CASE STUDY 7

Gifted and Talented Students and the Next Generation Science Standards

Abstract

A precise figure for the number of gifted and talented students in the United States is not available due to the variation in identification processes from state to state. For non-dominant student groups, precise figures are further complicated as states typically rely on only one measure, resulting in fewer students receiving gifted and talented education services. These services, furthermore, are uneven across states or even districts within the same state because there is no federal mandate. The lack of national data – at best, limited national data – on science achievement of gifted and talented students makes it even more difficult to address their achievement. Although the NGSS provide academic rigor for all students, teachers can employ strategies to ensure that gifted and talented students receive instruction that meets their unique needs as science learners. Effective strategies include (1) fast pacing, (2) different levels of challenge (including differentiation of content), (3) opportunities for self-direction, and (4) strategic grouping. The vignette below highlights effective strategies that promote learning life science for gifted and talented students in an inclusive elementary science classroom.

Vignette: Constructing Arguments about the Interaction of Structure and Function in Plants and Animals

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

Park West Elementary School in a suburb of a major metropolitan city has a population of about 450 students in grades preK-4. The demographics are 66.0% White, 4.4% Black, 6.7% Hispanic, 13.5% Asian, with the remainder multiracial. Twelve percent of the students are low-income. Approximately 12% of the students are identified as academically talented and receive accelerated instruction in reading, language, and/or mathematics in a pullout program for grades 3-4. Otherwise, the students remain with their grade level group for other subjects, including science. The school typically scores in the 90% range on the state assessments.

Mrs. J., the classroom teacher, generally has between 22 and 25 fourth grade students in a class that reflects the school's demographics. She enjoys teaching science most and is always alert to student needs, especially in science. The challenge of teaching gifted and talented students within the diverse classroom is assessing their background knowledge and then providing productive and engaging additions to the general science curriculum within the time constraints of the daily schedule. After pre-assessing her students' current understanding either with a pretest or questioning, Mrs. J. compacts the core content to give her students credit for what they have already mastered, so that the gifted and talented students can do independent or enrichment study while the class is engaged with the content that the gifted and talented students have already mastered. Mrs. J. is flexible with her students, allowing a faster pace for the required activities and offering her students extra time to extend their learning.

This vignette showcases the teacher presenting alternative activities that incorporate an increased level of complexity and abstraction and reflect the interests of gifted and talented students. They are academically engaged through the strategic grouping of students with similar interests, and intellectually challenged through the introduction of advanced ideas and student-generated information. In addition, they develop their own goals and evaluate their own work. They form part of the community of learners and reinforce a prevailing quest for scientific understanding that predominates in the classroom. As a result, all students, including Jerry, Allie, Kate and Bob, have access for entry at a variety of levels through disciplinary core ideas, scientific and engineering practices, and crosscutting concepts presented in the NGSS. Classroom strategies that are particularly effective for gifted and talented students according to the research literature are highlighted in parentheses.

Gifted and Talented Connections

Jerry's naturalist interests were immediately apparent in the first week of school. He chose a classroom book on insects as an independent reading choice and excitedly shared the contents with classmates and Mrs. J. As the teacher pre-assessed Jerry by questioning him, the depth of his knowledge was evident. Jerry had an extensive knowledge about butterflies in particular, knowing their structures, species, and survival needs. Whenever a "bug" arrived at school, Jerry either knew the name or looked it up to inform the class. He would find the other animals of the food web that interacted with the animal. Jerry was the identification expert. His enthusiasm was contagious. He advocated for planting milkweed and provided seeds to the class so that classmates could add milkweed to their gardens in order to help provide food for monarch larvae. Jerry seemed to possess an unusually high interest in nature, and with the pre-assessment information, Mrs. J. could enhance the curriculum with more rigorous expectations for Jerry. *(Extending level of content by compacting areas already mastered is differentiation strategy of pacing for gifted and talented students.)*

The topic of study in the 4th grade science curriculum at Park West was native barn owls' internal and external structures and their functions. Models of owls and their anatomy covered the science bulletin board. Mrs. J. was guiding the class to construct explanations about the functions of the structures, and facilitating argumentation. The class was organizing the observations by structures grouped in systems. They used the concept to focus on systems rather than memorization of individual structures of the owl itself. Owls were used as the lens by which the students studied the overall concept. (CCC: Systems and System Functions.)

During a formal pretest, Mrs. J. found that Jerry knew most of the content of the unit. She decided that praying mantis insects could form the basis of an interest center, functioning as an anchor activity to extend Jerry's learning. Two praying mantis insects arrived along with flightless fruit flies, and students named the insects *Lost* and *Found*. Jerry immediately volunteered when the teacher suggested that they needed someone to organize the maintenance of the praying mantis and its food. He found books that included the insects, and a learning center began for those students who went into a deeper study of the animals. *(The teacher promoted autonomy and authentic connections to the content.)*

The learning center became a focus for classroom activity. Not only Jerry, but also several other students, including Allie and Kate, were active participants. The center was populated with books. Then the sketches arrived. Jerry and others sketched the praying mantis and fruit fly insects, observing details in the body and researching their organs. The sketched diagrams became intricate models explaining the different functions of the animals' structures. The teacher met with Jerry and other students to discuss the goal of the interest center and their learning. The teacher reinforced that the goal was not only to describe the structures of the animals, but also to construct an explanation based on evidence about the function of those structures. (Practice: Constructing Explanations.) (DCI: LS.1A Structure and Function.) (*The teacher promoted autonomy for her gifted and talented students to follow interests and actively participate in their learning objectives.)*

Differences between the two praying mantises were noted and questions came up as to why they were not identical. Students became scientists as they observed, looked up information in books and online, and wrote reports answering questions that were posed by other students or the teacher. The reports were posted on the bulletin board, and new information was constantly added with disorganized sticky notes to suggest modifications and more details that would refine or add to the models. Questions about other insect species like bees and ants led the students to develop arguments about the functions of the structures they observed in the praying mantis, comparing them with other classroom insects. (Practices: Asking Questions, Engaging in Argument from Evidence.) (DCI: LS1A Structure and Function.)

The students, led by Jerry, took responsibility for the insects and their learning center. The small group that condensed around the center's activities conferred daily about the growth and health of the animals. Jerry was able to find the time for the center activities because of the flexibility of pacing in the regular curriculum. He was able to complete other classroom tasks quicker than his peers; the flexibility with pacing allowed Jerry and others to continue their investigations.

A problem arose as Jerry became alarmed that the food source for the praying mantises was running out. The group of students brainstormed solutions and voted for the teacher to buy mealworms. This new insect became another subject for observation and documentation. Jerry had collaborators, Allie and Kate, who were also passionate about insects. *(Grouping students of similar interests and ability shows a successful strategy for gifted and talented students.)*

The mealworms went through their life cycle and the small group of students informed the class about their progress. Allie described the changes almost daily. (Practice: Analyzing and Interpreting Data.) Differences between the individual mealworms were documented and discussed. Kate researched the insects and her reports were displayed in the interest center. (Practice: Obtaining, Evaluating, and Communicating Information.) Kate's reports on the internal structures were helpful to the group as the students created models comparing the internal and external structures of the mealworms, praying mantises, and fruit flies. Questions about reproduction were also addressed when small mealworm larva appeared. The group shared their findings with the class, and the teacher assessed the learning based on the reports the students created.

Another opportunity for independent study arose out of a science lesson about bulbs as a food source for a growing plant. Mrs. J. brought an amaryllis bulb into the classroom for the purpose of the lesson. Bob was a quiet child who worked hard. He had a strong interest in sketching. When the potted amaryllis bulb was placed on the windowsill, Bob asked the teacher if he could document the growth of the plant, using stop motion photography. (DCI: MS.LS1-7 From Molecules to Organisms.) Bob collaborated with Jerry and a new interest developed. They created a chart and a way to standardize the pictures and investigate the growth of the plant. They decided on the measurement tools and controlled the variable of sampling time. (Practice: Planning and Carrying Out Investigations.)

When Bob and Jerry had collected enough pictures on plant growth, they created and narrated a video to illustrate the rate of growth. When the flowers bloomed, the students had questions about pollination. The idea of plant reproductive structures is a middle school topic. *(The incorporation of standards from an advanced grade – higher-level core scientific ideas – is an effective strategy for presenting a higher level of challenge for gifted and talented students.)* The students described the structures responsible for reproduction in the flower and developed arguments to support their claim about how the flower could be pollinated. (Practice: Engaging in Argument from Evidence.) After discussing pollination methods with the teacher, Jerry decided to use a paintbrush to cross-pollinate the flowers. When the flowers dried, the students were initially disappointed that no seeds were produced as they had predicted. After carefully dissecting the flower, there was a surprising discovery: the pods contained very small seeds. This challenged a conception for the students, because they had an assumption that the seeds would be large based on the size of the flower. The students presented their findings to the class, describing their conclusions from evidence about the seeds.

Independent study of topics of interest led to real-world connections. The independent study was available to all students in the classroom, but the target group was the gifted and talented students. The classroom's wiki website provided an online place to collaborate and share interests. Students chose a topic of interest, worked alone or invited collaborators, and conferenced with the teacher. Once a topic was chosen, the students narrowed or widened the scope by asking a question to clarify their ideas about the topic. (Practice: Asking Questions and Defining Problems.)

Jerry's report on pit vipers broadened his knowledge of the subject as he found information on the physical characteristics of the animals, answering his question, "What characteristics of pit vipers make them excellent predators?" The wiki provided a versatile location that students could use at school or at home as they developed their interest reports. The science topics from just one year included flying critters, pit vipers, rock classification, falcons, robot characteristics, mastodons, zebra mussels, eclipses, and the end of the Earth. These "interest projects" provided an avenue for students to develop an expertise on self-selected topics and independent research skills. *(The interest projects combine the effective strategies of fast pacing, differentiated challenging content, and opportunities for self-direction including grouping choices.)*

NGSS Connections

The vignette illustrates gifted and talented students in a science classroom with a diverse mix of students. It highlights a range of effective classroom strategies, such as learning centers and interest projects, to support and challenge these students in the regular classroom. Students' work was informally assessed based on the products of their studies and questioning. The teacher addressed the unique learning needs of gifted and talented students who developed an understanding of science according to the three dimensions of the NGSS. The teacher designed her instruction to include higher grade band standards at a deeper and more challenging level.

Performance Expectations

4-LS1-1 Structure, Function, and Information Processing
Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

MS-LS1-4 From Molecules to Organisms: Structures and Processes
Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

Disciplinary Core Ideas

LS1.A Structure and Function (by the end of grade 5)
Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

LS1.B Growth, Development, and Reproduction of Organisms (by the end of grade 8)
Animals engage in characteristic behaviors that increase the odds of reproduction.

Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features.

The students were engaged in the disciplinary core ideas in life science. They explained the structures of animals and their functions. They also explored the role of specialized plant structures in the reproduction of plants, including the role of specific animal behaviors that lead to successful plant reproduction.

Scientific and Engineering Practices

Asking Questions and Defining Problems (by the end of grade 5)
Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.

Planning and Carrying Out Investigations (by the end of grade 8)
Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.

Analyzing and Interpreting Data (by the end of grade 5)
Analyze and interpret data to make sense of phenomena.

Engaging in Argument from Evidence (by the end of grade 5)
Construct an argument with evidence, data, and/or a model.

Obtaining, Evaluating, and Communicating Information (by the end of grade 5)
Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.

As the unit progressed, the students gained abilities in scientific practices through their exploration of insects and plants by *asking questions and defining problems; planning and carrying out investigations; analyzing and interpreting data; engaging in argument from evidence; and obtaining, evaluating, and communicating information*. Students argued from the evidence of their observations about the functions of the structures of plants and investigated plant growth and reproduction. The NGSS practice of *asking questions and defining problems* was illustrated when students engaged in the observations at the learning center and in the independent study.

Crosscutting Concepts

Systems and System Models (by the end of grade 5)
A system can be described in terms of its components and their interactions.

Students were able to demonstrate their understanding of the crosscutting concept of *system and system models* when they observed the structures of the insects and plants and explained how they functioned within the larger system. They generated information orally and in written and digital formats. The observations over time led the students to develop their models of internal and external structures and functions based on the crosscutting concept of *system and system models*.

CCSS Connections to English Language Arts and Mathematics

The NGSS are committed to the integration of the Common Core State Standards for ELA and mathematics within the content area of science. In the vignette, the teacher inserted reading and writing objectives of the CCSS for ELA with all students as part of her science curriculum, and differentiated outcomes for her gifted and talented students.

- **SL4.4** *Report on a topic or text…using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace*.
  The scientific practice of *using models* was seamlessly connected to this standard.

- **W.4.2** *Write informative/explanatory texts to examine a topic and convey ideas and information clearly*.
  The teacher was able to raise the bar with her gifted and talented students who were presenting scientific information and explanations not only in a written and oral format, but also in a digital format. As the students developed their online reports, their work connected to the NGSS practice of *asking questions* and the CCSS.

The vignette also highlighted the integration of the CCSS for math:

- **4.MD.1** *Know relative sizes of measurements within one system of units including km, m, cm*

- **4.MD.4** *Make a line plot to display a data set of measurements in fractions of a unit (1/2, ¼, 1/8)*
  Measuring and graphing plant growth highlighted this standard.

Effective Strategies from Research Literature

Gifted and talented students may have characteristics such as intense interests, rapid learning, motivation and commitment, curiosity, and questioning skills. While an "integrated theory-driven program characterized by internal consistency from goal setting to service and evaluation" is recommended (Renzulli, 2012), often teachers must make curricular decisions and choose instructional strategies that reflect the academic potential of gifted and talented students and target their unique needs as learners. Based on the research literature, teachers can employ effective differentiation strategies to promote science learning of gifted and talented students in these domains: (1) fast pacing, (2) level of challenge (including differentiation of content), (3) opportunities for self-direction, and (4) strategic grouping (Tomlinson, 2005).

First, gifted and talented students benefit from fast pacing as compared to peers. One strategy that involves pacing is called "compacting curriculum," which permits students to pretest out of curriculum already mastered and condense the content partially learned. Flexible pacing with connected extension activities allows sufficient time to explore the areas of study while avoiding redundancies. Teachers can include options for gifted and talented students to impose their own deadlines. Instead of requiring gifted and talented students to do simply more work, teachers provide differentiated instruction through the use of an anchor activity (motivating task).

The second strategy is to promote the level of challenge so that it extends the current mastery level of the student through the use of advanced materials and objectives, expectations for idea generation and creativity, complexity of ideas, and open-endedness (Tomlinson, 2005). Gifted and talented students benefit from experiences that are connected to the real world. The content should avoid repetitive tasks and be differentiated to encourage expression and foster higher-level and abstract thinking.

The third strategy is to encourage autonomy by allowing the student to follow and cultivate her/his interests and to play a role in her/his own learning trajectory. The teacher helps the student develop strengths and engage in pursuits for which the student has a passion (Tomlinson, 2005). In addition, the teacher can incorporate motivating, authentic connections to science content that allow for student-directed goal setting, exploration, and self-evaluation. Choices that reflect the different learning styles of the student should be included (Renzulli, 2012).

Finally, effective teachers encourage flexible grouping to enhance academic and socio-emotional development of gifted and talented students, such as classroom grouping that allows for both individual time on projects and opportunities in groups with like-minded peers in terms of ability and/or interests. Effective grouping can vary between teacher-selected and student-selected in order to offer a wide range of experiences.

Context

Demographics

Reporting the demographics for gifted and talented students is difficult due to wide inconsistencies in the definition, in assessments to identify them, and in funding for gifted and talented programs across the nation.

First, the definition of gifted and talented students varies from state to state and the demographics shift accordingly. Many states have no formal state definition. For this reason it is unrealistic to arrive at an exact number of students in the United States who are gifted and talented. The National Association for Gifted Children (NAGC, 2012) defines gifted as "outstanding levels of aptitude or competence in one or more domains" and estimates that this definition describes approximately three million students, roughly 6% of all K-12 students. There are two more definitions that have been widely applied by states (NAGC, 2012). Traditionally, gifted and talented status is for those students performing at the top 5% of an assessment, such as high-stakes testing in language arts or mathematics. An alternative definition is described in Response to Intervention (RTI) as it applies to gifted and talented students. RTI suggests that 5-10% percent of high performing students in a classroom benefit from strategic, targeted, short-term instruction in addition to core; and 1-6% of the students in a given environment are considered "exceptionally gifted" and need intensive, individualized instruction.

Second, although gifted children come from every demographic group, school districts often rely on only one method of identification. Relying on only one measure may not be effective in identifying the gifted and talented students who come from underserved populations by race or ethnicity, socioeconomic status, and language. In addition, students who have an area of giftedness along with a learning difficulty, referred to as twice-exceptional children, are similarly difficult to identify with only one measure (NAGC, 2012).

Finally, as there is no federal funding for gifted programs, school districts must rely on their own funds to support such programs. This results in variations in programming of support for gifted and talented students from state to state. Unfortunately, current policy and funding do not match the needs of students in poverty:

> One of the barriers to developing the talents of children of poverty is inadequate resources, both financial and in terms of personnel. Developing the talents of any gifted child requires resources for special programs, classes, and support services such as counseling or testing. For children of poverty, even greater amounts of support are needed to help with basic needs of families as well as additional support services such as psychological services for children and families and social workers to assist families with issues surrounding housing and basic subsistence. (Van Tassel-Baska & Stambaugh, 2007, p. 44)

Science Achievement

The National Assessment of Educational Progress *(*NAEP*)* does not disaggregate for gifted and talented students.

Educational Policy

In 1988, Congress passed the Jacob Javits Gifted and Talented Students Education Act to fund research grants aimed at better identifying and serving gifted and talented students, especially from underserved student populations. In 2001, ESEA (Elementary and Secondary Education Act, Title V Part D Subpart 6 Dec. 5461-5466) called for a coordination of scientifically based programs to meet the needs of gifted and talented students, and grants to assist agencies and institutions to meet educational needs of these students. ESEA (Title IX, Part A, Section 9101(22)) defines gifted and talented:

> The term gifted and talented, when used with respect to students, children, or youth, means students, children, or youth who give evidence of high achievement capability in areas such as intellectual, creative, artistic, or leadership capacity, or in specific academic and diversity fields, and who need services or activities not ordinarily provided by the school in order to fully develop those capabilities.

The above definition has no mandate and only serves as a guide for states that have developed state-mandated definitions. States are not required to use this definition, nor are they federally required to identify gifted and talented students or provide services to them, leaving these decisions to the state and local governments. States, and often districts within states, differ in definitions for gifted and talented students and guidelines for services and teacher accreditation, ranging from full implementation programming to little or none. Although ESEA continued the Javits Act, funds were inconsistent over the years and the Act was defunded in 2011 (NAGC, 2012).

ESEA calls for the support of state and local efforts to increase the number and diversity of students who participate in and are successful in Advanced Placement courses (Title 1 Part G Sec 1702-1702 cited as the "Access to High Standards Act"). The US Department of Education provides awards to support activities that increase the participation of low-income students in both pre-AP and AP courses and tests.

References

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4.Structure, Function, and Information Processing

MS. Growth, Development, and Reproduction of Organisms

Students who demonstrate understanding can:

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

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	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds from K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct an argument with evidence, data, and/or a model.	**LS1.A: Structure and Function** • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. **LS1.B: Growth and Development of Organisms** • Animals engage in characteristic behaviors that increase the odds of reproduction. • Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

CCSS Connections for English Language Arts and Mathematics

SL4.4 *Report on a topic or text…using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.*

W.4.2 *Write informative/explanatory texts to examine a topic and convey ideas and information clearly.*

4.MD.1. *Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec.*

4.MD.4. *Make a line plot to display a data set of measurements in fractions of a unit (1/2, ¼, 1/8)*