HIGH SCHOOL STUDENTS IN VIETNAM APPLY SCIENTIFIC METHOD TO SOLVE PROBLEM USED IN STEM EDUCATION

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Abstract Scientific method is one of the problem – solving approaches used in STEM education. Based on literature reviews on scientific method, this study presents 30 tenth-grade students of high school in Vietnam completed a scientific research-based problem on fabricating soaps involving integrated STEM learning. Students employed six – step of the scientific method and STEM disciplinary knowledge to make an observation, ask a question, form a hypothesis, make a plan and conduct an experiment, analyze the data and draw conclusions, and share result.

Keywords: *STEM education, scientific method, fabricate soaps, problem – solving approaches*

1. Introduction

Problem solving is an important 21st skill and knowing how to solve problems is also crucial. There are many ways to solve problems including scientific method.

The scientific method can be a useful tool for introducing students to the problem-solving nature of science. Although many scientists and science educators might argue that the scientific method is too simplistic in its approach to scientific inquiry [6] and older students may not need such a structured approach to solving scientific problems, middle school and elementary students may benefit from a structured, step-by step approach [13]. In despite of knowledge generated by the scientific method is not infallible, its stepwise process helps generate new knowledge and theories [11].

The scientific method is as a stepwise, circular approach to solving problems [11]. As an outline is a guide for writing a paper, the scientific method is a guide to solving a problem. As mentioned above, this is particularly important for younger students, who may benefit from learning the basic principles of science before they move on to more innovative, creative approaches. Another important factor is the value of the scientific planning process and experience itself. According to Harlen, children learn by planning for themselves, not by following plans developed by others [4].

Students often leave out the important step of addressing research. They should understand that background research should be completed before formulating a hypothesis, and that the seeking of information is an essential part of the scientific research process [3].

Science uses Scientific Inquiry to explore the natural word. Scientific Inquiry is the ways in which scientists study the natural world and propose explanations based on the evidence obtained from their work. Science often uses the Scientific Method to study the natural world. The Scientific Method is a way to ask and answer scientific questions by making observations and doing experiments. Scientists study how nature works and use the scientific method as a framework for performing experiments. To test whether an observation is true, they ask questions and develop experiments to try and answer that question.

In the previous article, we presented about the definition of STEM and how students solve problems through the Engineering design process [9]. Along with the Engineering design process, the Scientific method is one of the problem – solving approaches used in STEM education. This study presents 30 tenth-grade students of high school in Vietnam completed a scientific research-based problem on fabricating soaps involving integrated STEM learning.

2. Content

2.1. Literature Reviews on Scientific Method

The scientific method was first introduced to American science education in the late 19th century, as an emphasis on formalistic laboratory methods leading to scientific facts [7], [12]. It evolved toward a cognitive prescription after Dewey summarized his analysis of reflective thinking into a five-step complete act of thoughts [2]. While Dewey's articulation was responsive to context and dynamic in nature, his theory was decontextualized, reconstructed, and integrated into school science as the only safe method, under pressure of increasing high school enrollment and criticism of an over emphasis on laboratory method [12].

The appeal of an established, decontextualized, well-articulated scientific method was obvious. It made doing science an easy reform to carry out; instructions for students needed minimal changes to incorporate the prescribed set of ordered steps. Overtime, it became common for science educators and curriculum developers to break down the process of science into steps (or stages) and design inquiry models centering on them [12]. Many such models emerged, such as Strong Inference [10], Experiential Learning Cycle [8].

Although differing in details, these models shared the assumption that scientific processes could be stripped from the content being investigated and summarized into a regular account. Critics of such extraction of the scientific method have argued that scientific investigation can take various routes [1] and that decontextualized accounts overlook the guiding role and interpretive nature of scientific theory [7]. Arguing in particular against the common teaching practice of representing scientific processes as discrete steps, Windschitl (2004) emphasizes that such accounts fail to address show multiple steps are often considered in relation to one another at the outset of the investigation [14]. Studies of practicing scientists also highlight, among other aspects of practice, the dynamic and social nature of how science activity typically unfolds.

In response, some proponents of scientific method have emphasized that the steps are not rigid and do not follow a fixed order. Even these more nuanced step-based accounts of scientific processes, when formalized for school curricula, risk getting filtered and distorted into rigid steps, as illustrated by what happened to Dewey's contextualized and flexible acts of thought. Although such accounts of the scientific method are still subject to criticism, our paper does not enter into this philosophical debate. We focus instead on how the scientific method is represented in high school classrooms, the effects of these rigid step-based accounts on student inquiry, and teacher perceptions thereof. In our study, the scientific method denotes step-based, decontextualized accounts of scientific process as formalized in secondary school curricula, instruction, and assessment [12].

2.2. Scientific method process

When conducting research, scientists use the scientific method to collect measurable, empirical evidence in an experiment related to a hypothesis (often in the form of an if/then statement), the results aiming to support or contradict a theory.

The Scientific method is a systematic way of learning about the world around us and answering questions. The key difference between the scientific method and other ways of acquiring knowledge are forming a hypothesis and then testing it with an experiment. The Scientific method and the Engineering design process follow each other and form a cycle of scientific and technological innovation in the "spiral" model. After each cycle, the amount of scientific knowledge increases and with it the technology develops at a higher level.

Though different in content, the iterative quality of and steps involved in the scientific method and the engineering design process are largely similar. In fact, engineers often require the scientific method to provide proof of the quality and functionality of their designed product. The graphic below shows how both the scientific method and engineering design process originate with a question and are then followed by research that is used to generate a hypothesis. Scientists test hypotheses by conducting experiments, while engineers test hypotheses by building things. But both scientists and engineers collect data, analyze their data, and then refine their question or product. Educators do not need to teach STEM content and processes in isolation or approach them as disparate topics. Integrating technology and engineering into science content merges the best of these worlds and prepares students for the interdisciplinary challenges of the real world [5]. See figure 2.1.

In general, The Scientific Method includes 6 steps:

Step 1: Make an Observation

Almost all scientific inquiry begins with an observation that piques curiosity or raises a question. Make careful observations and write down what happens.

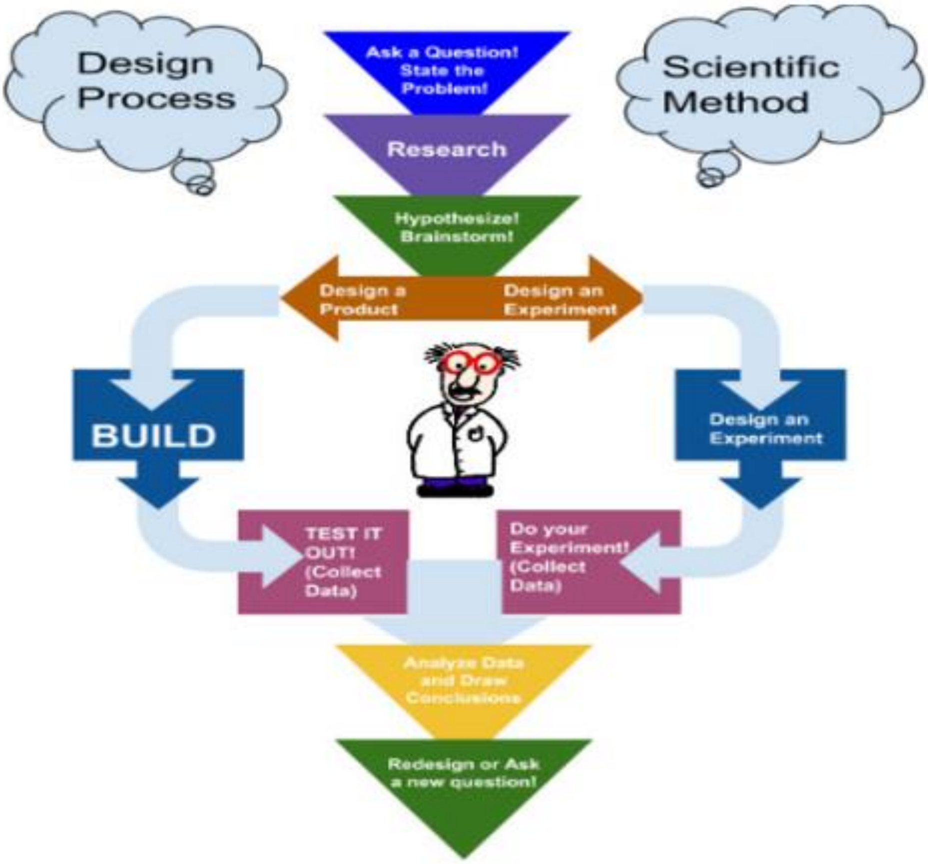


Figure 2.1. Relation between Scientific method and Engineering Design Process

Step 2: Ask a Question

The purpose of the question is to narrow the focus of the inquiry, to identify the problem in specific terms. Ask yourself, “What do I want to learn more about?” or “I wonder what would happen if…?” Coming up with scientific questions isn't difficult and doesn't require training as a scientist. If you've ever been curious about something, if you've ever wanted to know what caused something to happen, then you've probably already asked a question that could launch a scientific investigation.

Step 3: Form a Hypothesis

The great thing about a question is that it yearns for an answer, and the next step in the scientific method is to suggest a possible answer in the form of a **hypothesis**. A hypothesis is often defined as an educated guess because it is almost always informed by what you already know about a topic. Research to help you make an educated guess, or hypothesis, and then answer your question. Notice that there are two important qualities about a hypothesis expressed as an "if … then" statement. First, it is testable; an experiment could be set up to test the validity of the statement. Second, it is falsifiable; an experiment could be devised that might reveal that such an idea is not true. If these two qualities are not met, then the question being asked cannot be addressed using the scientific method.

Step 4: Make a plan and Conduct an Experiment

Test your hypothesis by making a plan and conducting an experiment. Many people think of an experiment as something that takes place in a lab. While this can be true, experiments don't have to involve laboratory workbenches, Bunsen burners or test tubes. They do, however, have to be set up to test a specific hypothesis and they must be controlled. Controlling an experiment means controlling all of the variables so that only a single variable is studied. The independent variable is the one that's controlled and manipulated by the experimenter, whereas the dependent variable is not.

Step 5: Analyze Data and Draw a Conclusion

During an experiment, scientists collect both quantitative and qualitative data. Use your information to draw conclusions about your experiment. Was your hypothesis correct? Buried in that information, hopefully, is evidence to support or reject the hypothesis. The amount of analysis required to come to a satisfactory conclusion can vary tremendously.

Step 6: Share results

Explain your results by presenting your experiment, observations, and conclusions.

2.3. High school students in Vietnam completed a scientific research-based problem on fabricating soaps

Objectives

At the end of this lesson, students will be able to:

1. Work in groups
2. Make observations and collect data
3. Graph data
4. Draw a conclusion
5. Present results to class

Situation: Soap is very important to modern life. Soaps allow us to keep clean and remove dirt from our body. Soaps save lives by stopping the spread of harmful bacteria in dirt. Soap is an emulsifier meaning it allows water and oil to mix. This allows it to remove dirt, making it a useful aid in maintaining good health every day. Nevertheless, whether the soap sold in the market is good for our health or not?

Make observations

Ask students to make an observation of soap products on supermarket, grocery stores, mall, Retail store, etc. it is commonly that it will be commercially made and not natural. These cleansers may be labeled as – body washes, body soaps, deodorant bars and beauty bars and are largely made up of detergent, hidden in a cocktail of surfactants. The artificial ingredients are petroleum-based and warp as they undergo chemical changes in factories. The correct term for commercial soaps is that they’re not made, but rather “manufactured” using high energy processes and various artificial cleaning agents. These are just chemical cocktails made of detergents and downright disturbing synthetic ingredients that dehydrate and age skin, cause allergic reactions and have been linked to various forms of cancer.

Ask a question

Can handmade soaps cleans skin from natural ingredients like coffee, turmeric, matcha green tea, coconut oil, olive oil, etc. to overcome the disadvantages of commercial soap?

Form a hypothesis

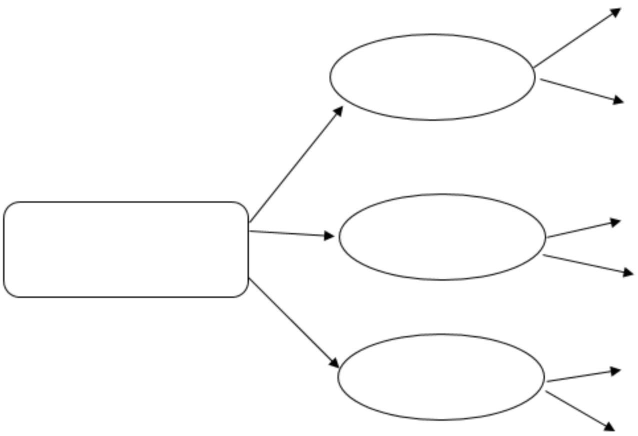
Can make handmade soap a safe and gentle product perfect for the skin

Make a plan and Conduct Experiments

Break up into groups. 10 students for a group

Make a plan

Initial ideas



Disciplinary areas: STEM

Science	
Saponification reaction	***Mathematics***
How does soap work	calculate a valid ratio of the compounds such as oil,
The effect of soap on bacteria	water, lye for the making of soap with suitable pH
Technology	value
Handmade soap bars	***Engineering***
Access the internet to find out relevant information	Make handmade soap bars

Assign tasks to members

Numerical order	Name	Task	Instrument	Completion time	Expected product	Self assessment	Evaluation team
1							
2							
3							
4							
5							

+ Investigate information from the internet, from shops, supermarkets, etc. Then make a reportage film.

+ Search information on how to create handmade soap and present the application of that soap.

+ Prepare the report

+ Set up time to implement and estimate costs

Materials: See figure 2.2 and 2.3

Coconut oil

Lye – called 100% sodium hydroxide

Cool water – use distilled or purified

Olive oil

Spice: coffee grounds, turmeric, green tea, lemongrass (each spice for a group)

Cake mold

Conduct experiments

Cover your work area with newspaper. Put your gloves and other protective wear on. Measure your water into the quart canning jar. Have a spoon ready. Measure your lye. Slowly pour the lye into the water, stirring as you go. Stand back while you stir to avoid the fumes. When the water starts to clear, you can allow it to sit while you move to the next step showed as figure 2.3 and figure 2.4.

In the pint jar, add your three oils together. They should just make a pint. Heat in a microwave for about a minute, or place the jar of oils in a pan of water to heat. Check the temperature of your oils – it should be about 120° or so. Your lye should have come down by then to about 120°.*This is critical for soap making.* Too low and it'll come together quickly, but be coarse and crumbly presented as figure 2.5.

When both the lye and oils are at the right temperature, pour the oils into a mixing bowl. Slowly add the lye, stirring until it's all mixed. Stir by hand for a full 5 minutes. It's very important to get as much of the lye in contact with as much of the soap as possible. After about 5 minutes, you can keep stirring or you can use an immersion blender. The soap mixture will lighten in color and become thick. When it looks like vanilla pudding it's at "trace" and you're good to go. See figure 2.6

Add your herbs, essential oils or other additions at this point. Stir thoroughly to combine. Pour the mixture into molds and cover with plastic wrap. Set in an old towel and wrap it up. This will keep the residual heat in and start the saponification process.

Saponification is the process of the base ingredients becoming soap illustrated as figure 2.7.

After 24 hours, check your soap. If it's still warm or soft, allow it to sit another 12-24 hours. When it's cold and firm, turn it out onto a piece of parchment paper or baking rack. If using a loaf pan as your mold, cut into bars at this point. Allow soap to cure for 4 weeks or so. Be sure to turn it over once a week to expose all the sides to air. When your soap is fully cured, wrap it in wax paper or keep it in an airtight container. Handmade soap creates its own glycerin, which is a humectant, pulling moisture from the air. It should be wrapped to keep it from attracting dust and debris with the moisture.

Analyze Data and Draw a Conclusion

Coffee grounds used as an ingredient for natural handmade soaps provide numerous skin benefits. It works as a natural deodorizer and as mentioned, it can exfoliate dead skin cells just as you use regular coffee grounds with other ingredients. Hence, when used as soap, it can make your skin glowing, smooth, and odor free.

Finely ground organic Matcha tea leaves act as a gentle exfoliant to give your skin a healthy glow. Green Tea, a mild astringent, has been used for centuries to cleanse, tone and purify the skin.

The lemongrass soap is made with high-quality lemongrass essential oil inhibits microbial and bacteria growth on the body, keeping you clean and healthier. It promotes toned skin, and helps purify the skin.

Fig. 2.2. coffee grounds, turmeric, green tea, food colors, pH papers, concentrated NaOH

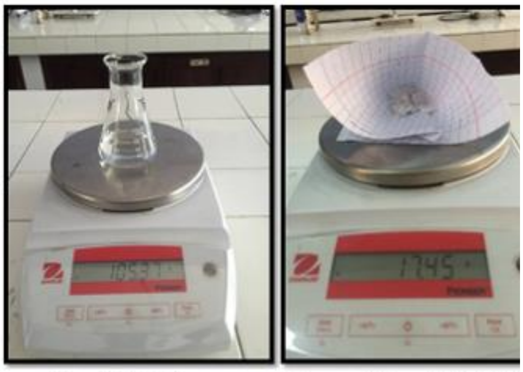


Fig. 2.3. Measure water and lye (NaOH)

Fig. 2.4. Slowly pour the lye into the water

Fig. 2.5. Place the bowl of oils in a pan of water to heat

Fig. 2.6. Slowly add the lye, stirring until it's all mixed

Fig. 2.7. Add herbs: turmeric, coffee grounds, green tea

Fig. 2.8. handmade soaps

Fig. 2.9. lemongrass handmade soaps

Fig. 2.10. coffee handmade soaps

Fig. 2.11. Green tea handmade soaps

Share result

The Hypothesis is Supported. See figure 2.8, figure 2.9, figure 2.10 and figure 2.11.

3. Conclusion

We have organized for 30 K-10 students in Vietnam to apply the Scientific method to a specific project. That is study and make soaps from natural materials help protect humans healthy. Obtained results: (1) Students participated actively in activities. (2) Students actively make an observation, ask a question, form a hypothesis, make a plan and conduct an experiment, share result appropriately and effectively. (3) Students developed much competencies in the 21st century. We value the mentality, attitudes and experiential products of our students. Hence, Scientific method-based problems, have the potential to foster this learning in young students

Acknowledgements

The authors would like to thank the leaders, teachers and students of Hai Ba Trung High School, Thuan Hoa High School, Thua Thien Hue Province, Vietnam for the supports given to this work.

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