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Universal design for learning (UDL) continues to be a topic of interest as teachers search for instructional strategies and activities to differentiate the general curriculum. This differentiation should provide access to and successful engagement with the curriculum for all students, including learners who have unique educational needs. Described here is an elementary science lesson on temperature planned and implemented using the principles of UDL. This example is offered that so that teachers may be encouraged to plan and implement instruction by using UDL principles in meeting diverse student learning goals.

Keywords: Universal design for learning (UDL) | instructional strategies | teachers

Article:

Universal Design for Learning with Elementary Science

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Abstract

Universal design for learning (UDL) continues to be a topic of interest as teachers search for instructional strategies and activities to differentiate the general curriculum. This differentiation should provide access to and successful engagement with the curriculum for all students, including learners who have unique educational needs. Described here is an elementary science lesson on temperature planned and implemented using the principles of UDL. This example is offered that so that teachers may be encouraged to plan and implement instruction by using UDL principles in meeting diverse student learning goals.

Introduction

Supporting all students' learning needs is challenging. However, Universal Design for Learning (UDL) as a framework for lesson planning offers promise for helping teachers manage this challenge and ensures that lessons are differentiated so that all students' learning needs are met.

The purpose of this article is to describe a UDL science lesson on *Taking Temperatures (TT)* that was taught in three kindergarten classrooms. *TT* was designed to meet the needs of all students including a child identified with language and speech delays, two children with specific learning disabilities, and a boy and a girl, each with attention deficit hyperactivity disorder. This lesson was also designed to meet the needs of students who had not been identified with special needs but who exhibited difficulties with following directions, lacked organization skills (for example, difficulty following written or spoken directions), and were not on grade level with reading and mathematics content knowledge. In addition, one child who was identified as having emotional difficulties, one child who had receptive language difficulty, a child who was hard of hearing with cochlear implants, and several children who do not know their numbers to ten were also included in the UDL lesson planning.

This number of children who have learning challenges is not surprising given that 95% of school-age students with disabilities are spending at least part of the instructional day in general education classrooms (U.S. Department of Education, 2011). If academically gifted and talented children are considered to have exceptional needs, then up to one half of each of these three classes could be composed of students who have special learning needs.

Now, imagine these same children taking temperatures - temperatures of water (in two states – liquid and solid) and air, inside the classroom and out-of-doors. Imagine some children 'reading' numbers on thermometers and others just indicating by the color line whether the air or water or weather is hot, warm, cool or cold. How can one teacher manage to teach the science content and the skill of taking temperatures to a class full of five and six year olds with so many different interests, strengths and needs, and at such different levels academically, socially and kinesthetically?

Overview of UDL

The teacher who embraces principles of UDL in lesson planning considers diverse students' needs to be the result of normal variance within a heterogeneous population (Mcguire, Scott, & Shaw, 2006). The philosophical premise behind UDL comes from the Universal Design movement in architecture (Preiser & Ostroff, 2011). The benefits of Universal Design for making public spaces and structures accessible to citizens with a wide range of physical needs are that architectural changes can be done from the outset with minimal costs and a wider range of people than those targeted is affected (Pisha & Coyne, 2001). For example, a curb planned with a cutout benefits the person in a wheelchair and a bicycle rider as well. Likewise, UDL lessons anticipate a wide range of learning styles and abilities in the classroom. The UDL lesson is flexible and deliberately multi-faceted in order to engage all students as they work to meet curricular goals through multiple and varied interactions with instructional materials and activities (Orkwis, 2003).

UDL provides the following three guiding principles to consider when planning lessons so that children are properly stimulated in ways that allow for learning: (1) multiple means of representation (recognition or the what of learning) - students can access information and content from multiple entry points, (2) multiple means of action and expression (strategic learning or the how of learning) – students can show what they know in varied ways, and (3) multiple means of engagement (affective learning or the why of learning) - students' interest and motivation for learning is stimulated (*Center for Applied Special Technology*, n.d.). The lesson that we highlight in this article on *TT* adheres to these UDL guidelines.

Science Education, Accessibility and UDL

There are a variety of issues and concerns for students' accessibility to learning about science (Marino, 2010). The NSTA (2004) describes several barriers that students with disabilities may experience in science activities including issues with equipment and tools and communication difficulties. By implementing principles of UDL, teachers can deliver the science curriculum and help students with disabilities overcome physical, affective or cognitive barriers that may leave them feeling cut off from the instructional activities (Pisha & Coyne, 2001). As such, the science content becomes engaging, meaningful, and accessible to all students.

UDL Science Lesson on TT for Kindergartners

This lesson begins with a read-aloud of *Winter is Here* (a picture book with watercolors of typical activities a child might participate in on a cold winter day (for example, drinking hot chocolate and playing in the snow). Following the read-aloud, the lesson continues by having students, as a whole group, think about the classroom bear (a stuffed animal that is dressed each day in weather-appropriate attire). The teacher leads students to make inferences about the weather and the outside temperature based on the class bear's attire. The class bear was dressed in a sweater, hat and gloves. The teacher then introduces the concepts of colder and hotter as they relate to weather and thermometers. She shows a large thermometer and asks students how many of them have seen a thermometer and know what it does. The teacher explains that a thermometer is an instrument or a tool that is used to measure temperature and temperature tells us how hot or cold it is.

The large thermometer is placed in a bowl of ice (to match the snow on the ground from the story) and another large thermometer is placed in view of the students in the classroom. Students are shown how to "read" the thermometer. For those students who do not yet know their numbers, the teacher provides qualitative ways to read the thermometer (temperature readings in the top (one-fourth) part of the thermometer are hot; next (one-fourth) are warm; etc.). For students who can identify numbers, the teacher requires them to quantitatively read the thermometer.

A kinesthetic activity teaches students that the “red-colored liquid” rises when the temperature increases (gets warmer) and falls as temperature decreases (gets cooler). When it is hot, students stand on their tiptoes, with their hands straight up in the air, reaching as far up as they can with their finger tips. As the temperature lowers from hot to warm, students come down to a standing position with arms crossed at their chests. For cool temperatures, students stand but lower their arms towards the floor. Finally, for cold temperatures, students crouch down toward the floor and curl up into a ball with their feet on the floor.

Teachers lead students in a Simon-says type activity where the teacher begins by calling out a temperature and showing the temperature on a thermometer. For example, “Simon says, ‘hot’”. Students then respond by standing on their tiptoes, arms straight up and fingers reaching toward the ceiling.

Students create paper thermometers and the teacher uses a large paper thermometer as a model. The teacher and students label their thermometers with words (top ¼ “hot”, next ¼ “warm”, third ¼ “cool” and bottom ¼ “cold”) rather than or in addition to numbers depending on the student. All students participate in guided practice by adjusting the “red-colored liquid” in the big paper thermometer in response to given temperature changes and then “reading” the represented temperatures. The teacher takes students outside to “read” an outside thermometer and adjust their paper thermometers accordingly. Returning to the classroom, readjustments of their paper thermometers occur. Finally, students color blank paper thermometers to match their readings from inside, outside, and from the thermometer in the bowl of ice and label these as hot, warm, cool and cold relative to one another. This simple activity provides an assessment of whether or not students understand the concepts of increasing and decreasing temperatures or getting warmer and getting cooler with respect to ‘reading’ a thermometer. For students who have difficulty with fine motor skills you can have a couple of sets of paper thermometers with all four temperature readings (hot, warm, etc.) and students can select one of these thermometers for their answer to each question.

Taking Temperatures - Teachers represent curriculum in multiple ways

The teacher offers multiple opportunities for students to ‘read’ thermometers and see the changes in the “red-colored liquid” as the temperature changes. The teacher provides explicit instruction through demonstrations and modeling. Repetition supports students who miss information because of difficulties with attention. Modeling is a visual scaffold for students with language processing problems; students do not have to hold verbal information in mind but can construct knowledge based on what they see as opposed to what they hear.

Kinesthetic activities make the abstract concepts of increasing and decreasing temperature more concrete for children who struggle with abstract thought and language processing. Changing environments (inside, outside, and in ice) helps children generalize the concept of temperature across environments.

Taking Temperatures- Students express knowledge in multiple ways

Students put thermometers in ice and take the thermometers out and set them in the room or outside. Creating accurate paper thermometers helps children show that they know facts about temperature, are skilled in tool use and measurement and understand the concept of relative change. The act of making the paper thermometers and adjusting them to temperature conditions allows children who have communication problems to demonstrate their understanding of the lesson.

"Reading" the thermometers gives students a chance to think through the process and verbalize their understanding. It also involves organizing their thoughts, which helps them understand the concept and articulate any misunderstandings so the teacher can redirect students' thinking immediately. The kinesthetic activities allow students to use their bodies to express their knowledge of how temperature changes in different environments and demonstrate their ability to read thermometers.

Taking Temperatures - This lesson is engaging because:

Kinesthetic activities engage students who need physical stimulation in order to maintain focus over time. Students can use non-verbal means to demonstrate their understanding of the lesson and to stay engaged in the lesson. Children with receptive and/or expressive language difficulties will be able to participate, learn from, and express their understanding of the lesson objectives. The lesson does not require students to talk, read, or write in order to demonstrate their understanding of the concept of temperature and the skill of "reading" a thermometer.

Multiple exposures to the concept across environments and using multiple representations of the thermometer help students generalize across situations and environments. Students who have memory problems have multiple representations with which they can associate the concept of temperature, thus increasing the likelihood that they will remember the big ideas in this lesson.

The *Next Generation Science Standards (NGSS)* and UDL

The *NGSS* (2013) establish learning expectations in science for K–12 students combining three important dimensions: (1) science and engineering practices, (2) disciplinary core ideas, and (3) crosscutting concepts.

The *Framework* (National Research Council, 2012) for the *NGSS* (2013) highlights the power of integrating students' conceptual understanding of science with engagement in the practices of science by identifying eight science practices, six of which are addressed in *TT*. These six science practices included in *TT* are (1) asking questions, (2) using models, (3) planning and carrying out investigations, (4) analyzing and interpreting data, (6) constructing explanations and (8) obtaining, evaluating, and communicating information.

When instruction incorporates these practices of science, students engage in tasks that mimic the work of scientists and use tools and equipment, verbal and written collaboration, observation and collection of data as well as complete analysis of data and communication of findings. Tasks such as these provide multiple entry points for students to make meaning of science concepts and practices, and express what they know about science, all while immersed in meaningful engagement with the science curriculum.

TT addresses disciplinary core ideas in Physical Science, PS1 Matter and Its Interactions and Earth and Environmental Sciences, ESS2 Earth's Systems. From the *Framework,* the grade band endpoints for PS1.A and ESS2.D at the end of second grade verify the appropriateness of *TT* for grades K-2 (National Research Council, 2012).

Conclusion

TT reflects the principles of UDL in physical science and earth/environmental science appropriate for elementary students. UDL helps ensure that instruction provides equal opportunities for all students in inclusive classrooms. For example, with the *TT* lesson, the student identified with speech language disorders, struggling with expressive language, was able to make the paper thermometers to demonstrate his understanding of temperature. For the children identified with specific learning disabilities, "reading" the thermometers allowed them to organize their thoughts to understand the concept of temperature. The kinesthetic activity helped students who needed to focus their attention on the learning activities, keeping them engaged through the hands-on activity of putting thermometers in ice to observe the changing temperature. Each of these examples demonstrates how multiple means of representation, expression and engagement, the principles of UDL, allowed all students in the science class to be part of the learning.

Our kindergartners enjoyed the science and mastered the art of *TT* and we were satisfied that they had built a foundation for very important science content knowledge and practices in the years to come. *TT* aligns well with the *NGSS* (2013) that will guide our work as science educators for the next decade.

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