices by expert mentors who themselves have been coached. We see the SSTELLA framework, which builds on the NGSS and CCSS, as central to this integrated model of pre service secondary teacher preparation. Although this article has focused on the preparation of teachers to work with ELs, the new standards recognize the critical role that language, literacy, and discourse play in the learning of science for all students. One cannot learn science without also learning the scientific register: the specialized, cognitively demanding language functions, and structures needed to understand, conceptualize, symbolize, discuss, read, and write about topics in academic subjects. Similarly, one cannot *do* science without using scientific tools for sense-making and thinking that are mediated through language. Thus, secondary science teachers also need to understand how ELs and English proficient students benefit from the integration of science with academic language and literacy development. The critical points are that language processes promote understanding of content across all subject matter domains, and that language use should be contextualized in authentic and concrete activity.

Notes

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2. Many thanks to Dr. Trish Stoddart[5] the Professor of Education at the University of California, Santa Cruz for inviting me for a scholar visiting position to study the project and develop it.

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[5]Principal Investigator: Dr. Trish Stoddart is a Professor of Education at the University of California, Santa Cruz. Dr. Stoddart is an expert at improving the teaching of science in culturally and linguistically diverse classroom. She has extensive experience in research on instructional innovation and science education and has led several large federally funded projects including the NSF funded Effective Science Teaching for English Language Learners (ESTELL) project, the NSF funded Local Systemic Initiative LASERS (Language Acquisition through Science Education for Rural Schools) which brought together seven school districts to improve the teaching of science to English Language learners in California's Central Valley and the USDOE Federal Eisenhower Project CCTD (California Consortium for Teacher Development) which brought together 18 CSU and UC campuses in a research and development project on preparing pre-service teachers to work with diverse learners.

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