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Preparing Future Teachers in the Age of NGSS: An Investigation of a Preservice Teacher Curriculum

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Introduction

The Next Generation Science Standards (NGSS) [1], based on *A Framework for K-12 Science Education* [2], currently guide teachers in facilitating K-12 students' science and engineering learning in Washington state. The NGSS calls for science learning be composed of scientific practices, crosscutting concepts, and disciplinary core ideas, i.e. "three-dimensional". Because incorporating three-dimensional learning into K-12 science education requires transforming the way teaching occurs, practicing and pre-service teachers need to be trained in methods that likely are different from the ways they first learned fundamental science and engineering ideas [3].

The *Framework* calls for changes in teacher certification programs "to ensure that all students learn science from teachers who are well prepared" [2]. Within the Woodring College of Education at Western Washington University (WWU), all undergraduate prospective teachers for the elementary or early childhood, special, or general education programs are required to take SCED 201, "Matter and Energy in Physical Systems" [4], which uses the *Next Generation Physical Science and Everyday Thinking (Next Gen PET*) curriculum [5].

In this work, we assess the extent to which the *Next Gen PET* curriculum meets the criteria for 3DL. We analyzed the first unit in the studio version of the curriculum, Energy Model of Interactions, which is taught by all SCED 201 instructors at WWU.

3-Dimensional Learning Assessment Protocol (3DLAP)

Use and Adaptation of the 3DLAP

One published framework for determining whether curricula meet the NGSS concept of three-dimensional learning is the Three-Dimensional Learning Assessment Protocol (3DLAP) [6]. It has been used to assess transformation of undergraduate science instruction in introductory biology, chemistry, and physics [7].

We applied the 3DLAP to evaluate NGSS alignment in the *Next Gen PET* curriculum, by revising the core ideas section to agree with physical science standards for grades 6-12 in the NGSS and the *Framework*.

In the Energy Model of Interactions unit (Unit EM), we analyzed each "step" of each exploration, each summarizing question, and the entire initial ideas section, using the 3DLAP individually, then compared and discussed until reaching consensus.

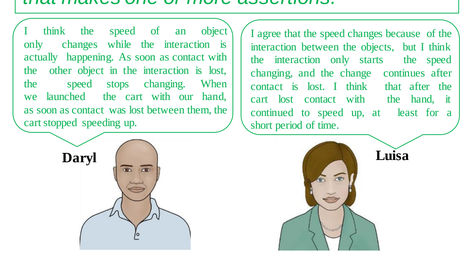
Physical Science Core Ideas in the NGSS

- **Matter & Interactions**
- **Motion & Stability**
- **Energy**
- **Waves & Applications**

3D Exemplar from *Next Gen PET*

Activity EM 1 Summarizing Question 1

1. Question gives an excerpt from a conversation, student solution, video (or similar) that makes one or more assertions.



Do you agree with Daryl or Luisa, or neither? Use ideas about energy transfers and changes to support your answer.

2. Question gives a conclusion about the validity of the assertion(s) made or asks student to make a conclusion about the validity of the assertion(s) .

3. Question asks student to provide reasoning to support their conclusion(s) about the validity of the assertion(s).

3DLAP Analysis

A. Scientific Practice: Evaluating Information (3DLAP criteria are highlighted in figure to the left)

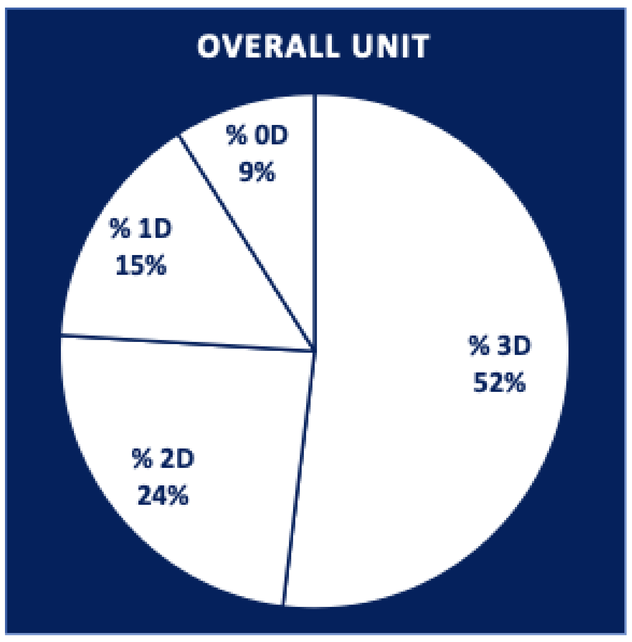
B. Core Idea: Motion & Stability

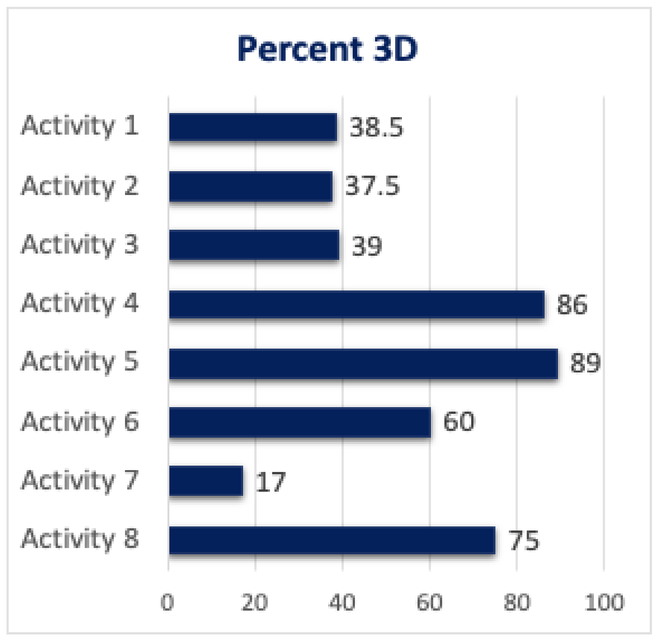
C. Crosscutting Concept: Cause & Effect (Mechanism & Explanation)

In this question, the effect is the object's changing speed. The **cause** is given as a contact push/pull interaction. The **mechanism** is to be provided by the student in the form of supporting one of the students:

- ❑ Does speed change only *during* the interaction, while the hand is in contact?
- ❑ Does speed only *start to change* during the interaction and continue after the hand loses contact?

Characterization of Next Gen PET Unit EM (Energy Models of Interactions)





Number of Appearances	Scientific Practices	Core Ideas	Crosscutting Concepts
Least Common (0-1)	❑ Asking Questions ❑ Planning Investigations ❑ Communicating Information ❑ Defining Problems & Designing Solutions	❑ Matter & Interactions ❑ Waves & Their Applications	❑ Scale ❑ Systems & System Models
Most Common (>10)	✓ Developing & Using Models ✓ Using Math & Computational Thinking	✓ Motion & Stability ✓ Energy	✓ Proportion & Quantity ✓ Energy & Matter: Flows, Cycles, & Conservation

Discussion & Future Work

While over half (52%) of the tasks and questions in Unit EM characterized as 3D according to the criteria in the 3DLAP, there was wide variety among individual activities within the unit, ranging from 17% 3D (Activity 7) to 89% 3D (Activity 5). We speculate that the relatively low %3D of the first three activities may relate to an attempt to build student capacity to engage in 3DL by first developing knowledge of energy ideas and models before applying their understanding in later activities. However, Activity 7 deviated from this trend and was characterized as the least 3D of all the activities in the unit. Discerning potential reasons for this large dropoff is still underway.

Future work on this project will involve characterizing the remaining units that are typically taught by SCED 201 instructors at WWU. We also plan to use our 3DLAP characterization data to identify gaps and limitations in the curriculum, which will allow us to make recommendations that teachers can use to adapt the course materials for use in their classrooms. For example, while it may make sense that the Core Idea of Matter & Interactions was not represented in Unit EM, which is about energy-based models of interactions at a macroscopic level, we do not see a similar justification not to include engagement with all of the Scientific Practices or Crosscuttting Concepts. An example of how one might revise a question to engage with each of the three dimensions is provided to the right. Through this work, we hope that we will be able to prepare our preservice teachers to engage their future students with 3DL as described in the NGSS.

Adapting Question from 1D to 3D

Original 1D Question: Activity EM 2 Summarizing Question 2

What evidence would you look for that would tell you that a stationary object is involved in a contact push/pull interaction? What about if the object is already moving?

Limitations of the Question

- ❑ Question is unlikely to elicit engagement in a Scientific Practice: It does not ask students to explain or justify how the proposed evidence would indicate involvement in a contact push/pull interaction.
- ❑ Question does not ask students to engage in a Crosscutting Concept.
- ❑ Question is 1D in that it does ask students to engage in the Core Idea of Motion and Stability.

Revised 3D Question:

a) What evidence would you look for that would tell you that a stationary object is involved in a contact push/pull interaction?

b) Explain how this evidence would indicate involvement in a contact push/pull interaction. Be sure your explanation includes ideas of energy by describing the relationships between the observed behavior and energy.

c) Would you look for different evidence if the object is already moving? Why or why not?

Scientific Practice

Question now meets all 3DLAP criteria [6] for **Planning Investigations** with the addition of the justification component .

Core Idea

Question now has the potential to engage students in multiple core ideas: **Motion & Stability** and **Energy.**

Crosscutting Concept

Question now meets all 3DLAP criteria [6] for the crosscutting concept of **Proportion & Quantity**.

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Acknowledgments & Contact Info

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