Supporting English Language Learners Through Inquiry-Based Science: Three Strategies for Your Classroom

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Abstract This chapter uses inquiry-based learning as an approach to discuss three strategies for teaching English Language Learners science content: (a) short silent movies, (b) interactive word walls, and (c) interactive science notebooks. This approach has theoretical grounding in cognitive and social learning theories (i.e., Piaget, Vygotsky, and Cambourne). We discuss the best methods to implement these strategies, suggestions to modify them, as well as the limitations of each. We provide vignettes that focus on natural selection to give context for each strategy. The chapter concludes with a summary of each strategy, a brief discussion on how to combine these strategies for maximum benefit, as well as, questions to reflect on how to promote best practices with these strategies.

1 Introduction

Recommendations and standards for K-12 science teaching and learning advocate for the scientific literacy of students (Next Generation Science Standards [NGSS] Lead States, 2013). Hodson (2009) stated scientifically literate individuals "…must be able to read, write and talk the language of science appropriately, comfortably and effectively" (p. 241). The importance of teaching English Language Learners (ELLs) science is vital due to increasing student diversity, consistent testing gaps, acceptance of new science standards, and the knowledge that all students need to understand science (Buxton & Lee, 2014). ELLs struggle with science and scientific literacy, due to the difficulty of scientific vocabulary (Jackson & Narvaez, 2013).

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Effective classroom instruction must be provided to foster scientific understanding and thus academic success.

This chapter discusses Inquiry-Based Learning (IBL) as an effective instructional strategy to promote scientific vocabulary acquisition in students, especially ELLs. We operationalize IBL strategies as constructivist methods to engage students in metacognition, promote student discourse, and foster higher-order processing skills (Stoddart, Pinal, Latzke, & Canaday, 2002). This chapter presents a rationale for using IBL for teaching vocabulary to ELL students via integrating science and literacy instruction.

We present a description of the three specific strategies of Short Silent Movies (SSM), Interactive Word Walls (IWWs), and Interactive Science Notebooks (ISNs), along with the theoretical underpinnings of IBL from cognitive and social learning perspectives. The chapter includes implementation strategies and an exemplar lessons focused on the topic of natural selection. We also present modifications for teaching further content along with the importance of integrating science inquiry and literacy for ELLs.

2 Approach to Teaching Science to ELLs: Inquiry-Based Learning

Students are diverse – both linguistically and culturally (Lee & Fradd, 1998). For example, students who speak a language other than English in their homes and who may have varying levels of proficiency with English, will make up over 40 percent of K-12 students by 2030 (Collier & Thomas, 2001). Therefore, to be effective, teachers must be prepared to face such diversity (Bruna, Vann, & Escudero, 2007). Science teachers face several issues when planning and implementing instruction for their ELL students and possibly the easiest approach is to integrate the teaching of content (i.e. science) with second language acquisition via literacy (Carrier, 2005; Lee & Buxton, 2013; Lee & Fradd, 1998; Stoddart et al., 2002). Research has indicated that this combination has a much stronger impact on achievement than either alone, particularly with ELLs (Amaral, Garrison, & Klentschy, 2002; Bravo & Garcia, 2014). We become capable speakers of a language when participating in using it for some purpose rather than for its own sake (Roth, 2005). Integrating science literacy and language acquisition has considerable positive impacts on narrowing the gap between ELLs and their English-speaking peers in content area learning (Bruna et al., 2007; Cuevas, Lee, Hart, & Deaktor, 2005).

Learning science is critical so that students not only think and reason, but are able to make informed decisions on scientific and environmental topics locally and nationally. Four strands of science instruction (i.e., understanding scientific explanations, generating scientific evidence, reflecting on scientific knowledge, and participating productively in science) were identified by Michaels, Shouse, and Schweingrubber (2008). Traditional class models (i.e., teacher-centered) follow a text, lecture, quiz format with teacher led investigations and fail to address three of the four strands. Using science inquiry as an instructional approach allows for all four strands in science classrooms, thus more closely resembling the work of scientists and the Nature of Science (NOS), and promotes student-centered instruction. The best way to foster critical thinking and reasoning is to engage students in the processes of science inquiry.

The National Science Education Standards (National Research Council, 1996) defines science inquiry as:

> The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p. 23)

Science inquiry is more than using a kit for hands-on learning, although kits may serve as a springboard for inquiry. Science inquiry involves some of the same skills as a science fair project, but is more sophisticated than testing a hypothesis and analyzing data. It is systematic reflection of one's ability to generate knowledge, to state, test, and ultimately revise their hypothesis, and perhaps most importantly to *communicate* their findings. The National Science Teachers Association (NSTA, 2003) recommends that science teachers, regardless of grade level, engage in science inquiry with students via planning and implementing an "inquiry-based science program" (para. 5). Teachers are encouraged to create learning environments and to use approaches that encourage exploration of the natural world, provide time for inquiry, and promote students' understanding of what scientists do to learn about the world.

Martin (2000) defines inquiry skills as "… a set of broadly transferable abilities, appropriate to many science disciplines and reflective to the behavior of scientists." Inquiry skills, sometimes referred to as process skills, include but are not limited to observing, classifying, measuring, inferring, predicting, communicating, using numbers, making models, defining operationally, collecting and interpreting data, identifying and controlling variables, forming and testing hypotheses, and experimenting. Learning environments that support these actions is critical to promoting scientific literacy in all students, especially ELLs.

In education, literacy is defined as encompassing reading, writing, listening, and speaking and the ability to make sense of, engage in, and communicate with others on a variety of complex topics. According to the National Council of Teachers of English (NCTE), literacies are "multiple, dynamic, and malleable" (2013, para. 1) and includes verb usage like that of science inquiry skills such as solve, design, analyze, create, and critique. Therefore, integrating science inquiry and literacy is not at odds pedagogically or in practice.

2.1 Three IBL Strategies for ELLs

The integrated activities described below combine science inquiry with best practices in literacy and English language learning and are steeped in social constructivism, which emphasizes the collaborative nature of learning (Vygotsky, 1978). Collaborative methods allow the learners to develop leadership and teamwork skills while scaffolding their learning. These activities encourage student literacy development while engaging them in exploring the science content via science inquiry skills.

Short Silent Movies (SSM) Science teachers traditionally define student collaboration as the work students do with laboratory partners or in groups as they complete investigations and assignments. Peer collaboration approaches require planning and preparation for purposeful grouping: who to collaborate with whom (considering student diversity), grouping/pairing students strategically for success, and assembling thoughtful combinations of students with an eye to friendships and familiarity between and among them. SSM's are a strategy that utilizes the affordances of peer collaboration.

When using SSM's and other peer collaboration techniques, instructors should be attentive to how classroom pairings or groupings can also boost social and academic achievement and how the English-speaking peers play a role in providing language support as the students work through assignments and classwork. This role is often invisible as the students ask and answer questions, paraphrase information, elaborate and provide feedback to one another as ideas during information sharing and discussion.

Interactive Word Walls (IWWs) IWWs build academic content vocabulary, a vital part of science instruction for students like ELLs who struggle with the academic language of science (Jackson & Narvaez, 2013). A class word wall can serve as an effective tool to assist with the acquisition of science vocabulary. Traditional word walls in elementary settings are a group of words displayed on a wall, bulletin board, whiteboard, or poster that are easily viewed and used to assist students with spelling and writing, model high frequency words, spelling patterns and more. The teacher normally determines what words to include.

IWWs extend this idea using visuals and student-led construction of the wall. Visuals may include student generated drawings, pictures, concept maps, graphic organizers, video clips, and physical items. Thus, these visual aids allow students to develop multiple approaches to learning vocabulary and personalize word definitions, by promoting vocabulary knowledge and deeper comprehension (Soto Huerta, 2012). Multimedia such as tangible artifacts, PowerPoint presentations, and interactive smart-boards are excellent IWW tools.

It is not enough to simply display word walls at the secondary level; higher comprehension and understanding occurs when social interaction, active engagement, and student choice are included (Gambrell & Marinak, 1997; Reynolds & Symons, 2001). This allows the learner to associate word features and meanings with familiar ideas, concepts, and experiences and is actively engaged in multiple, varied, and meaningful experiences with words (Harmon, Wood, & Kiser, 2009). Students build vocabulary knowledge and make connections between the words and their IBL experiences as they construct the IWW and use it to support scientific discourse (Jackson & Durham, 2016).

Interactive Science Notebooks (ISNs) The objective of the ISN is to increase students' science content knowledge and conceptual understanding, to use writing as a part of IBL, and to promote students' ability to link thinking with writing (Young, 2003). ISNs provide students with opportunities to write about their science experiences by discovering and modifying current knowledge and reflecting on knowledge acquired thereby promoting deeper conceptual understanding (Butler & Nesbit, 2008). Such notebooks support differentiated learning by allowing students with diverse abilities (including ELLs) to learn and succeed (Gilbert & Kotelman, 2005).

Using ISNs, the teacher can evaluate individual progress of students and collectively address challenges, concerns, and progress. ISNs provide students with an organized reference for topics covered in class while modeling scientific behavior by accurately recording scientific investigations (Young, 2003). ISNs vary in the type of notebook used (spiral or bound), layout, and mode of representation (paper or digital) (Butler & Nesbit, 2008; Miller & Martin, 2016; Murcia, 2014; Young, 2003). Every student has their own notebook, and all science lessons become a part of this notebook. A table of contents at the beginning and an index of terms are constructed for easy reference. Some teachers also provide a rubric at the beginning (Young, 2003).

Each of these strategies, explicitly described later in this chapter, integrate science inquiry and literacy activities to the benefit of ELL students. Students work together to create meaning and construct higher order understanding of scientific processes and content while developing their English language skills.

3 Theoretical Foundations of the Approach

Inquiry is a powerful way to acquire science content and has theoretical underpinnings in constructivism; a theory used to explain how we know what we know. Constructivists' view learning as a process in which students *actively* construct or build new ideas and concepts based upon prior knowledge and new information (Herr, 2008). The constructivist science teacher implementing inquiry is a *facilitator* encouraging and *guiding* students to discover principals and to create personal knowledge.

Piaget & Inhelder (1969) and Vygotsky (1978) are two constructivist theorists whose theories differ, but both support active construction of knowledge by students. While Piaget's theory focused on the child and their environment, Vygotsky believed the development of understanding was dependent on the social interaction of language and culture, and that this social learning led to cognitive development.

Three key elements to Vygotsky's social constructivism are reflected in our integrated approach teaching ELLs: the zone of proximal development (ZPD), scaffolding, and approximation or guided participation. The first, ZPD, is described as the difference between the learner's developmental level when working independently and their developmental level when working with a teacher or more capable peers. Scaffolding requires the teacher to find the learner's ZPD and involve them with peers on a learning task. Supports are offered and gradually removed as the individual and group increase in their independence. IWWs, ISNs, and SSMs are three ways that these supports can be offered so students become more vocabulary proficient. The final aspect is that of approximation, a process in which learners imitate the behaviors of their models. Approximation allows language development and is particularly relevant to ELLs. Examples include when infants repeat sounds or ELLs mirror the language of peers. The use of approximation by skilled educators means that ELLs will not address listening, speaking, reading, or writing in English as separate activities but engage in integrated language and literacy tasks (Lee & Buxton, 2013).

Children acquire abilities with oral and written language most easily when certain conditions exist in their learning and home environments (Cambourne, 1995). These conditions of learning align with Vygotsky's social constructivist theory and allow ELLs maximum capacity in English language learning. Cambourne's eight conditions and classroom implications form a theory of literacy and language acquisition that can guide all ELL teachers regardless of content area:

1. *Immersion* refers to being "saturated by, enveloped in, flooded by, steeped in, or constantly bathed in that wish is to be learned" (p. 185). For our ELLs, that is science content, science vocabulary, and English.
2. *Demonstration* allows for students to observe "actions and artifacts" (p. 185). This may include teachers modeling scientific phenomena as well as the everyday language used by peers.
3. *Engagement* takes immersion and demonstration further and includes attending to the tasks. This engagement is in part set by establishing the "perceived need or purpose for learning in the first place" (p. 185).
4. *Expectation* are messages communicated to learners. They are "subtle and powerful coercers of behavior" (p. 185). ELL science students must expect to receive the clear message that they are expected and capable of learning English.
5. *Responsibility* refers to allowing the learner personal choice in how they will engage in the learning.
6. *Approximation* means that children are not expected to wait until the language has been mastered before using it. Instead, approximation should be encouraged, thus the learning environment should be free of anxiety and allow the use of word approximations until more conventional English is acquired.
7. *Employment* refers to opportunities we give to learners to use and to practice their developing language skills. This may begin with teachers asking students to respond with physical gestures or a simple yes or no to including ELLs in small and whole group discussions.

8. *Response* refers to the "feedback or information" (p. 185) that learners receive from the learning community because of effort. These responses from teachers or peers, must celebrate learner approximations, reply via modeling the appropriate language, and encourage interaction.

ELLs benefit from a social constructivist and integrated approaches to learning science and English language via inquiry because learning opportunities are authentic and are focused on active meaning-making and problem-solving. Through IBL students engage in personal thinking, discourse, and higher-order processing skills (Stoddart et al., 2002).

The strategies presented in this chapter align with cognitive and social learning theories of Piaget, Vygotsky, and Cambourne. Peer collaboration through SSMs supports ELLs in learning science vocabulary by allowing them a safe space to approximate English language. Peer collaboration is also promoted through ISNs and IWWs and encourages vocabulary acquisition through student choice and autonomy.

4 Implementation of the Approach

Because SSMs, IWWs, and ISNs are encompassed in the cognitive and social learning theories that support knowledge acquisition, the following section provides specific instructions regarding each strategy and implementation suggestions which include a vignette of a foundational concept in the teaching of evolution: natural selection. We discuss modifications and limitations of each strategy and provide additional resources for each in a table at the end.

Implementation: SSMs Good inquiry requires conversation, either between the teacher and student or between and among students themselves. SSMs allow students to build conceptual understandings as they talk, share, and discuss a science concept. For example, many students recognize the idea of survival of the fittest. Often, they believe this only applies to prey species and/or the phrase means the largest, most fierce, fastest organism will have better chances of survival. They seldom realize that fitness may describe the organism that is smallest, has the best disease resistance, or can hide regardless if they are predator or prey species. Instructions for implementation of the short silent movie strategy are below:

1. *Choose a video or video segment that is no more than five minutes in length*. Several high-quality videos are available from *The Shape of Life*, a PBS series. For our example, we have chosen a short clip on octopuses from the series http://shapeoflife.org/video/molluscs-octopus-camouflage. These creatures have no shell in which to hide, so they use camouflage as a means of defense. In a short two-minute video, a few of these creatures rapidly change in color, texture, and appearance.

2. *Turn the sound off/down and show the video clip.* We begin 10 seconds into this video. This ensures that no words are displayed on the screen prior to the segment students view so titles and narrative do not influence viewers.
3. *Stop the video and have student pairs or small groups discuss what they have seen.* The first few times using this strategy you may wish to offer discussion prompts to foster discussion. Provide 5 to 15 minutes for sharing. The amount of time offered will depend upon several factors including video subject and length, amount of student engagement, and prompts that may or may not be provided. We have found that students are unsurprisingly interested in the natural world and for some clips we bring the discussion to a close while discussion is at its high point. Because of the lack of narration, students become close observers of what they view. They use their own words and together build vocabulary that helps to explain what was witnessed. As student pairs or small groups discuss, all are responsible for taking notes, asking questions and attempting to answer their own questions, as well as predicting what happens next. The teacher does not provide language or vocabulary because it will organically surface as pairs and/or small groups share the experience.
4. *Bring the group conversations to a close and facilitate a class discussion regarding the video clip.* The students or teacher can write vocabulary, questions, and other information on the board. Are groups thinking alike? Have they posed questions that can be answered by other groups? Are there questions that the class cannot answer? Are students in agreement with one another or are there views that conflict? The rich discussion that arises in both small group and class discussions enables learners to make sense of the world around them as they learn the language of science.
5. *Play the video again; turn on/up the sound and listen to the narration that accompanies the visuals.* Another pair/small group sharing session may follow this. Are there gaps in information students have in their notes? Are students' questions answered? Do additional questions arise? Be aware that it is common for students to ask to view additional segments of the video or to see the entire video. Whether you choose to do so is a matter of personal preference.

Language and literacy courses, as well as science courses, can utilize the short silent movie strategy. It provides a way to support language acquisition as it promotes higher order thinking skills and conceptual understanding regardless of language abilities. Academic language spontaneously develops through discussion and conversation. Research (Clark, Nelson, Atkinson, Ramirez-Marin, & Medina-Jerez, 2014) supports that ELL students especially benefit from the incorporation of science content, language scaffolding (support), and technology. As students switch between English and their native language they learn and build personal understandings in a meaningful way.

An additional caveat is that, depending upon the field of science being studied and the video used, it is quite possible to incorporate and reinforce many of the basic science inquiry skills. For our natural selection activity, students use the skills of observation, classification, inferring, predicting, communicating, and defining operationally. This is an excellent educational return on a short investment in a class video of approximately two minutes and accompanying discussion among students. An additional biology example includes a time-lapse video of seeds germinating and/or of seedlings as they grow and move toward the light is shown. Many students do not believe plants move and seeing a seedling growing and moving is eye opening for them and provides a rich backdrop for vocabulary acquisition and expansion.

Modifications SSMs are easily used in a variety of science content areas (chemistry, physics, physical science, earth science, astronomy) and videos on concepts and ideas are freely available and easily found via an Internet search or by talking with colleagues who also teach content courses. As educator's plan these lessons and seek appropriate videos, they will spontaneously plan to teach a language lesson as well as a science lesson where students build language and science literacy in a very organic way. Variations for this approach exist in the literature. One the reader may find of interest is that of pedagogical subtitling (Danan, 2004; Talavan & Rodriguez-Arancon, 2014). In this variation, pictures or videos are subtitled. This captioning helps ELLs visualize what is heard and can increase language comprehension and depth of processing.

SSMs can be used to introduce a concept which may encourage students to complete accompanying readings in the text and find information on their own. Additionally, incorporating this strategy for teaching science content may also motivate and engage students in the reading process (Elliot, 2007). SSMs are also an excellent way to end a unit and have students self-check their understanding.

Considerations and Limitations Although numerous videos are available, it takes time and effort to identify useful videos and clips. Many on YouTube for example, incorporate written words on the screen, which, in our opinion, reveal too much information. We want students to think deeply and believe the words and/or titles are too leading or revealing.

It is important that groups report-out and/or discuss the information in the large group and that the instructor facilitates this discussion. Peers have teaching advantages unavailable to you as the teacher, but if they are passing along incorrect information this can be costly to the learner. An overall class discussion helps to avoid errors.

Implementation: IWWs To begin an IWW, students might brainstorm words through an introductory learning segment such as homework feedback, initial classroom discussions, responses to required readings, and/or peer collaborations. This allows the instructor to ascertain the basic background knowledge of students regarding a topic such as natural selection. This informal pre-assessment enables instruction planning. As class readings, discussions, and learning occurs, students and the teacher identify key content vocabulary to include on the IWW, determining how to organize and add key words and visuals. Teachers can support student understanding by providing a concept map template, sentence starters such as "an example of natural selection in nature is…" pictures, etc. These ancillaries particularly assist ELLs because they provide ELLs with the opportunity to make connections between their native language and understanding and the English language and understanding. However, all students participate in constructing and adding to the wall as they learn information. The wall can then be used as a reference point and continually refined for the students' ISNs and class activities. Fig. 1 provides an example of an IWW.

Modifications IWWs can be an actual classroom physical display, but a virtual word wall on an interactive whiteboard, Padlet, Chromebook or other such devices allows diverse multimodal opportunities (Wong, 2014). Virtual IWWs are a technology-enhanced alternative providing an option to link to bilingual dictionaries, video clips, an online ISN, and other hyperlinks. This provides ELLs with additional supports to access and learn the science vocabulary in a mode that works best for them. As a formative assessment, all students could use the wall as a word bank for a quiz before a cumulative assessment.

Considerations and Limitations This effective strategy does require planning and attention (Jackson, Tripp, & Cox, 2011). While students generate many of the vocabulary words, teachers must help organize the information to ensure that key concepts are included and that misconceptions are addressed and corrected. Those who teach multiple sections must also determine whether to have word walls for each section to directly differentiate instruction for each class or have a general

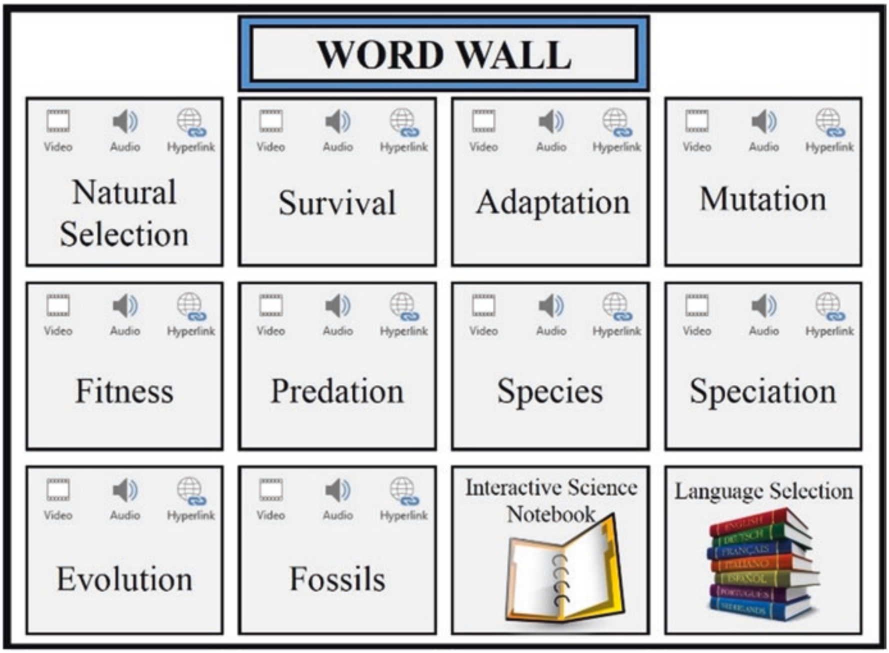

Fig. 1 Exemplar IWW for teaching natural selection

word wall for all sections of the same subject for easier management. Other challenges might include wall space and/or technology access, supplies and materials, and how long to use and then rotate IWWs (Jackson & Narvaez, 2013). We recommend the rotation of IWWs as core concepts rotate in the curriculum. For example, the IWW for natural selection may rotate out when the curriculum shifts from evolution to microbiology.

Implementation: ISNs ISNs are easily adapted and used at any grade and in any content area (biology, chemistry, or physical science) by changing the vocabulary, notes, and activity, and providing students with content and ability-appropriate writing prompts. The example format for ISNs provided in Fig. 2 is adapted from studies that used notebooks and journals aimed to create a student-centered learning resource to promote student success, including ELLs (Sibold, 2011; Towndrow, Ling, & Venthan, 2008; Young, 2003).

Regardless of construction, the teacher must be well prepared so that ISNs are beneficial to students and not merely an assignment. By creating a notebook of several upcoming completed lessons, the teacher can stay ahead of students while also providing an example for students.

ISNs use both the left and right hand side of the notebook and employ three sections: academic vocabulary and notes, scientific investigation or activity, and journal entry. The academic vocabulary and notes section is on the right-hand side, the scientific investigation or activity section on the upper left-hand side, and the journal entry on the lower left-hand side.

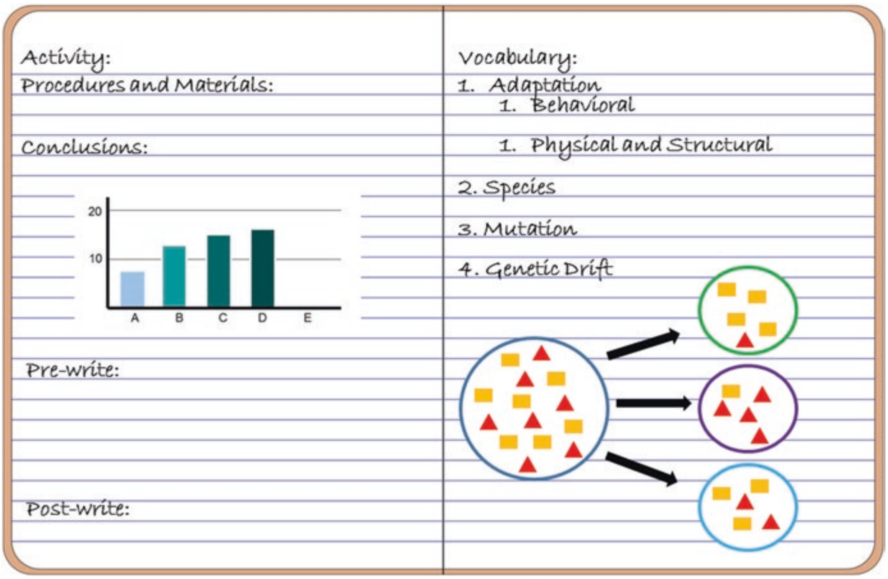

Fig. 2 Exemplar of an ISN

Academic Vocabulary and Notes: Right-Hand Side This section contains vocabulary and/or notes pertaining to the lesson. Within this section, students may write vocabulary words, definitions, descriptions, examples, pictures, and related vocabulary. Students may define vocabulary such as population, species, adaptation, natural selection, and evolution and include notes that pertain to the lesson of natural selection.

Scientific Investigation/Activity: Upper Left-Hand Side This section includes information regarding the scientific investigation including title, goal and purpose, questions proposed, the procedure (materials, steps, and data collected), and conclusions. Students can attach supplemental materials pertaining to the investigation such as graphs or tables, laboratory reports, or drawings to the upper left-hand side.

Journal Entry: Lower Left-Hand Side The journal entry provides an opportunity to reflect on acquired knowledge and learning and is divided into a pre-write and post-write. The pre-write occurs prior to instruction and allows students to write about current knowledge, understandings, and beliefs concerning the topic. This also serves as an opportunity for students to ask questions. The pre-write introduces the topic of natural selection and permits the teacher to recognize current knowledge of the topic.

The post-write occurs after instruction and the scientific investigation. Layout is like that of the post-write. The teacher may provide a topic-appropriate writing prompt or several questions. Students may try to answer their own questions proposed from the scientific investigation, activity, or journal entry pre-write. The post-write journal entry gives students the opportunity to demonstrate their understanding of the concept and provides a formative assessment on student progress from the pre-write entry. A benefit of this aspect of ISNs is that ELLs can write in their native language which has been shown to promote student understanding of the science content (Manz, 2012).

Modifications Depending on technology access, students can create digital ISNs (Miller & Martin, 2016). Multimodal representations of the notebook create "opportunities for students to experience knowledge and demonstrate what they know in an increasing range of modes" (Murcia, 2014, p. 77). The affordances of digital ISNs also includes the ability for easy sharing of data and work among students and teachers, enhanced visualization of data, and engaging opportunities for students (MacKinnon & Williams, 2006).

Considerations and Limitations Careful selection of vocabulary should be considered to limit use of words with multiple meanings and "complex argument structures" (August, Carlo, Dressler, & Snow, 2005, p. 55). In addition, the teacher must ensure the science notebook is student-centered; a tool for ensuring conceptual learning and understanding, rather than merely an assignment comprised of questions, ideas, and beliefs that the student thinks the teacher wants to see (Fulton & Campbell, 2004).

Table 1 Additional resources

Strategy	Links and resources
SSMs	http://www.openculture.com
	http://www.teachwithmovies.org/snippets-index.html
	http://www.sciencechannel.com/videos/
	Other sources: National Public Television, National Park Service, Department of Agriculture
IWWs	https://www.youtube.com/watch?v=qGujpt_-3Pc
ISNs	**Non-digital**
	https://www.youtube.com/watch?v=Cr898o3mXP8
	https://www.youtube.com/watch?v=TfZtvc61ZD4
	Digital
	https://www.youtube.com/watch?v=IL-x2mwlnO4
	http://www.kaysemorris.com/guide-to-using-digital-interactive-notebooks/

Table 1 provides additional resources for each of the three strategies we have shared here.

5 Conclusion

Current reform efforts advocate for the development of scientifically literate students. However, science learning has a multitude of barriers that prevent students from being successful learners. One barrier is a limited understanding of the complex language of science. This is even a greater concern for ELLs because they have a need to learn English as well as the language of science.

This chapter presented three inquiry-based strategies to teach natural selection. Each promotes IBL: (a) SSMs, (b), IWWs and (c) ISNs. Natural selection was the topic chosen to illustrate these strategies, but any cross-disciplinary and cross-content instruction can be achieved as promoted in the NGSS (NGSS Lead States, 2013).

In addition to the cross-disciplinary aspect of these strategies, the coordination of each approach promotes optimal learning of the language of science. For example, a 3-day lesson could incorporate the ISNs throughout all 3 days. SSMs may introduce a unit and IWWs could be used for formative assessment. Day three could incorporate peer collaboration through discussion of the ISNs and IWWs. Individual instructors should take the strategies and modify as needed for their learners. Even in a student-centered classroom, the additional use of these strategies will further support inquiry and the science language and knowledge acquisition of ELLs.

Reflection Questions

1. This chapter presented three strategies to IBL. Reflect on how your classroom environment supports the uses of these strategies. How could you incorporate them into your classroom and how can you use these strategies to teach "cross-cutting concepts" as indicated in the NGSS?

2. There are many ways to define science inquiry. Think about the three strategies presented in this chapter. How do these align with your personal definition of science inquiry? Provide specific examples of how you currently support science inquiry in your classroom.
3. What small steps can you do to implement these strategies?

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