Universal Design for Learning in the Science Classroom

Successful STEM Education Conference
San Francisco, CA – Feb. 1, 2016
Samantha Daley, EdD

AFFECTIVE NETWORKS:
THE WHY OF LEARNING

Engagement
For purposeful, motivated learners, stimulate interest and motivation for learning.

RECOGNITION NETWORKS:
THE WHAT OF LEARNING

Representation
For resourceful, knowledgeable learners, present information and content in different ways.

STRATEGIC NETWORKS:
THE HOW OF LEARNING

Action & Expression
For strategic, goal-directed learners, differentiate the ways that students can express what they know.

STEM Smart workshops are funded by the National Science Foundation grant #1449550. Any opinions, findings, and conclusions or recommendations at this event or in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
We need a model to let us consider this infinite variability...
Three major dimensions of how learners vary
Recognition Network: “what of learning”

Identify & interpret patterns of sensory information from the environment.
Strategic Networks: “how of learning”

Plan, execute, and monitor actions on the environment.
Affective Networks: “why of learning”

Evaluate & set priorities for attention and action
UDL Framework

Provide Multiple Means of Representation

Provide Options for Action and Expression

Provide Multiple Means of Engagement
## I. Provide Multiple Means of Representation

1. Provide options for perception
   1.1 Offer ways of customizing the display of information
   1.2 Offer alternatives for auditory information
   1.3 Offer alternatives for visual information

2. Provide options for language, mathematical expressions, and symbols
   2.1 Clarify vocabulary and symbols
   2.2 Clarify syntax and structure
   2.3 Support decoding of text, mathematical notation, and symbols
   2.4 Promote understanding across languages
   2.5 Illustrate through multiple media

3. Provide options for comprehension
   3.1 Activate or supply background knowledge
   3.2 Highlight patterns, critical features, big ideas, and relationships
   3.3 Guide information processing, visualization, and manipulation
   3.4 Maximize transfer and generalization

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## II. Provide Multiple Means of Action and Expression

4. Provide options for physical action
   4.1 Vary the methods for response and navigation
   4.2 Optimize access to tools and assistive technologies

5. Provide options for expression and communication
   5.1 Use multiple media for communication
   5.2 Use multiple tools for construction and composition
   5.3 Build fluencies with graduated levels of support for practice and performance

6. Provide options for executive functions
   6.1 Guide appropriate goal-setting
   6.2 Support planning and strategy development
   6.3 Facilitate managing information and resources
   6.4 Enhance capacity for monitoring progress

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## III. Provide Multiple Means of Engagement

7. Provide options for recruiting interest
   7.1 Optimize individual choice and autonomy
   7.2 Optimize relevance, value, and authenticity
   7.3 Minimize threats and distractions

8. Provide options for sustaining effort and persistence
   8.1 Heighten salience of goals and objectives
   8.2 Vary demands and resources to optimize challenge
   8.3 Foster collaboration and community
   8.4 Increase mastery-oriented feedback

9. Provide options for self-regulation
   9.1 Promote expectations and beliefs that optimize motivation
   9.2 Facilitate personal coping skills and strategies
   9.3 Develop self-assessment and reflection

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**Resourceful, knowledgeable learners**

**Strategic, goal-directed learners**

**Purposeful, motivated learners**

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CAST | Until learning has no limits
“Universal Design for Learning (UDL) means a scientifically valid framework for guiding educational practice that —
(A) provides flexibility in the ways information is presented, in the ways students respond or demonstrate knowledge and skills, and in the ways students are engaged; and
(B) reduces barriers in instruction, provides appropriate accommodations, supports, and challenges, and maintains high achievement expectations for all students, including students with disabilities and students who are limited English proficient.”
Fixed, uniform, learning technologies

Diverse, varied, learners.

CAST | Until learning has no limits"
The Result?

Children are the problem
New media changes the equations
An example

Science Notebooks

• Can effectively support active science learning and development of scientific literacy (Hargrove & Nesbit, 2003; Klentschy, 2005)
• Opportunity for students to engage in authentic scientific practice
• Support students to reflect, revise their thinking, focus on “big ideas”
• Provide formative assessment data for teachers
The nature of the task is critical
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Resourceful, knowledgeable learners
Strategic, goal-directed learners
Purposeful, motivated learners
Answer Focus Question

How can you make two lights burn brightly in a series circuit?

10/28/2010

I connected a wire from the bottom of the D-cell to the bottom of the lightbulb. I added another wire from the side of the first bulb to the bottom of the second bulb. I connected another wire from the bottom of the second bulb back to the side of the D-cell.
SNUDLE vs Traditional Paper Notebooks in inclusive 4th-grade science classrooms (n=621)

- There was a significant impact of SNUDLE (γ = .34, p<.01) use over and above that of traditional science notebooks – representing a 10% difference on average between treatment and control.

- SNUDLE raised the floor and the ceiling on content and process knowledge for all students

- Students of teachers who had more experience with science notebooking tended to use SNUDLE features more productively.
In their own words...

[video removed for permission reasons]
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Science in the Learning Gardens
SciLG
Factors that Support
Ethnic and Racial Minority Students’
Success in Low-Income Middle Schools, 2014-2017

Dilafruz Williams & Sybil Kelley

STEM smart: Lessons learned from successful schools
San Francisco. February 1, 2016
Project funded by NSF Grant: DR K-12: DRL 1418270

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Overall Goals of SciLG

• Advance equity in STEM
• Strengthen pipeline to higher education
• Honor diversity and inclusivity
Our Core BELIEFS and VALUES

Unyielding commitment
  – to diversity and inclusion
  – to non-marginalization

Reject deficit-based models of education

Students do not have to give up who they are and what defines their identity
For culturally and linguistically diverse students, the garden has potential to empower and to encourage pride and respect in their cultural heritage.

Karen Payne, Program Director of the American Community Garden Association
Curriculum:
NGSS/Culturally responsive

Instruction:
Garden as milieu/
Hands-on, experiential, holistic

Research:
Motivational engagement
Science learning outcome

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<thead>
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<th>Category</th>
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<tr>
<td>TOTAL</td>
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SCIENCE-NGSS/ASSESSMENT
Cary Sneider
Sybil Kelley
Stephanie Wagner
Dilafruz Williams

CULTURAL UNDERSTANDINGS
Judy Bluehorse Skelton
Dilafruz Williams
Nakisha Nathan
Dunya Minoo
Esperanza De La Vega

GARDEN-BASED EDUCATION
Dilafruz Williams
Sybil Kelley
Judy BlueHorse Skelton

MOTIVATIONAL ENGAGEMENT RESEARCH
Ellen Skinner

STUDENTS

Motive teachers
Jim Anderson/Bruce Reiter
Rob Wright
Paige Miller
Lindsey Hibbert

Motivated students
Morgan Dill
Jesse Hunter
Christine Olivera

PEDAGOGICAL PRINCIPLES

Cultivating a Sense of Place
Fostering Curiosity and Wonder
Discovering Rhythm and Scale
Valuing Biocultural Diversity
Embracing Practical Experience
Nurturing Interconnectedness
Awakening the Senses
Living Soil

PSU is on later start schedule—Starting this unit first will allow kids time to learn some of the concepts that they can apply in the late fall garden design challenge (and they will start with a truncated series of lessons from "Studying People Scientifically")

First design iterations in classroom? Could make and test prototypes, monitoring temperature changes, moisture loss, etc (tie in water cycle (ESS2-4)

Garden Unit (Late Fall): Energy Engineering Design Challenge: How can we grow more food through the winter? (PS3-4; PS3-5)

Collect weather data all year long (all grades/all classes); input into Google sheets—use for data analysis and claim making in spring

Enrichment/Classroom connection: Fall (LS1-1; LS1-2): Structure & Function of plants: Compare & contrast plants and bodies (in-class connections)

Enrichment: LS1-4: Plant/Animal interactions/reproductive success

Enrichment: LS1-1 & LS1-2—plant cells; and LS1-3—cells and systems: Perhaps take specimens to class (microscope investigations? other?)

Supplementing ESS3-5, ESS3-6: look at guiding questions in Framework

Enrichment for winter/spring (LS3.2) Asexual & Sexual reproduction—May just be a thread in the garden all year as students try a variety of propagation techniques

Enrichment: LS1-8: Sensory stimuli (e.g. sunflowers)

Gap in SEPUP: ESS2-4 (Water cycle) & ESS3-3 (minimizing human impacts): Great opportunity to bridge classroom and garden. In spring, water cycle lesson can be included during long-term investigation.

Environmental & Genetic factors (LS1-5): Introduce in fall while harvesting; 1st investigation could be in conjunction with Eng. Des. Challenge in winter; Spring, apply new understandings in garden/spring plantings (investigation)
**Fall Garden Unit/Focus (PS1-3, PS1-2; PS1-6; LS2-3)**:
Investigate the cultural, medicinal, and synthetic applications of plants in the garden; build compost/worm bins to investigate chemistry of materials and energy flow through systems. (This gets at concepts for both integrated and non-integrated alignment and different sequence of non-integrated)

**Winter Garden Unit (LS2-2; LS2-4)**—Interactions among organisms across ecosystems; changes in ecosystem components impacting populations

**Spring Garden Unit (LS2-1; LS2-5)**—Resource availability, populations, biodiversity, and design solutions

"Teachable" moments in the garden

- **PS Integrated focus for 7th grade: Northwest Region/Bioregion**
- **Bottle Ecology: Yearlong ecosystem**
- **Ecology**
- **Erosion and Deposition**
- **Plate Tectonics**
- **Switch order??**

**Sit Spot all year long—Change over time/journaling & writing**

**Studying Materials & Chemistry of Materials (Fall)**

**7th Grade Yearlong Map**

**SEPUP Units**

**2015-2016 Non-Integrated**

**Water & Force & motion (Winter)**

**Energy & Waves (Spring)**
Warms to break down the compost
- Green
- Brown
- Green
- Brown

Holes for air

Funnel for water to pour in

Holes for bugs to get in
GARDENS AS A MOTIVATIONAL MILIEU

(Predicting from Winter to Spring Term)

STUDENTS’ EXPERIENCES IN THE GARDEN

- Autonomy (personal importance of activities) & Purpose

TEACHERS’ PERCEPTIONS OF STUDENTS

- Engagement In the Garden (having fun, working hard)
- Expectations of Students’ Potential to Succeed in Science

ACADEMIC OUTCOMES

- Science Grades

n = 104. Arrows show individual regression analysis paths in which earlier experiences predict changes in the levels of later outcomes, after controlling for the prior effects of those outcome variables. Survey items used 1-5 scale where higher levels showed stronger agreement with statements. Science grades were converted to a standard 4.0 scale. Mean of Autonomy & Purpose = 4.08, SD = 0.81. Mean of Belonging & Competence = 3.77, SD = 0.77.

STUDENTS’ EXPERIENCES (Predicting from Spring to Fall Term)

- Belonging and Competence
- Engagement In the Garden (having fun, working hard)

STEM Identity
What do you feel?

“I feel safe at the Learning Gardens.”

“It releases stress from me. I feel really happy.”

“No one (is) judging me for who I am. It is a circle of life, of friendship.”

“It's like I'm a member. I'm home. I'm safe. I'm comfortable.”

“I feel smart. I feel like a better learner.”
“It's hands-on (with) plants. You actually get to touch them, see them, when we learn about plants. There's fresh air. At school, we just sit on our butt on our desk and write. It's more interesting here. We get to walk around and learn stuff. We get to get dirty.”