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Play-Doh Volumes: An Experience in Science/Math Lesson Integration

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Abstract
This article demonstrates integration of mathematics and science lessons for 5th grade students with preservice teachers. The article shares a lesson where mathematics and science content are fully integrated, allowing students to make sense of conceptual understandings in both subject areas and the lesson also allows students to view mathematics and science as tools to question, analyze, represent, and communicate findings. The lesson is one the authors used in Spring 2022 and Spring 2023 with preservice elementary teachers. The description of the lesson includes lesson objectives and connections to relevant science, math, and cross-cutting concepts for 5th grade (although it could be adapted for various grade levels).

"Where did the science go?" I asked myself as I dug deeply into an inherited syllabus where preservice teachers were expected to teach science lessons to each other in class as an assignment instead of in their practicums. It seemed that preservice teachers could not teach science in their placements because science was not being taught in every classroom, thus the assignment could not often be fulfilled in elementary classrooms.

No science in many schools was a startling thought and one that I could not accept. Somehow in the last seven years, science has exited the elementary classroom. I immediately knew that if science was not explicitly being taught in the classroom, I was going to have to teach my preservice teachers how to sneak it in. This would have to become a course objective.

As I drove to work that next morning, my thoughts were swirling about how I could do this. It led me to stash my stuff in my office, find out who the math methods professor was, and head up to his office unannounced. I introduced myself and asked if he wanted to partner to model for preservice teachers how we could integrate science content into math content because elementary students deserved to learn science in school too, even though many schools stopped explicitly teaching it. After he likely got over the thought of, "Who is this lady and why is she so caffeinated," we jumped in feet first discussing how we could combine two subjects of content and what could be a starting place.

The idea of integrating content or subject areas is not new and even seems like common sense to educators in the field (Czerniak, Weber, Sandmann, & Ahern, 2010). Life is not separated into different content areas, and neither is learning. Students typically ask the question, "Will I even use this in real life?" Integration of content areas allows students to see how different content areas naturally connect and overlap as they maneuver problems at work, in their homes, and in society. Educators know and tell students this, but students fail to take teachers at face value and only believe what they experience, so educators need to provide experiences where students can see the connection of ideas and subjects.

As teacher educators we need to support our future teachers by identifying and implementing effective strategies to meaningfully and purposefully integrate mathematics and science. While we communicate the

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value of this integration, we must also model it within our classes. One of the best ways to model this integration is by combining the science and mathematics classes as they pursue a common objective.

For the past three years we have done this at our school by combining our science and mathematics methods classes in a lesson on conservation of mass that corresponds with a lesson on the volume formulas of solids. As one student commented, "Integrating science concepts like scientific method is helpful when exploring the origin of math equations and concepts. Science topics, like the conservation of mass, can also be defined and explained in math which was seen today. The other subject adds a whole new layer of depth to the understanding of the topic in another subject." The National Council of Teachers of Mathematics (NCTM) and the National Science Teaching Association (NSTA) concur with this student's observations and have demonstrated that by recent entire publications dedicated to the integration of mathematics and science (NCTM, 2024; NSTA, 2024).

It is our goal that lessons like "Play-Doh Volumes" inspire future teachers to explore science and math topics together. Beck and Park (2011) conclude that students exposed to integrative approaches such as math and science demonstrated greater achievement in STEM subjects.

When approached to consider a math/science integrated lesson I loved the idea, but, like many teachers, I wondered if I had enough scientific background to develop a lesson that would authentically integrate the two subjects. In a survey of 221 in-service and preservice teachers, Lehman (1994) reported that less than 50% felt they had sufficient knowledge to integrate mathematics and science. Working with a colleague who can provide support in the other content area is a great way to get these lessons started. Looking through my lessons I noted that I taught a lesson on finding the volume of solids that needed an opportunity for students to actively find volumes of different solids. It would also be good for students to create prisms, pyramids, cones, cylinders, and spheres, forcing them to connect the abstract attributes and definitions with actual solids. I loved the activities where you could pour water or sand from a pyramid into a prism with the same base and height to see that it takes three pyramids to equal the prism, but that didn't seem to capture an authentic scientific principle. I then recalled how students often struggle with the concept of conservation of mass when the mass changes shape. Checking with my science colleague reinforced that this was an important concept and fit well with the science standards. The lesson on Play-Doh volumes started taking shape!

Play-Doh Volumes

Objectives:

- Students will explore volume and develop the general formulas for prisms, cylinders, pyramids, cones, and spheres making models of each shape to plan and carry out their investigation.
- Students will use the volume formulas to calculate the volume of a set amount of play doh in various solid shapes – hoping to get the same volume each time.
- Students will create a claim based on evidence collected in their investigation.

Materials:

- 1 can of Play-Doh (various colors).
- 1 ruler.
- 1 set of calipers (optional).
- 1 measuring tape (optional).
- 1 worksheet packet.
- 1 set of pencils and erasers.
- 1 container or bag for storing Play-Doh.
- 1 set of hand sanitizer or soap and water access.

Play-Doh Volumes

Classroom Management and Safety Considerations:

- Clear and explicit instructions
- Model each step- there are many steps to perform in this activity
- Remind students of formulas and how to use the tools
- Monitor student performance and work
- Set the rules for Play-Doh and tool use- no eating of the Play-Doh
- Keep hands clean

Inclusivity, Grouping, and Accommodations:

- Multimodal instructions, practical examples of volume
- Interest-based grouping, knowledge or ability grouping, heterogeneous grouping across ability levels (suggested by authors)
- Scaffolds such as adaptive or digital tools, sentence starters, calculators

Related Fifth Grade Curricular Standards:

From the NGSS Science:

5-PS1-2. *Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.*

From the Common Core Math:

5.MD.C.5 *Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.*
(b.) Apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole-number edge lengths in the context of solving real world and mathematical problems.

From NGSS Crosscutting Concepts

CC.3: Scale, Proportion, and Quantity *- In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.*

From NGSS Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.

From NGSS Science and Engineering Principles

- *Developing and Using Models*
- *Planning and Carrying Out Investigations*
- *Using Mathematics and Computational Thinking*
- *Engaging in Argument from Evidence*

As this was a lesson for preservice teachers, we provided a quick overview of how to develop volume formulas for solids with students. A "bell ringer" puzzle that scaffolded the concept of finding the volume of a rectangular prism by first counting identifiable cubes, to illustrations of prisms with the grids removed, to just the quantities provided for length, width and height provided a starting point that develops the concept of volume as recommended by the common core standards (Marcy & Marcy, 1978).

We showed students prisms with different bases to note that the volume could always be found by multiplying the area of the base shape to the height of the prism. This was even extended to cylinders. Next, students observed videos where pyramids were used to fill prisms of the same base shape and height with water to note that pyramids have 1/3 the volume of a prism with the same base shape and height. This was also extended to cones being compared to cylinders. (YouTube Video #1) Finally, we watched a quick video that demonstrated how a cone and a sphere with the same radius (the cone having the height of the diameter of the sphere) could be used to show the development of the formula for the volume of a sphere. (It takes 2 of these cones to fill the sphere.) (YouTube Video #2)

Quickly supplied with these different volume formulas, students were tasked with using a set amount of playdoh to create solids of different shapes. They were then to take measurements to find the volume of each solid. Prior to engaging with the task, they were to create a hypothesis regarding what would happen to the volume as it was transformed into the different solids. (see Figure 1) Something we plan to include with future opportunities to teach this lesson is to have the students weigh each solid after it has been formed. We also plan to dive deeper into the science concept of conservation of mass and matter as a result of our claims backed by evidence and supported by reasoning.

Figure 1
With your clump of Play-Doh, create each of the given solids. Draw a diagram of each solid with the appropriate measurements and then calculate the volume of each solid.

Create a hypothesis that relates volume and the different types of solids.

My hypothesis:

_____

_____

_____

Solid	Diagram with Needed Measurements	Volume
Cube		
Triangular Prism		
Square Pyramid		

Solid	Diagram with Needed Measurements	Volume
Cylinder		
Cone		
Sphere		

5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
The law of conservation of mass states that mass can neither be created nor destroyed. The volume occupied by the matter may be changing and the density of the matter within the system may be changing, but the mass remains constant.

CLAIM-EVIDENCE-REASONING: Reflect on your hypothesis. What worked? What didn't? How would you adjust this? Make a claim backed up with evidence that you explain about volume and mass.

Figure 1. Student handout for activity.

Upon debrief at the end of the activity, students were asked to "think like a scientist" and discuss the effect of changing shapes and volume as well as conservation of mass during the changes. They then reflected on their hypothesis and made a claim backed up with evidence that explained their observations about volume and mass. Students applied the Claim, Evidence, Reasoning (CER) principle that they had frequently used after making observations and participating in a discovery activity.

Many students made solid connections between conservation of volume and matter as well as demonstrated understanding of the concepts individually. Students experienced irregularities because of measurement and concise shape creation. This led to additional observations and discussion to determine what should have happened and conclusions that should be drawn. The results of one of our students is shared (see Figure 2). Note how she effectively provided several representations of her volumes (both in pictures and through symbolic representations), she looked for regularity in her data, and she drew a conclusion based on her original hypothesis.

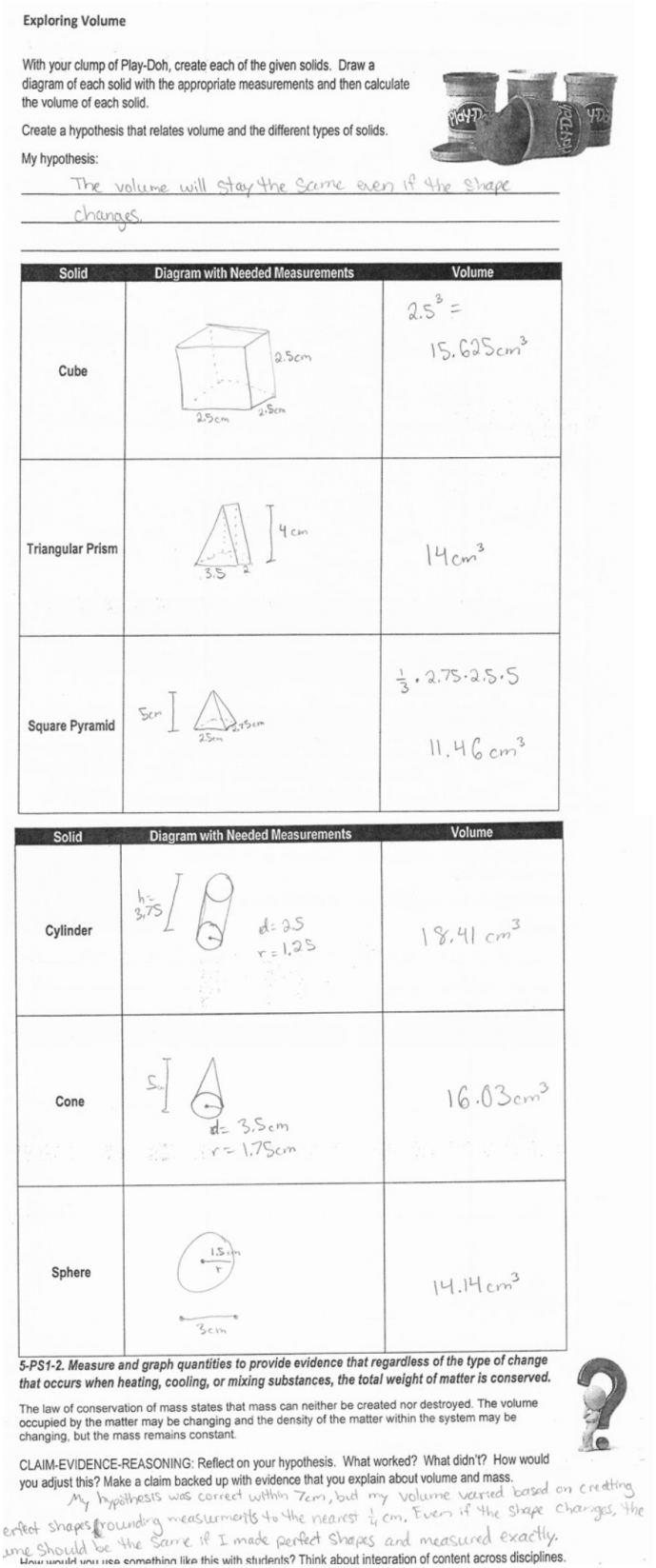

Figure 2. Sample of student observations and data.

We followed the activity by getting survey responses from the preservice teachers regarding how they might integrate content across disciplines and how authentically math and science were connected in the Play-Doh volume lessons. All the students who responded (n=29) stated that the concepts were moderately or very well connected. One student shared,

"In my future teaching, I would like to also integrate the subjects of science and math because they go hand-in-hand so well, with minimal extra effort on the teacher's part. I can see myself creating projects for my students that integrate many domains of learning into a culminating piece. This allows students to see more purpose and value in their learning because application is present in the classroom, not just a faraway potential."

Another student stated, "I would love to integrate subjects as much as I can. … Science really helps to bring math alive especially when doing lots of measurements and experiments."

While we did not use a rubric to grade these responses and simply used it as a formative in-class activity, a rubric like the one below could be used to score preservice teachers or fifth-grade students (OpenAI, 2024). (See figure 3)

Rubric for Play-Doh Volume Assignment

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)	Points
Hypothesis	Clearly stated, relevant, and testable hypothesis.	Clearly stated but somewhat general hypothesis.	Hypothesis is unclear or partially irrelevant.	Hypothesis is missing or completely irrelevant.	
Diagrams and Measurements	Diagrams are accurate, detailed, and correctly labeled with appropriate measurements.	Diagrams are mostly accurate with minor errors in detail or labeling.	Diagrams are somewhat accurate but lack detail or correct labeling.	Diagrams are inaccurate or missing, with incorrect or missing measurements.	
Volume Calculations	Volume calculations are accurate and correctly shown for all solids.	Volume calculations are mostly accurate with minor errors in calculation.	Volume calculations have several errors or are incomplete.	Volume calculations are incorrect or missing.	
Application of Law of Conservation of Mass	Clearly demonstrates understanding of the law with accurate reasoning in reflection.	Shows understanding of the law with mostly accurate reasoning.	Shows partial understanding of the law with some reasoning errors.	Shows little to no understanding of the law with incorrect or missing reasoning.	
Claim-Evidence-Reasoning	Claim is clearly stated, evidence is relevant and well-explained, reasoning is logical and thorough.	Claim is clear, evidence is mostly relevant and explained, reasoning is generally logical.	Claim is somewhat clear, evidence is partially relevant, reasoning is somewhat logical.	Claim is unclear, evidence is irrelevant or missing, reasoning is flawed or missing.	
Neatness and Organization	Work is neat, well-organized, and easy to follow.	Work is mostly neat and organized with minor issues.	Work is somewhat organized but may be difficult to follow.	Work is disorganized and difficult to follow.	

Total Points: _____ / 24

Additional Comments:

- **Strengths:**
- **Areas for Improvement:**

Figure 3. Rubric for assessing responses

Conclusion

Whether you are teaching preservice teachers or a teacher in the classroom P-12, integration across disciplines and within content areas allows students to make authentic connections to real world learning. Czerniak, Weber, Sandmann, & Ahern (2010) recommend that preservice teachers receive instruction on the integration of mathematics and science and experience the teaming process of content with experienced teachers. While this advice focuses on preservice educators, the same advice can still be applied to current classroom teachers.

Take a risk and partner with an experienced teacher in science or mathematics and put together one lesson that seems to make sense. This is exactly what we did, and we saw great success with students. Had we taught this lesson to fifth grade, we predict we would have achieved great success in the classroom as well. In fact, many preservice teachers, our students who will be out in the classroom within a year, stated that they would likely use this exact lesson with their students.

The hands-on element of this lesson also allowed students to experience different solids, the measurements associated with volume, and exploration of a hypothesis. This solidifies the mathematical and scientific concepts for their learning. In the follow up survey one student commented, "[Integrating subjects] shows how to apply learning to life … that life is not divided into subjects. We use the knowledge from ALL the different subjects to work together in our lives." We never want even a hint that science is lacking in the curriculum. If we need to sneak it in, mathematics seems like a natural path.

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