EXPERIMENTAL DESIGN AT THE INTERSECTION OF MATHEMATICS, SCIENCE, AND TECHNOLOGY IN GRADES K-6

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Interdisciplinary courses, highlighting as they do the area(s) the disciplines have in common, often give the misperception of a single body of knowledge and/or way of knowing. However, discipline based courses often leave the equally mistaken notion that the disciplines have nothing in common. The task of the methods courses described in this paper is to reach an appropriate balance so that our pre-service elementary (K-6) teachers have a realistic perception of the independence and interdependence of mathematics and science.

At the College of William and Mary each cohort of pre-service elementary teachers enrolls in mathematics and science methods courses taught in consecutive hours. Both instructors emphasize the importance of the content pedagogy unique to their disciplines such as strategies for teaching problem solving, computation, algebraic thinking, and proportional reasoning in mathematics and strategies for teaching students how to "investigate" and "understand" the concepts of science. The instructors model interdisciplinary instruction by collaboratively teaching common content pedagogy such as the use of technology, data analysis, and interpretation. Students also identify real-life application of the mathematical principles they are learning that can be applied to science. The concept of simultaneously teaching appropriately selected math and science skills are stressed. Given this approach students are not left with the notion that mathematics is the handmaid of science nor the notion that it is the queen of the sciences. Rather, they view mathematics as a co-equal partner.

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At the College of William and Mary each cohort of pre-service elementary teachers enrolls in mathematics and science methods courses taught in consecutive hours. (See Mason and Giese [1].) Both professors individually emphasize the importance of the content pedagogy unique to their disciplines. The mathematics methods professor emphasizes strategies such

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as teaching problem solving, computation, algebraic thinking, and proportional reasoning in mathematics. The science methods professor emphasizes strategies for teaching students how to "investigate" and "understand" the concepts of science. Both professors want the disciplines they are responsible for, taught as a way of knowing; as a body of knowledge; as interrelated to other disciplines; and as a functioning part of students' everyday worlds.

The mathematics and science methods professors model interdisciplinary instruction by collaboratively teaching common content pedagogy such as the use of technology, data analysis, and interpretation. The concept of simultaneously teaching/reinforcing appropriately selected math and science skills is stressed.

Teaching selected aspects of science and mathematics methods courses in an interdisciplinary way is fully consistent with Virginia's Standards of Learning [2]. In the Virginia's Science Standards of Learning "investigate" is defined as designing and conducting experiments and analyzing the experimental data. For each grade the first science standard defines both the concepts and level of sophistication of experimental design and data analysis to be focused on. Virginia's Mathematics Standards of Learning mandate, "Students also will identify real-life application of the mathematical principles they are learning that can be applied to science..." Both sets of standards specify the teaching of measurement.

Strategies for teaching experimental design include strategies for teaching the components of an experiment, i.e., independent variable (IV), dependent variable (DV), constants (C), control, repeated trials (R), hypothesis, and title. Given scenarios of simple experiments, students then practice identifying each of the listed components in an experimental design diagram and suggesting ways to improve the described experiment. Students are then taught strategies for using different science-related prompts, a general topic, a neat demonstration, an advertisement or a newspaper article, and the Four-Question-Strategy to design an original experiment.

Four-Question-Strategy

1. What materials are readily available for conducting experiments on ___(Plants)___ ?

Soil	Water
Seeds	Light
Fertilizer	Containers
Temperature	Environmental conditions

2. How do ___(Plants)__ act?

Plants grow.	Plants flower.
Plants fruit.	Plants wilt.
Plants die.	Plants exhibit tropism.

3. How can I change the set of _____(Plant)____ materials to affect the action?

Soil	Seeds	Water	Container
Composition	Size	Amount	Volume
Amount Color	Frequency	Depth	Color
Color	Age	Application method	Diameter
Depth	#/ container	pH	Location & # holes
Substrate	Mutilation	Type/source	Saucer
Compaction	Treatment	Additives	Cover
Substitutes	Depth	Substitutes	
Critters Specie(s)	Temperature	Material	
Layers or homogenous	Brand/variety	Time of day	
	Mix		
	Orientation		

(Lists for Light, Fertilizer, Temperature, and Environmental conditions)

4. How can I measure or describe the response of ____(Plants)____ to the change?

Measure height. Record color. Count blossoms. Calculate growth rate. Assess health. Measure stem diameter. Calculate germination rate. Measure root development.

To complete an Experimental Design Diagram for an experiment, from Question 3, one response is selected as the independent variable and single values are assigned to each of the other responses as they become the constants in the experiment. From Question 2, the action selected is the dependent variable and from Question 4, a means of measuring or describing any changes in the dependent variable is selected. Now the student has only to select the values of the independent variable to test, determine a control, how many repeated trials are needed, and write a title and an hypothesis. At this point an initial draft of his/her experimental design is complete.

Experimental Design Diagram

Title: The Effect of the Number of Seeds Planted in a Container on the Average Height of the Plants in the Container

Hypothesis: If the number of seeds planted in a container is increased then the average height of the plants will decrease.

<table>
<tr><td colspan="4">IV: The Number of seeds per container</td><td>← Independent variable</td></tr>
<tr><td>2</td><td>4
(control)</td><td>8</td><td>1</td><td>← Level of IV including control</td></tr>
<tr><td>4</td><td>4</td><td>4</td><td>4</td><td>← Number of Repeated Trials</td></tr>
<tr><td colspan="4">DV: Average height of plants in the container (cm)</td><td>← Dependent Variable</td></tr>
<tr><td colspan="4">C: (All responses in Question 3 except IV)
water, seeds, fertilizer, containers, etc.</td><td>← Constants</td></tr>
</table>

It is at this point that the mathematics and science methods classes (same students) are taught jointly to practice using and to extend their knowledge of the quantitative skills that are part of the domains of mathematics, technology, and science are pertinent. Their knowledge of the applications of computers, basic spreadsheets, and basic graphing software packages is enhanced.

The class reviews the draft of the experimental design diagram to determine if the most appropriate measurement tools, units, relationships, and skills have been identified and used appropriately. A data table is constructed and data properly recorded, graphed, and analyzed using the technology and descriptive and/or inferential statistics which are developmentally appropriate for the students to be taught. Given this approach our pre-service teachers are not left with either the notion that mathematics is the handmaid of science nor is it the queen of the sciences, but rather a co-equal partner. ■

References

[1] M. M. Mason and R. N. Giese, "Using Technology as a Vehicle to Appropriately Integrate Mathematics and Science Instruction for the Middle School", *The Journal of Mathematics and Science: Collaborative Explorations* 2(2) (1999) 171-173.

[2] *Standards of Learning for Virginia Public Schools*, Board of Education, Commonwealth of Virginia, Richmond, VA, 1995.