Teachers' Visual Literacy Practices in Middle and High School Science Classrooms

Xiaoning Chen, Mark Newman, & Vito M. DiPinto

National Louis University, USA

Abstract. The study investigates how six middle and high school science teachers used what they learned in their teacher preparation programs and professional training to implement visual literacy practices to facilitate student learning. The teachers had varying levels of experience. They were graduates from teacher preparation programs at one higher education institution in a large metropolitan area. A case study method documented snapshots of the teachers' visual literacy practices. The findings indicate that, while the participants did not have a shared definition of visual literacy, they used practices shaped by the curricula of their teacher preparation programs and their school context. The participating teachers had students examine visuals in various ways to support understanding of science content. In addition, some visual literacy practices provided opportunities for students to analyze visuals, apply the analysis to scientific content being studied, and create visual narratives.

Keywords: visual literacy practices, science teaching and learning, secondary teacher preparation, professional development

As teacher educators, our primary goal is to equip candidates in teacher preparation programs with research-based and field-tested practices they can implement in their future classrooms. Using visual literacy as the example, the goals of this study were 1) To investigate the impact of teacher education programs on the graduates' teaching practices; and 2) To identify their continuing professional development needs.

Three faculty researchers examined how six graduates used visual literacy practices in science learning experiences that met the needs of all students. The research team assessed the connections between what the participating teachers taught in their classrooms and visual literacy practices learned in their teacher preparation programs and professional training. The faculty and participating teachers came from teacher preparation programs at a private, non-profit university in a large metropolitan area. The team employed a case study method to document snapshots of visual literacy practices of middle and high school science teachers.

Visual Literacy

A commonly agreed upon definition for visual literacy does not currently exist. Combining the ideas of several scholars, the researchers defined visual literacy as the ability to *read* and *make sense* of information presented in visual representations as well as to use visual formats to *communicate* ideas and findings (Baker, 2015; Newfield, 2011; Rowsell, McLean, & Hamilton, 2012).

Numerous studies have concluded that visual literacy is an important skill that promotes science learning. Aberšek (2008) argues that visual literacy is "one of 21st century literacies for science teaching and learning" (p. 9) and that it must be intentionally developed. Studies suggest that visual literacy improves both student understanding (Kelly & Akaygun, 2016; Mayer et al., 1996; Miller, Cromley, & Newcombe, 2016) and retention (Newton, 1984) of science content.

Visual means of representation highly motivate students to learn science (Dambekalns & Medina-Jerez, 2012) and promote learning. High school students reported that examining the illustrations of meiosis in biology classes helped them understand structures and phases of meiosis (Cook, 2008). Kelly and Akaygun (2016) concluded that using cartoon tutorials of molecular variations to complement traditional representations improved student understanding. Students noticed the differences between their initial mental models of molecular variations and the critical features portrayed in the tutorials.

Several studies noted that there is a connection between the effective use of visuals and the development of visual literacy skills. The explicit use of visual literacy practices in classroom settings creates opportunities for viewers to discover, analyze, and critique meaning embedded in the interplay of visual and other modes (Coskie & Davis, 2008; Rowsell et al., 2012). Reading and comprehending a highly abstract science diagram involves different skills than reading an everyday image (Lowe, 2000). As a result, it can be challenging for students to construct meaning from visual representations found in science texts and tests (McTigue & Flowers, 2011). Therefore, "it is essential that today's students develop the general visual literacy skills required for dealing with scientific graphics" (Lowe, 2000, 2nd para.).

For example, middle schoolers who received sustained instruction on conventions of diagrams outperformed those who did not have similar learning experiences (Miller et al., 2016). Knowledge of conventions of diagrams supported learning science content, in part by increasing student engagement (Miller et al., 2016). Dambekalns and Medina-Jerez (2012) reported similar results. By integrating science and art, they captured student interests and promoted learning among middle school students.

Despite the proven importance of visual literacy in science education, limited empirical studies explore teachers' visual literacy practices in science in diverse middle and high school settings (e.g., Cook, 2011; McTigue & Flowers, 2011). This study contributes to the literature by seeking an answer to the following question: How does instruction on visual literacy practices in teacher preparation programs and professional development venues impact the teaching practices of graduates?

The Study

The three researchers were faculty members from a private, non-profit university in a large metropolitan area of the United States and taught courses in the teacher preparation programs. One of the researchers was the science methods instructor who taught all the participating teachers in their teacher preparation programs. The other researcher taught a participating teacher in the ESL methods course. The third researcher was the social studies methods instructor and was not acquainted with any of the participants before the start of the study.

The faculty team followed up with the six graduates from the teacher preparation pro-grams to investigate how and why they used visual literacy practices in science classrooms. Important considerations for the study included investigating the impact of teaching practices especially how visual literacy practices affected student learning, and identifying future professional development needs.

These considerations led to posing the following supporting research question: How and why were graduates of varying levels of experience able to use visual literacy practices learned in their teacher preparation programs to facilitate students' learning in science courses?

The Participants

A convenience sample method was used to recruit the participants. Six teachers, two females and four males, participated in the study. Two teachers represented each cate-gory:

- First-year new teachers;
- Novice teachers who have been teaching for less than five years; and
- Experienced teachers who have been teaching for more than five years.

The names used in this report are pseudonyms. The participants' teaching positions are as follows:

- The first-year new teachers were Karina and Kristin. Karina is the only science teacher in a small Catholic middle school while Kristin teaches in a science department in a diverse high school (over 78% of minority enrollment) with over 3,500 students.

- The novice teachers were Alex and Chris. Alex teaches in a community charter middle school with around 400 students. Over 90% of the student population is from low income and minority categories. Chris teaches in a high school with over 2,000 students. The school has about 16% minority enrollment.

- The experienced teachers were Bob and Frederick. Bob teaches in a public school that serves students from PK-8. It houses over 800 students and about 35% of students are from low income and Hispanic backgrounds. The sixth teacher, Frederick, teaches in the same high school as Kristin.

All participating teachers have white, middle class background except Karina, who identified her cultural background as Filipino.

Methods

This is a qualitative study that describes how and why teachers used visual literacy practices in science teaching and learning. The data collection occurred during the 2016-2017 school year. Data came from the following four sources:

1. A completed survey by participating teachers at the beginning of the study describing their use of visual literacy practices in teaching science.

2. Transcript of two individual interviews of the participating teachers, one at the beginning and the other at the end of the study.

3. Completed notes on two classroom observations of each teacher.

4. The instructional materials related to visual literacy practices used by participants during the 2016-2017 school year.

A case study method was used to examine each teacher’s visual literacy practices in his/her science classroom. The interviews were transcribed for analysis and triangulation with the survey and classroom observation data. The field notes regarding the observations were documented and analyzed by all three researchers. Key words related to visual literacy practices from all data sources were identified to develop categories and themes.

Findings

The findings identified two major themes:

1. Though the participating teachers implemented visual literacy practices, there was no long-term, systematic planning and instruction on visual literacy skills.

2. The participating teachers' working definitions of visual literacy and their visual literacy practices were largely shaped by the teacher preparation training and the school context.

Based on the survey, interview, observations, and the instructional materials, the participating teachers implemented visual literacy practices that used real objects, images, videos, and hands on/lab activities for demonstration. They also used graphic organizers for notes or lab reports, tables and maps for analysis, making models, and drawing. For instance, Karina creatively set up a visual display of the student rosters in the periodical table format in her science room. While working with 8th graders to introduce the digestive system, Karina employed a PowerPoint presentation of images. She distributed graphic organizers for taking notes (Appendix A) and conducted several hands-on activities (e.g., the digestion activity where students pushed a bead through a straw (Observation 1, December 12, 2016)). In a lesson on states of matter, she had students demonstrate the distances of molecules in different states of matter by arranging pieces of cereal on a sticky note (Observation 2, April 27, 2017). In her interview, Karina shared how she, as a new teacher, was trying different visual literacy practices to help her students learn science:

> I do PowerPoints. So I have images so they can connect to what we are learning to see something. I try to do videos here and there although that doesn't really hold their attention very often. But I know this is not really visual literacy. But just being able to, more hands-on stuff that I try. It's all just trying right now though because I'm mostly just learning (personal communication, December 12, 2016).

Kristin was the other first year teacher included in the study. The faculty researchers observed her conducting several labs for sophomore students. For instance, during a lab at the beginning of the unit on equilibrium, students worked in small groups using two straws of different diameters to transfer volumes of water from two cylinders until they reached a new balance of water level in the cylinders (Observation 2, May 8, 2017). In a unit assessment, Kristin presented a number of unknown elements and asked students to identify where they should go on a blank periodical table based on the physical and chemical properties of these elements (Appendix B). In her interview, Kristin explained that most of her visual literacy practices were hands-on, including making models in the physical science classrooms. She noted that she would like to include more visually oriented activities in the Chemistry class (personal communication, November 18, 2016).

As an experienced teacher, Frederick reported that he frequently encouraged his students to draw and make models (e.g., the LEGO activity in his instructional materials, Appendix C) to explain the science concepts and processes. While exploring the topic of reflection with 9th graders, he drew a visual to show how a mirror reflects light on a board (see Figure 1). Then he had students draw an explanation demonstrating how the surface of mirror vs. paper reflects light differently (Observation 2, May 5, 2017).

Frederick confirmed that: "I'm big on the creation of models, a lot of drawing. The big idea I always try to do is just to have kids be able to explain through drawing models and describing models that they see" (personal communication, November 18, 2016).

Bob was the other experienced teacher. He showed three different types of video clips when he introduced the concept of a virus to his 7th graders (Observation 2, May 30, 2017). The first was a dramatic clip to explain what a virus is. The second was a Brain POP video that involved digital cartoon-like animations that defined what a virus is and how it fundamentally works in the body. The final animation employed cartoons and real imagery to show how viruses can "invade" human bodies and reproduce, but not necessarily cause a disease. In helping 8th graders engage in scientific discourses, Bob designed an activity in which students used data to support a claim by examining the historical data of a cholera outbreak in a certain part of London in the 1850s. Students were asked to observe the data presented in a table, transfer the data to a blank map, and analyze for patterns (Observation 2, May 30, 2017). For an example of the map, go to this URL --- http://sepuplhs.org/pdfs/IAPS-P11.pdf).

Bob also mentioned that "when there are pictures in the book, we usually look and see what information we can gather out of these pictures" (personal communication, May 30, 2017).

Novice teachers, Chris and Alex, used visuals to support their practice. In Chris' earth science class on December 27, 2016, he started the class with a simple but powerful graphic with little text to review the "life cycle" of a star. The visual helped students understand the importance of using appropriate visuals for particular purposes.

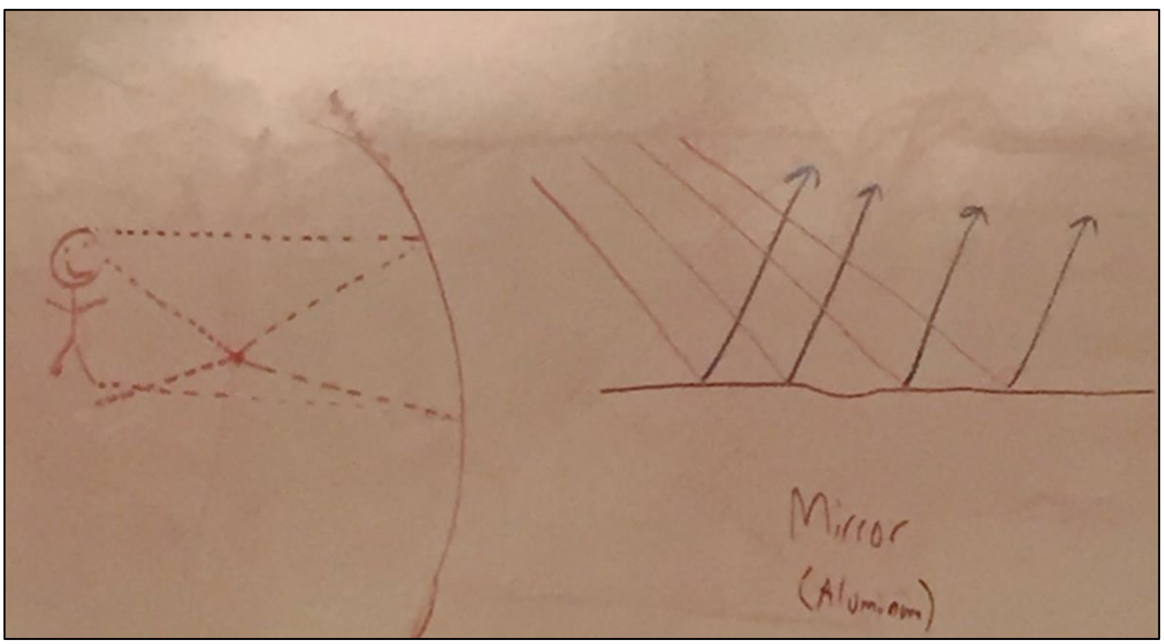

Figure 1. Frederick's drawing on the board shows how a mirror reflects light.

When Chris' class had to prepare a PowerPoint presentation on natural disasters, he encouraged students to explain the reasoning behind choosing a specific image. During the observation of Chris' chemistry class, he had the students do a standard lab to collect data on acids and bases by observing the visually focused data of color and formation changes

(Observation 2, May 6, 2017). In his interview, Chris mentioned that visuals were the key for his students to start building an understanding of the "big picture:"

> Well most of it is to get context, right? To give images, because when I was working a lot with my Earth Science students, talking about the big picture stuff, talking about the universe, so I would get just blank faces if I don't have any images up there. So I need something, to point at something, to give them a reference, even if it's a diagram they've never seen, if I can keep putting the diagram up there each day, it helps them understand it, eventually starting to put the pictures together (personal communication, December 27, 2016).

In a lesson on electromagnetism, Alex asked 8th graders to draw the patterns of iron filings for a bar magnet, followed by a hands-on challenge to make the strongest electromagnet they could with an iron nail, copper wire, and a flash light battery (Observation 1, December 13, 2016). He did a similar design challenge during the second observation, in which students were encouraged to draw out their ideas before using or designing simple machines to move a heavy cylindrical object (Observation 2, May 22, 2017). In his interview, he reported that:

> I'm a big fan of multimedia — we do a lot of video presentations; integrating more video games in, especially with this group of electron magnets, we play video games where they would have to create their own electron magnets to pick up certain amounts of things (personal communication, December 13, 2016).

For personal and educational reasons, the teachers used a variety of visual literacy practices. Table 1 below presents the different types of visual literacy practices observed by the researchers or self-reported by the participating teachers. It aligns the categories according to Bloom's revised taxonomy (Anderson & Krathwohl, 2001) and provides examples that support the categorization. Overall, these visual literacy practices seemed to climb the revised taxonomy, from lower level, knowledge based understanding to higher-order thinking such as analyzing, applying, evaluating, and creating. However, the most dominant use of visual literacy practices was focused either on the teacher presenting visuals to help student *understand* science concepts and processes or on students being asked to use visuals to demonstrate their *understanding (author's emphasis)*. Further, the observed and reported visual literacy practices seemed to center on building content understanding.

Table 1. Teachers' Visual Literacy Practices

Visual Literacy Practices	**Aligned Bloom's Taxonomy Categories**	**Examples**
Real Objects	Understanding	Frederick showed students different types of mirrors in his reflection unit.
Images	Understanding	Chris presented a simple but powerful image of the "life cycle" of a star.
Videos/Movies	Understanding	Bob showed three different types of video clips to introduce the concept of a virus.

	Applying	Frederick shared his plan to have students to watch the movie *The Martian* and see how the physics concepts discussed in the course were applied.
Hands-on activities (not involving standard lab equipment)	Understanding	Karina had her students push the bead through a straw to demonstrate how the digestion system works.
	Applying/Creating	Alex engaged his students in a challenge to make the strongest electromagnet they could with an iron nail, copper wire, and a flash light battery.
Labs	Understanding	Kristin had her students do a lab to transport water using two straws with different diameters to understand the concept of equilibrium.
Graphic organizers (notes/lab reports)	Understanding	Karina provided her students a graphic organizer to jot down notes on the molecular characteristics of three different states of matter.
Maps/tables	Analyzing/Evaluating	Bob had his students transfer the data of 1849 Cholera Epidemic in London on the map to analyze the patterns.
Making models	Understanding	Frederick had his students use the Legos to demonstrate understanding of balancing equations (the Law of Conservation of Mass).
	Applying/Creating	Frederick had his students apply their understanding of a rearrangement of the reactants in a chemical reaction to create and build one more chemical equation with the given Legos.
	Analyzing	Frederick had his students balance the chemical reactions with shapes.
	Evaluating	Frederick had his students create Lego models for the stoichiometry.
Drawing	Understanding	Alex had students draw the patterns of iron filings for a bar magnet on the board as a review.
Assessment	Analyzing	Kristin had her students do a mystery element test based on their understanding of the periodic table.

The observed visual literacy practices were consistent with the survey data. Most teachers reported that they used visual literacy on a weekly, if not daily basis. All five teachers who completed the survey indicated that they used visual literacy activities for two major reasons. First, visuals helped make abstract concepts and processes more concrete and, second, they met the needs of students with diverse learning styles. In thinking about her 8th graders learning about the abstract concept of digestion, Karina stated:

> So you can’t really see what’s going on inside of you. So one of the things we are going to do, if we have time, is just mimicking peristalsis. So I have some straws and I have tiny little beads for them to put inside the straws. And they are going, it’s kind of, they are not loose in there so you have to push them through. So the kids are gonna physically have to push that bead through to see how peristalsis moves food through the esophagus (personal communication, December 12, 2016).

The participating teachers firmly stated that the use of visuals and hands-on activities were ways to accommodate students' comprehension of the content. For instance, Bob shared how he used visuals to differentiate instruction and support diverse learners:

> I feel like it can be very effective for the diverse learners because they, naturally their strength is not usually going to be reading of a text. They usually are way more insightful when it comes to looking at some sort of image or watching a movie because that's often the way they learn best is not just through reading because it's not their strength (personal communication, May 30, 2017).

In addition, over half of the participating teachers indicated in the survey that the purposes of using visual literacy practices included activating students' background knowledge, introducing new knowledge, motivating students' learning, engaging students in inquiry-based learning, and creating meaningful class-room discussion.

Overall, the participating teachers implemented visual literacy practices that covered both low and higher-level thinking on Bloom's revised taxonomy. Certain practices seemed prevalent. They used certain practices to meet identified needs, but there was no evidence that the teachers had strategically designed a sequential visual literacy curriculum.

Teachers' Definitions of Visual Literacy

How teachers employ visual literacy practices in the classroom provides insight into how they define visual literacy. In turn, the definitions offer clues as to why such practices are effecttive. The researchers asked the participating teachers to define visual literacy. Most of them provided a description-like definition. For example,

> Karina: I think it's a way for students to be able to not only just *read* something, but it's also to be able to *translate* it into their writing, to be able to *organize* what they are learning so that they can see, and it will be in a form that's easier for them to remember it by. So it's more like just techniques to help them learn the content better, and to *visualize* things, not just to be by the book, just to *apply* to the real world to what's written (Personal communication, April 27, 2017, italics added).

> Frederick: So hopefully that visual literacy aspect is strengthened both where they can actually *draw* better, and *communicate* better visually as well as they *understand* when someone is communicating to them visually back. Hopefully strengthen that kind of aspect of their knowledge and skills based of the science part of it (Personal communication, May 8, 2017, italics added).

The teachers' descriptions of visual literacy indicated that they had some ideas about visual literacy that meshed well with the existing definitions that focus on 1) reading, 2) understanding/ making sense of, and 3) communicating and creating visuals (Baker, 2015; Newfield, 2011; Rowsell et al., 2012). For instance, teachers used images, video clips, and graphic organizers to help students understand science concepts and processes.

However, there was a lack of explicit instruction on how to read the static and dynamic visuals and on how to make sense of them. The participating teachers also expected students to use visuals to explain concepts and/or processes by creating drawings or making models (e.g., Frederick's class observation of asking students to draw the light reflection on paper versus mirror and he discussed the Lego models in his interview). It seems that each teacher had his/her own spin on different aspects of visual literacy, yet none of them developed a comprehensive understanding of what visual literacy was. Nor does it appear that there was specific literacy training over time to improve student skills.

Impact of Teacher Preparation Programs

In their interviews, the participating teachers shared where they learned about visual literacy and what practices were most important for their teaching.

> Karina: I do integrate other subjects into science. So, a lot of what Saia [pseudonym of a social studies methods instructor] had taught in social studies, art, and art integration (personal communication, December 12, 2016).

> Frederick: I think a lot of that was probably with you [the science methods instructor], with just every time doing something that was more hands-on, you know, a little different than the same old notes, quizzes, tests, we didn't do any of that. It was hands-on, let's learn how to show this idea, but with a visual, or a model, or a building of something, or a drawing of something, or a video showing something, the digital storytelling, for instance, whatever it may be, just there's different ways to go about showing an experiment step by step (personal communication, November 18, 2016).

It seemed that the methods courses that the teachers took in the teacher preparation program had a significant impact on their understanding of visual literacy and effective practices in teaching and learning science. In addition, Alex mentioned how he incorporated some of the ideas from his student teaching experience:

> Other than your class, we didn't really go into visuals all that much. During the student teaching, I picked up some of the ideas of stopping a video, asking questions, talking through things. Constantly checking in, asking them, before the video, how they would solve the program etc. (Personal communication, December 13, 2016).

At the time of the study, none of the participating teachers mentioned that visual literacy was a top priority at their schools. In addition, the participating teachers indicated that they had rather limited opportunities to attend professional development or conferences focusing on visual literacy. As a new teacher, Kristin said that she would love to have a list of visual literacy strategies as a reference (personal communication, November 18, 2016). The availability of professional development experiences focusing on visual literacy that aligns with schools' priorities would be appropriate to guide the teachers. Having these experiences would help the teachers in developing a long-term plan to systematically introduce and practice visual literacy skills.

School Contexts Shaping Up Visual Literacy Practices

Besides the teacher preparation programs, the schools where the participating teachers worked also played a role in determining what visual literacy practices were considered appropriate and relevant to use in their classrooms. Their colleagues had adopted their own way of teaching different subjects over the years, which in some cases was in conflict with what the participating teachers had learned in their teacher preparation programs. Karina was in her first year of teaching science. She taught a group of students who were used to textbook-focused learning. Further, there was a situation where teachers and the administration held different opinions on how standards should be aligned to the curriculum, assessment, and classroom instruction. For instance, Frederick pointed out that building the science curricula at his school was based on a literal view of Next Generation Science Standards (NGSS, 2013).

Discussion

This study examined the visual literacy practices of six classroom science teachers with varied teaching experiences. It identified several different ways these teachers implemented visual literacy practices in their science classrooms. Based on Bloom's revised taxonomy, the use of visual literacy was prevalent in the category of understanding, with a few cases addressing the analyzing, applying, evaluating, and creating categories. However, there was no strong evidence showing how students were taught to engage critically with visual materials. That is, students were not taught to evaluate and reflect on what was presented visually or why it was presented that way. Nor were students taught to ask what is missing from the visual or how visuals interact with text to create meaning and perspectives. Moreover, the observed and reported visual literacy practices primarily focused on the short-term building understanding of content, rather than on the long-term goal of developing visual literacy competency. There was no mention of any consistently used, well-defined visual literacy strategy. Rather, these visual literacy practices were more ad hoc and informal.

It is critical for teachers to use visuals and other multimodal instructional materials to help students build and demonstrate understanding of abstract science concepts and processes. But, it was disconcerting that none of the participating teachers explicitly provided instruction on how to read and make sense of the visuals. It was falsely assumed that visuals were straightforward and that students were already visually literate enough to comprehend the content (Martins, 2002).

As a result, there appears to be a theoretical and pedagogical gap in the participating teachers' understanding between using visuals and implementing visual literacy practices. Using visuals in teaching and learning is just a beginning step toward building students' visual literacy competency. Ausburn and Ausburn (1978) suggest that students do not develop higher-order visual literacy skills unless they are explicitly taught so. Avgerinou and Ericson (1997) argue that visuals "have their own vocabulary, grammar, and syntax" (p. 285). Only when teachers provide opportunities for students to discuss visuals using the unique visual language, will they "be able to decode (interpret) visual messages successfully and to encode (compose) meaningful visual messages."

The participating teachers in the study expressed some basic understanding of visual literacy as they mentioned some key categories such as reading/visualizing, understanding/interpreting, applying, and communicating in their descriptions. This basic comprehension might be a start toward a clear definition of visual literacy. The teacher preparation programs, especially their science methods course, had a significant impact on how they understood visual literacy and what visual literacy practices they implemented in their science teaching.

In addition, the school contexts played a role in what visual literacy practices were legitimized in their classrooms. School priorities, colleagues' teaching styles, and the administration's view on how standards should be implemented in the curriculum affected the use of visuals in the classroom. Even though there is not much control over school contexts, teacher educators can help teacher candidates and classroom teachers develop a clear understanding of what visual literacy is and how it works. Teacher educators can model how to provide a systematic introduction of effective visual literacy strategies in the teacher preparation programs and continuing professional development.

This study has not only identified how and why the participating teachers implemented visual literacy practices in the science classrooms, but also shed some light on several curricular issues regarding science education. It is important to mention that in all of the participating teachers' classrooms, students did not read or discuss written science discourses (e.g., reading a chapter in science textbook or a science report where information is presented through the interplay between visuals and other modes). The primary source of information was what their teachers provided by PowerPoint presentation, handout, or worksheet, for instance. The researchers shared two reasons why no textbook was used. The first reason is that most of the science textbooks were outdated. In addition, most of the students' reading levels were below the textbook level. Due to these reasons, science textbooks seemed not to be an ideal choice.

Further, research indicated a mismatch between the visual formats presented in the biology textbooks and the techno-scientific graphical conventions (Dimopoulos, Koulaidis, & Skaveniti, 2003; Lynch, 1985; Trumb, 1999). If the students did not have the opportunity to read and critically analyze authentically written science discourses presented both in visual and text formats, how do educators expect them to be competently engaged in critical thinking and problem solving when they advance their study at the college level? What should educators do to fill in the gap?

Conclusion

This study provides an opportunity for educators to gain a better understanding of how and why visual literacy plays such an important role in academic learning. Visuals, occupying about one-third or more space, play a significant role in the genre of science textbooks, research articles, and technical manuals (Darian, 2001). Moreover, the NGSS has created a strong need for pre-service and in-service teachers to adopt a more holistic approach in science education. Students need to be engaged in asking critical questions, developing hypotheses, and making evidence-based claims.

This study identified visuals and visual literacy practices implemented by the participating science teachers to support students' content learning and meet diverse students' different needs. Further, it sheds some light on ways to revamp teacher preparation program curricula and to provide continuing professional development. Teacher candidates and classroom teachers need to be more confident and strategic in using visual literacy practices in their current and future classrooms. Hopefully, the findings of this study can stimulate further research that will have an impact on the advancement of science education at the secondary and higher education levels.

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Appendix A: Karina's Graphic Organizer for Notes

Chapter 2 Section 1 Notes
Solids, Liquids, and Gases
Section 1: States of Matter (pages 42-47)

Learning Target: Explain the molecular characteristics of a solid, liquid, or gas.

What is matter? ____

Characteristic	Solid	Liquid	Gas

Appendix B: Kristin's Mystery Element Assessment

Alien Period Table

Purpose: To correctly place given physical and chemical properties of unknown elements in a blank period table.

Materials: Alien element cards with observations of the unknown elements.

Background Information: Earth's scientists have announced that they have made radio contact with intelligent life on a distant planet. One of this alien planet's languages has been translated, and scientific information has begun to be exchanged, The planet is composed of the same elements as Earth. However, the inhabitants of the planet have different names and symbols for them. Since the alien scientists do not know the names of our elements, they have radioed the following data on the known properties of the elements. Strangely, but luckily there are no transition or rare earth elements on the alien planet. This means that their periodic table consists only of the "A" groups of elements. The data of the alien elements are listed on the element cards in the envelope. Using the descriptions of the properties of the elements listed on the cards, construct the periodic table of these elements for the group "A" elements. Fill in each alien element symbol on the periodic table on the back of this page.
Good Luck!

Alien Period Table: Name: ________________ Period: __________

	I	II	III	IV	V	VI	VII	VIII
1								
2								
3								
4								
5								

Appendix C: Sample Page in Frederick's Lego Activity

Name ________________________________ Date ________________ Period _______________

Balancing Equations with LEGOs

Introduction

A balanced chemical equation tells the relative proportions of each of the molecules in particular reaction. Dalton's Law tells us that "*atoms are conserved in chemical reactions*." This means that any atoms that appear on one side of a chemical equation have to also appear on the other side. In other words, atoms are never created or destroyed but they are rearranged. **The Law of Conservation of Mass** states that the mess of what you end with (products) is always equal to the mess of what you start with (reactants).

For example, consider the following chemical equation: SiO_2+4HF--- SiF_4+2H_2O
This equation tells us that one molecule of SiO_2 (silicon dioxide) reacts with four molecules of HF (hydrofluoric acid) to form one molecule of SiF_4 (silicon tetrafluoride) plus two molecules of H_2O (water). In other words, if we were to take apart the one SiO_2 molecule and the four HF molecules, we would have one Si, 2 O, 4H and 4F atoms. This would give us exactly enough atoms to produce one SiF4 molecule plus two H_2O molecules.

Objective

Apply the law of conservation of mess to balancing chemical equations.
In this lab activity, you will use LEGO blocks to represent individual atoms.

Materials

Legos:	2: Tan/Yellow Blocks (T)	2: Blue Blocks (B)	
	4: Red Blocks (R)	1: Orange Block (O)	Total: 12 LEGOs
	2: Green Blocks (G)	1: Gray Block (Gy)	

Procedure

1. Build the reactants and the products with the appropriate Lego block color according to the equation in the problem. (**Remember**: Polyatomic ions are in parenthesis and they stay together!)

2. Add more reactants/products with the appropriate Lego block color to correctly balance the equation with Legos. (**Remember**: The number written in front of the reactants and products is called a coefficient don't confuse it with the subscript in a compound.) Once balanced with Legos, draw your illustration in the space provide for that equation and color coded appropriately.

3. After you have drawn your illustration, balance the equation with numbers.

4. ***GET YOUR TEACHER'S STAMPS*** before you proceed to the analysis questions! If a problem is not ***STAMPED*** go back and ***DOUBLE CHECK*** and ***CORRECT IT*** before proceeding.

5. Once you have completed the 8 Lego equations you and your partner **MUST COUNT YOUR INVENTORY OF EACH OF YOUR BAGS** to make every LEGO is counted for!