CASE STUDY 6

Students in Alternative Education and the Next Generation Science Standards

Abstract

Alternative education encompasses many non-traditional models, some of which are intended to target students at risk for dropping out. A significant proportion of economically disadvantaged students, racial and ethnic minority students, and English language learners attend dropout prevention schools. State and federal accountability for alternative education has increased, and there is a call to methodically measure the effectiveness of alternative education policy. The Next Generation Science Standards raise the bar for all students. This magnifies the need for teachers in alternative education to foster engagement and increase exposure to rigorous science. The vignette of a high school chemistry class in an alternative education setting for dropout prevention highlights five strategies: (1) structured after-school opportunities, (2) family outreach, (3) life skills training, (4) safe learning environment, and (5) individualized academic support.

Vignette: Constructing Explanations about Energy in Chemical Processes

While the vignette presents real classroom experiences of NGSS implementation with diverse student groups, some considerations should be kept in mind. First, for the purpose of illustration only, the vignette is focused on a limited number of performance expectations. It should not be viewed as showing all instruction necessary to prepare students to fully understand these performance expectations. Neither does it indicate that the performance expectations should be taught one at a time. Second, science instruction should take into account that student understanding builds over time and that some topics or ideas require extended revisiting through the course of a year. Performance expectations will be realized by utilizing coherent connections among disciplinary core ideas, scientific and engineering practices, and crosscutting concepts within the NGSS. Finally, the vignette is intended to illustrate specific contexts. It is not meant to imply that students fit solely into one demographic subgroup, but rather it is intended to illustrate practical strategies to engage all students in the NGSS.

Introduction

Curie Senior High School has a diverse student population of more than 700 students. Its motto as quoted on the school website attests, “It is never too late to earn a high school diploma.” The mission is to deliver a high quality academic and career/technical program that will lead to a high school diploma or vocational certificate. The school offers traditional and accelerated programs: GED preparation; External Diploma programs; and vocational programs including automotive technology, barbering, cosmetology, Microsoft Office courses, and culinary arts. The median number of years of high school a typical student has attended prior to enrollment at the school is one year. Seventeen percent of the students are of high school age, 45% are 18-24 years old, 14% are 25-29 years old, and the remaining 24% are over 30 years old. Fifty are in-boundary students whose neighborhood boundary school was Curie Senior High School.

Alternative Education Connections

Ms. B.'s 10th and 11th grade afternoon chemistry class has an average attendance of 17 students, varying in age from 17 to 26. Ms. B. had already faced a number of the usual challenges developing a supportive classroom community and maintaining high expectations. The number of students who were registered for the semester course dropped after a few months due to truancy. Each day a different assortment of the students greeted her. Teaching was further complicated by the fact that many students had uneven or disrupted school careers and thus had significant gaps in their understanding of basic science concepts. The classroom was outfitted with an interactive whiteboard, black lab tables, and ten large desks with computer workstations in the corners of the room. The walls were covered with science and engineering posters, the periodic table, student-created historical timelines of the periodic table, and student-constructed chemistry family trees. Class sessions were one hour and forty-minute blocks. The vignette highlights a public alternative school focused on increasing graduation rates for students at risk of dropping out of high school. Throughout the vignette, classroom strategies that are particularly effective for students in alternative education are highlighted in parentheses.

Introducing career connections to chemistry. One of the main interests of Ms. B.'s students was to explore career choices. To this end, prior to the introduction of chemical reactions, Ms. B. and two of her math colleagues took a combined math and science class to a STEM Career Workshop. *(Focusing on career connections is one of the life skills strategies promoted in alternative education.)* The school collaborated with the Central Office of the District to coordinate field experiences in conjunction with the Science and Engineering Festival. A group of approximately 25 students sat on a chartered bus heading to the Learning Center downtown. The students were welcomed, registered, and given a choice of workshops to attend.

At the Forensic Science workshop, three students, Deshawn, Rosalee, and David, examined different objects; the office had been transformed into a crime scene. A shoe with a huge footprint was displayed in one corner of the room. Other items had been placed in the office. The students drew an outline of the office and the shapes of the objects they encountered in their notebooks. The students noticed a white powder on the shoe. Rosalee listed the physical properties for the white powder found on the shoe. She looked at the powder under a microscope, and noted "tiny cubes, different sizes. Some have knocked off corners with straight sides."

Students from various schools sat in their chairs and went over their observations and the evidence they collected. Deshawn predicted that the unknown white compound was "salt." Ms. B. asked how she had come to that conclusion. Deshawn told Ms. B. that she remembered the introductory lab on physical and chemical changes. Rosalee described the substance in terms of color, odor, and texture. She too thought it was salt, and noted that the white solid dissolved in water and made the temperature of the water go down slightly indicating a chemical reaction. Ms. B. agreed that their findings were consistent with it being a salt, but added that they would need to do some additional investigating to test if it was a salt and what kind of salt it was. Ms. B. asked Rosalee to predict what elements were in the chemical compound she observed for salt. Rosalee took out her notebook and looked at her periodic table. She then wrote sodium and chlorine on a piece of paper. Ms. B. made sure that Rosalee identified her predicted substance as sodium chloride.

The facilitator explained that forensic scientists find, examine, and evaluate evidence in a crime scene. The facilitator asked students what skills might be good for someone entering a forensic science career. One student said good observation skills, another said good reasoning skills or logic, and still another said chemistry. As Rosalee came away from the forensic science workshop, she remarked to Ms. B. that she had learned that forensic science involves chemical reactions.

The next day, Rosalee and Deshawn made the case for the conclusion they had reached the day before. They studied some compounds to see if they could predict chemical reactions of ionic compounds on their own. Rosalee took out an interactive science notebook and reviewed her article on salt. Her task was to find the author's central idea of the passage and locate evidence that supported her prediction of the compound's chemical name, sodium chloride. Rosalee explained to Deshawn the properties she discovered about salt: dissolves in water, cubic-shaped, crystalline, white color, a compound with ionic bonds forming from a metal and a non-metal. (DCI: HS.PS1 A Matter and Its Interactions.) She also described the main idea of the passage and the evidence she thought supported the conclusion that salt, sodium chloride, was on the shoe in the crime lab. (Practice: Obtaining, Evaluating, and Communicating Information.) Rosalee and Deshawn recorded the chemical formula of salt accurately.

Introduction to the core idea: Finding patterns in the periodic table. Ms. B. wrote the driving question or theme of the next few weeks in large letters on the board: *Why do some substances react and others don't?* This question would serve as the focus for questions and discussions, guiding the students' written reflections in their journals. (Practice: Asking Questions and Defining Problems.) One of the sub-questions they explored was the energy changes that might take place when ionic structures form and dissolve. (DCI: HS.PS1.B Chemical Reactions.) On a video that they observed in class, the explosive reaction of sodium metal to chlorine gas formed sodium chloride. The class developed a claim that energy changes due to electrical interactions by building on explanations for why various materials react. They formed partners and collaborated on their reflections using their science notes, the periodic table, and their initial understandings of elements. *(Student mentoring is an academic support strategy that promotes engagement.)*

Earlier in the month, while studying static electrical charges, students constructed the explanation that positive ions attract negative ions, positive ions repel positive ions, and negative ions repel negative ions. Their explanations were supported by testing potential compounds of metals and nonmetals on element cards with positive and negative superscripts on the upper right side of the cards. The class had turned the cards into a matching game, gathered testable scenarios in their notebooks, and attempted to find patterns.

David, Deshawn and Rosalee, along with their classmates, applied their organization of student-created chemistry family tree models to the periodic table model and divided the elements into groups and periods. They had developed a beginning conceptual understanding of the patterns of different behaviors of elements on the periodic table: electronegativity, ionization energy, and electron affinity. Conceptualizing chemical properties as patterns can help students build an understanding of the core idea. (DCI: HS.PS1.A Matter and Its Interactions.) (CCC: Patterns.) Provided with two small white boards, students diligently worked together to draw models showing the electrical attraction involved among atoms when forming ionic compounds. They also used the models to predict what would happen when various ionic compounds were dissolved in water. (Practice: Developing and Using Models.)

Ms. B. used an analogy of a tough rubber band to describe the energy involved in an endothermic reaction that they were familiar with: "The ions in the sodium chloride salt have to be pulled apart. The force that holds them together is like a rubber band. If we give them energy to move apart, the rubber band will stretch. To pull the ions away from each other requires energy, similar to stretching the rubber band." The students played around with big rubber bands for a while and wrote down a corresponding rule in their notebooks: "As ions get pulled farther apart, they are taking a lot of energy and cooling everything down. Breaking bonds is endothermic." Ms. B. told them that they would need this idea to understand the exothermic and endothermic processes they would be working on throughout the following week. (DCI: HS.PS1.B Chemical Reactions.)

Ms. B. told the class, "Water is also involved in these energy interactions, and I want you to observe these magnets." The students pulled magnetized balls apart in order to place a marble in the middle of the balls. They discussed when the effort had taken up energy, and when the task had "given up" energy. Ms. B. asked if they thought that, in the crime scene experience with sodium chloride and H_20, either compound was getting pulled apart. She asked, "Are you releasing energy to the system or taking energy when you pull the magnets apart?" She added that water molecules have both positive and negative ends that pull the water molecules together similar in effect to magnetic forces pulling magnets together.

Developing explanations for chemical properties of matter. David, Deshawn and Rosalee had decided to stay after school to work on the experiment on chemical interactions. At 4 pm, as the other students slowly filed out, Ms. B. bustled around the small lab, putting things away and cleaning up. She nodded to Deshawn and said she would be with them in a minute. *(Providing structured after-school opportunities is an effective strategy for alternative education students.)*

David, Deshawn, and Rosalee were building on their previous learning by exploring endothermic and exothermic chemical interactions. In order to engage with the crosscutting concept energy and matter, the students considered the question, "How is the temperature of water affected when calcium chloride is mixed in it?" David and Rosalee joined Deshawn at the lab table. The partners were relaxed and easy with each other and with Ms. B. They enjoyed spending time in the science classroom and appreciated Ms. B.'s enthusiasm for chemistry.

With her goggles on at a black lab table, Rosalee read over the question, "How is temperature of water affected when materials dissolve in it?" Deshawn read the sub-questions, "Is H_2O and $CaCl_2$ an endothermic or exothermic reaction? Or how is the temperature of water affected when calcium chloride is mixed in it?" David adjusted his goggles and looked over the materials in the center of the table: a graduated cylinder filled with about 100 ml of water, a pack of hand warmers, a thermometer, a container of calcium chloride, a container of ammonium nitrate, a container of baking soda, small sandwich bags, measuring cups, and a small sandwich bag filled with iron filings. *(Promoting students' safety is important in alternative education.)*

"I don't know how the temperature of the water will be affected when combined with calcium chloride," Rosalee announced to her partners. She looked over at Deshawn, who said, "You have to state a claim first. See here." Deshawn pointed to the word "claim" in bold print and read the words, "In your science notebook, write a claim supported by evidence to address this question." David read the question again to himself. Rosalee pulled out a separate sheet of paper to jot down her thoughts. She began to read out loud: "Part 2 – How is the temperature of water affected when calcium chloride is mixed in it?"

All three students pondered the question, unsure where to start. After a few minutes of silence and pencil tapping, Ms. B. interjected, "Think about what we did yesterday when we pulled apart the magnetic compounds, and think about whether the process may require energy or whether it will release energy."

Deshawn pointed at Ms. B. with her pencil, "The calcium chloride… it will heat up!" Rosalee started to form her statement, "The temperature… if I combine the water with…" and then she slowly formed the claim on the sheet of paper and transferred the sentence to her science notebook. Rosalee was focused and again recited her statement out loud, "If I mix water with calcium…" Deshawn helped out, "with calcium chloride, girl."

"Where do you write this at?" David inquired while Rosalee continued forming her thoughts out loud to Deshawn. "The temperature…." She stopped, noticing Deshawn had something to say. Deshawn said, "I think it's going to get the water warm." David located the little space between the question and claim where he could write the group statement.

Ms. B. acted as a facilitator for the session. "So, when you are making a claim, what are you guys expecting to observe? What are you expecting to look at? I heard Deshawn make a prediction. Why did you predict that the water will get warm when we add calcium chloride, Deshawn?" "You mean calcium like… milk… calcium?" David asked. "Yes. This time it is not going to be just calcium; it is going to be calcium chloride, the compound." Ms. B. responded to David, pointedly looking at the definitions on the white board that the class had made about ions and ionic compounds. She asked, "Deshawn, what do we know about calcium chloride?" Deshawn responded, "Chloride is in the form of chlorine, but now that it is combined with calcium, it has formed a product." David listened to his partner.

After a few more minutes, Rosalee sighed, "I don't know, Deshawn. I think it is going to be endothermic." She stated, "The temperature is going to decrease." Rosalee slowly nodded, satisfied with her statement. "The water molecules are going to have to pull apart and move around on their own. That takes energy, like those rubber bands, making everything cool down." (Practice: Developing and Using Models.)

"What is going to decrease?" Ms. B. asked. "The temperature of the mixture. The calcium chloride and water mixture." Rosalee responded, unsure. Ms. B. inquired, "What is happening with the energy when there is a decrease in temperature?" Deshawn and Rosalee said, "Makes it colder." Deshawn added, "Endothermic, takes energy to pull apart the bonds."

"What questions do you have?" Ms. B. asked the group. Rosalee surmised, "If I combine water with calcium chloride, will the temperature decrease?" Deshawn suggested, "I'll write both decrease or increase 'cause we don't know which it is going to be yet." David asked, "Hold on, at room temperature would you say that water is cold or warm?" "Warm!" Rosalee and Deshawn agreed in unison. "Kinda both," Deshawn offered. Rosalee disagreed, "I say warm."

After another minute of discussion, everyone agreed to the water being warm at room temperature. Rosalee took the temperature and inserted the thermometer into the 100 ml graduated cylinder filled with water. Rosalee measured the temperature and reported the temperature was 16 degrees. Ms. B. encouraged the group to proceed to the procedures using their agreed-upon lab roles from the previous day. (Practice: Planning and Carrying Out Investigations.)

Deshawn read the first step of the procedure. Rosalee repeated her statement, "If I combine water with calcium chloride, the temperature will decrease, be endothermic, and the substance will become a powder, form a powdery liquid." "No, I would say a solution," Deshawn said. Rosalee restated, "If I combine water with calcium chloride, the temperature will decrease, be endothermic, and the substance will form a solution because the calcium chloride mixed in. This is my claim for part 2." Deshawn and David wrote down claims in their own words.

Rosalee read the next step out loud: "Pour 10 ml of water in an empty plastic bag." She opened the plastic bag, asking, "Who wants to pour the water into the bag?" Deshawn laughed, "You are irritating." Rosalee grabbed the small measuring cup and handed it over to Deshawn. Deshawn took the graduated cylinder and poured 10 ml of water into her measuring cup. She checked her tick marks on her cup. David was eager for Deshawn to place the water into the bag. "You are making me nervous, Rosalee." Rosalee expected Deshawn to hand over the measuring cup, but Deshawn poured the water into the sandwich bag proudly and said, "It is 10 ml. I made sure."

"Feel the bag and observe how the temperature feels and record the temperature in your science notebook," David read. Rosalee directed Deshawn, "Feel that. It's cold." Rosalee observed, "Yeah, it's real cold." Deshawn agreed. David wrote down their observations. Deshawn wrote, "The water is cold. The temperature is cold."

Rosalee read, "Place the thermometer in the bag. Make sure the bulb of the thermometer is in the water. Record the temperature of the water in your science notebook. Leave the thermometer in the bag." She concluded, "When I put the water in the cylinder, it was 16 degrees. When you put the thermometer in the water, it was 17. Now it is going up to 18 degrees. Maybe this water is warmer than that water." The group recorded the temperature of the water in the bag at 18 degrees C.

Rosalee read, "Carefully pour 4 ml calcium chloride into the water and gently mix." Rosalee located a new measuring cup and the calcium chloride. Deshawn opened a sandwich bag filled with iron. She thought it was calcium chloride. "Deshawn, are you sure that what you have is calcium chloride?" Ms. B. warned. Suddenly, there was confusion as to what was on the table. David started to pick other items up, "What is this?" Ms. B. encouraged them to check all of the materials on the table.

Rosalee took her textbook and examined the periodic table. Ms. B. asked, "What are the elements for calcium chloride?" Deshawn responded, "Ca and Cl." David found the calcium chloride. Deshawn remarked how similar it appeared to the baking soda. David laughed, "Baking soda is not on the material list." Rosalee grabbed the container of calcium chloride and handed it to Deshawn.

As Rosalee read the instructions out loud, Deshawn poured 4 ml of calcium chloride into the measuring cup and then into the sandwich bag. They tried several times before finally achieving success. "Gently pour," Deshawn murmured as the solid white substance fell out. "It says gently pour. It is coming out. Listen to directions," Deshawn reminded the group.

Rosalee continued reading instructions, "Wait 30 seconds and record the temperature again. Remove the thermometer from the bag and carefully zip the bag. Feel the bag again and note the temperature change." "Gently mix. Are you going to mix?" Rosalee tried to use the thermometer to mix the reactants. "The temperature is 44 degrees!" she called as she removed the thermometer.

Deshawn felt the bag, "That thing is hot!"

"It's hot?" Rosalee felt the bag, "I thought it was going to get cold!"

"Aaw! Feel it, David. It got warm," Rosalee laughed.

"Oooh, yes! I knew it!" Deshawn smiled.

Using evidence to develop claims. Ms. B. smiled back, "Was this process of dissolving exothermic or endothermic?" Deshawn paused, "It was exothermic because it got hotter; energy was released." Ms. B. reached for the magnetized balls, "Remember the water molecules? They had to part, right? What about the ions?" After more talking and going over the periodic table and their drawings of the electric structure of the ions in the calcium chloride, the threesome determined that they had also had to separate. (Practice: Developing and Using Models.)

"There are things that are coming apart, which, as you predicted, would have caused the temperature to decrease, but there are also things coming together." Ms. B. held up the cluster of magnetized balls around the marble, "Which one was more important here?" With the student's help, Ms. B. listed what was coming apart and what was coming together in the process.

Rosalee reviewed for the group, "The Calcium ions had to be pulled away from the chloride ions, and the water molecules also had to be broken apart." Ms. B. nodded, "Those both took energy, right? Pulling magnets apart takes energy." (DCI: HS. PS1.A Structure and Properties of Matter.) David nodded but looked confused. Ms. B. still had the magnetized balls, "What's happening here with these water molecules that are coming together around the ion, the calcium chloride?" She showed the magnetized balls coming together with a loud snap, "When the water surrounded the ions, it released lots of energy." Rosalee said, "The bonds clap-snap together, releasing the energy. That makes it get hotter, exothermic. Sometimes it's one and sometimes it's the other." David added, "Energy is making it warm. It has to go someplace; it can't just disappear." Deshawn summarized her thoughts slowly, "Sometimes the things, the bonds that are coming apart, are more important than the things coming together…" Rosalee added, "… and then it is endothermic." (Practice: Analyzing and Interpreting Data.)

Ms. B. was pleased but planned to strive for clearer and more scientific language from her students. She was about to start a similar discussion with the ammonium nitrate and water endothermic process. She was certain that soon she would be able to bring the conversation back to ions being formed in a way that makes them attract. Students would then be able to make connections with the concept of energy conservation and flow to help them better understand the transfer of energy within a solution. (CCC: Energy and Matter.)

NGSS Connections

A Framework for K-12 Science Education (National Research Council, 2011) focuses on the integration of science and engineering practices, crosscutting concepts, and disciplinary core ideas for comprehensive and rigorous science learning for all students. Students who meet these expectations will have the capacity to think critically about science related issues. They will also have the knowledge and skills to pursue careers in science or engineering if they choose. Students in alternative education, like all students, benefit from meaningful opportunities where they can authentically engage in the three dimensions of the NGSS. The lessons described in this vignette help students build toward a deeper understanding of the core ideas in physical science PS1.A and PS1.B in the high school grade band.

HS. Performance Expectations

HS-PS1-2 Matter and Its Interactions
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-4 Matter and Its Interactions
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

The lessons in the vignette ultimately lead to an assessment of student understanding as described in the performance expectations above. These performance expectations blend all three dimensions, and the students who are able to perform the objectives described in the performance expectations exhibit grade level understanding. Even though the students in this vignette initially required a reinforcement of core ideas from the middle school grade band, the expected learning outcomes are still drawn from the high school grade band. The objectives for alternative education students remain at the rigorous level designated for all students.

Disciplinary Core Ideas

PS1.A Structure and Properties of Matter
The periodic table orders elements horizontally by those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

PS1.B Chemical Reactions
Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

The NGSS identifies a basic set of core ideas meant to be understood by the time a student completes high school. Due to disrupted schooling, students in alternative education may first need to reach standards from previous years in order to build toward proficiency in current grade level standards. The vignette illustrates this point by building on incomplete middle school ideas before attempting the disciplinary core ideas required in high school. Revisiting incomplete ideas helps students build and strengthen connections among core ideas.

Science and Engineering Practices

Developing and Using Models
Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Planning and Carrying Out an Investigation
Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems.

Constructing Explanations and Designing Solutions
Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

The students in the vignette engaged in many science practices thereby building a comprehensive understanding of what it means to do science. Students incorporated the scientific practice of *asking questions and defining problems, planning and carrying out an investigation, developing and using models, analyzing and interpreting data,* and *constructing explanations.* This entailed constructing and revising claims from evidence obtained from a variety of sources and experiences. Students developed written and oral explanations from the evidence as they analyzed data and evaluated how well the evidence supported the claims.

Crosscutting Concepts

Patterns
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (by the end of grade 12)

Energy and Matter
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

The vignette demonstrates the teaching and learning of the crosscutting concepts to reinforce deeper understanding that can be used to make connections to new scientific ideas. The crosscutting concepts of *energy and matter* and *patterns* were found throughout the vignette. The students explored the energy changes in chemical reactions and used patterns observed in the periodic table to predict the behavior of atoms.

CCSS Connections to English Language Arts and Mathematics

All students, including students in alternative education, effectively learn scientific ideas and practices in a cross-disciplinary context. The vignette illustrates how students connect scientific ideas and practices with the CCSS for ELA:

- **WHST.9–10.9** *Use evidence from informational texts to support analysis, reflection, and research.*
  Students engaged with scientific texts in written materials and other informational texts in media.

- **RSLHS 11–12.4** *Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing the text in simpler but still accurate terms.*
  Students engaged in reading informational texts to determine the author's central idea.

- **RSLS 11–12.4** *Determine the meaning of symbols, key terms, and other domain specific words and phrases as they are used in a specific scientific or technical context.*

> Students determined the meanings of symbols from the periodic table and key terms, such as endothermic and exothermic reactions, to support their claims of the occurrence of scientific phenomena.

As the students collected data and engaged in experimentation, the vignette illustrates connections to the CCSS for high school math:

- **SPM.b** *Reason quantitatively and use units to solve problems.*
- **SPM.d** *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.*

Effective Strategies from Research Literature

The term "alternative education" encompasses an array of non-traditional school models (Fitzsimmons-Hughes et al., 2006) including, but not limited to, charter, magnet, residential, court, Waldorf, and public alternative schools. These schools are routinely categorized as type 1, 2 or 3 (Gable et al., 2006). Type 1 schools are identified as "choice" schools, serve a range of students from gifted students to pregnant teenagers, or have a philosophical or magnet focus (e.g., Afrocentric). Type 2 schools are punitive in nature and may be mandated by court. Type 3 schools have a remedial focus. Although type 3 schools are intended to prevent dropout rates, the research is insufficient to either support or refute this goal. Furthermore, there is virtually no research that relates alternative education to science education.

The research literature focuses on type 3 alternative education, especially school-wide approaches to promote increased attendance and high school graduation. Specific factors, taken collectively, correspond with alienation from school prior to dropping out. Public alternative schools employ strategies to counteract these factors and increase engagement: (1) structured after-school opportunities, (2) family outreach, (3) life skills training, (4) safe learning environment, and (5) individualized academic support (Hammond et al., 2007; The National Dropout Prevention Center Network, n.d.).

First, after-school opportunities increase success for students in alternative education. Effective programs offer structured and challenging after-school opportunities in a positive environment that increases engagement with the school. After-school experiences are especially important for students at risk of school failure because these programs fill the afternoon "gap time" with constructive social activities.

Second, effective alternative education programs have family engagement to tackle student alienation through outreach to families. These programs connect schooling with families by organizing field trips, picnics, and other informal activities. They also strengthen families by offering classes on communication, parenting, and student academic support.

Third, effective alternative education programs promote students' life skills, including behavior management, communication skills, and career education. Students improve their ability to make positive choices, express interests, and cope with difficult decisions.

Fourth, effective alternative education programs provide students with a safe learning environment. Although all schools strive to ensure safety, alternative education is sometimes more comprehensive in this area, with policies that forbid harassment and take critical action to ensure compliance, such as removing offenders. In this way, schools become a safe place for students to learn, an expressed need of alternative education students (Quinn et al., 2006).

Finally, individualized academic support is an effective means of engagement for students in alternative education. Academic support includes specially designed instructional techniques that encourage risk taking, participation, and self-efficacy. Individualized instruction focuses on academics and core subjects and address specific learning needs through mentoring, tutoring, and homework.

Context

Demographics

A student in alternative education is defined by attendance in non-traditional schools, which can include public, private, or charter schools. Reporting the demographics of students in alternative education is difficult due to wide inconsistencies in state definitions. States may define alternative schools according to inconsistent criteria, such as the number of students enrolled, a statutory definition of "at-risk," compliance with state regulatory definitions of alternative schools, centralized or independent administration, and funding sources. The three types of alternative education defined above occupy various niches in society and address different needs. Accordingly, students in alternative schools are diverse and come from every demographic group.

Recent data specific to students attending dropout prevention schools do not include non-public alternative schools or "push-in" schools-within-a-school. This type of alternative education (type 3) is defined as schools that are "designed to address the needs of students that typically cannot be met in regular schools. The students who attend alternative schools and programs are typically at risk of educational failure" (National Center on Education Statistics [NCES], 2012, p.55). During 2010-11, slightly over 500,000 students through 12th grade were enrolled in alternative public schools. A significant proportion of these students were economically disadvantaged students, racial and ethnic minority students, and English language learners (NCES, 2012).

Science Achievement

Science achievement for students who are considered at risk for dropping out, in alternative schooling or another form of non-traditional education has not been specifically identified on National Assessment of Educational Progress (NAEP).

Educational Policy

The No Child Left Behind (NCLB) Act of 2001 (the reauthorized Elementary and Secondary Education Act [ESEA]) demanded that stakeholders set high academic standards and increased accountability for the nation's students. In 2008, new federal regulations were adopted, requiring states to utilize more precise means of counting dropouts. With increased accountability at the federal level, there is a call to methodically measure the effectiveness of alternative education policy (National Alternative Education Association, n.d.).

At the state level, the language for alternative education in laws and policies is inconsistent, ranging from very general to detailed explanations (Hammond et al., 2007). Some states with formal legislation have an official definition for alternative education (sometimes referred to as an alternative program or alternative school). Other states have a policy or language in the law that addresses alternative education funding. In general, state-level alternative education policy is often vague, confusing, inconsistent, and at odds with general education policies. A significant amount of alternative education policy is established locally, and state departments of education may have alternative education efforts that are not captured in law or regulation.

Effective policies for all types of alternative education may contain elements that cut across multiple models or approaches. They must confront multiple risk factors; increase community, family and student partnerships; and respond to local circumstances. Effective policy responds to the needs expressed in the community and is driven by local initiatives (Hammond et al., 2007). Strategic efforts must target exemplary policies that create innovative pathways for disengaged youth to get back on track to a high school diploma.

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HS. Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Planning and carrying out investigations
Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct and investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design; decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g. number of trials, cost, risk, time), and refine the design accordingly.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

CCSS Connections for English Language Arts and Mathematics

RSLHS 11–12.4 *Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing the text in simpler but still accurate terms.*

RSLS 11–12.4 *Determine the meaning of symbols, key terms, and other domain specific words and phrases as they are used in a specific scientific or technical context.*

SPM.b *Reason quantitatively and use units to solve problems.*

SPM.d *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.*