

17 June 2017

Dear HESS editor and staff,

On behalf of my coauthors, I would like to thank you for the opportunity to respond to the reviewer comments on our manuscript entitled, “Every Apple Has a Voice: Using Stable Isotopes to Teach About Food Sourcing and the Hydrologic Cycle.” We also thank the reviewers for their thoughtful evaluation and comments. They bring up several key issues and points where more detail, clarification and discussion will improve the manuscript.

Below I outline our responses (in red) to each reviewer comment:

Reviewer #1 (Sally Male):

This manuscript describes a novel approach to teach school students, school teachers, and university science students about isotope hydrology and the water cycle. The laboratory exercise developed for this teaching purpose has great promise as an interesting and relevant teaching exercise, being a forensic exercise about the origins of food - a topic of obvious relevance to everyone.

COMMENT: There is confusion in the manuscript, arising from insufficient clarity about three separate purposes of the study and the manuscript. You have: (1) developed modules to teach about isotope hydrology and the water cycle (2) including developing a laboratory exercise with the research question on page 5, lines 21-23 ‘Can we use the stable isotopes of hydrogen and oxygen in water as ‘fingerprints’ to determine where fruits and vegetables come from?’, and (3) evaluating the efficacy of the learning modules. A clear statement to address the following questions would have helped me.

Are all three of the above purposes original and equally central to the manuscript?

RESPONSE: This suggestion to clarify the general scope and aims of the paper and the learning exercise is a good one, and we will do so in the Introduction and Overview of Teaching Activities section (3.1), and add discussion in the Synthesis of Concepts section (4.2) and Participant feedback section (4.5).

COMMENT: Is the laboratory exercise novel, or only its use as a teaching tool?

RESPONSE: The laboratory exercise itself is novel, as this is the first application of membrane-inlet laser spectroscopy to measure fruit water isotopes in situ. Following that, its use as a teaching tool is also novel, as we do not know of another instance of this measurement system’s use in teaching. We will change the language in this section to be specific about what we are claiming is novel and discuss why.

COMMENT: Similarly, it was perhaps not clear to the participants whether the main learning was about isotope hydrology or the water cycle. This would explain the participants’ divided opinions about what should go on their posters.

**RESPONSE:** This is a good point, and may well explain the divergence in poster content at the end of the exercise. We will add some discussion of the notion that there are several main aspects of the lesson content, and that each is an important part of the whole. This relates to the prior comment about making the goals of the lesson (and this manuscript) more apparent.

**COMMENT:** My research experience is in higher education rather than isotope hydrology, and therefore my specific comments relate to these aspects of the manuscript, although much of the manuscript is about (1) and (2) above.

The design of the modules is sensible. The learning activities are consistent with the learning outcomes, and scaffolded by a presentation and demonstration.

Further detail about the data collection to evaluate the modules is necessary.

**RESPONSE:** We will add more detail and description of the evaluation activities to section 3.4.

**COMMENT:** A table summarising demographic data about the participants should be added.

**RESPONSE:** We will add a table as suggested to section 3.1.

**COMMENT:** Early in the manuscript you report using participant feedback surveys. However on line 13 of page 11 we learn of 'informal, qualitative participant feedback'. Please explain what is meant by this. Is this the feedback surveys?

**RESPONSE:** Yes, these were the feedback surveys as well as student feedback throughout the activities. We will add details about these surveys and the results to Section 4.5.

**COMMENT:** Page 2, line 1: What is meant by 'engagement'? This sentence does not make sense.

**RESPONSE:** This line will be revised to clarify.

**COMMENT:** Page 2, line 9: I suggest a new paragraph here. The first 8 lines are about how important the topic is. The following lines are about to difficult it is to teach.

**RESPONSE:** We will follow this suggestion and start a new paragraph at this point.

**COMMENT:** Page 3, line 1: Please explain the United States Next Generation Science Standards, especially for readers outside the US.

**RESPONSE:** Yes, of course this is a good suggestion and we will add explanatory detail on the standards.

**COMMENT:** Page 4, lines 27,28: This sentence is half in the past tense and half in the present.

**RESPONSE:** This sentence will be corrected.

**COMMENT:** Page 6, lines 14 and 15 discuss a 'stumbling point'. On what basis is this

considered a stumbling point? It would be sensible to describe later in the manuscript what evidence you collected for how well your participants did or did not overcome this point.

RESPONSE: We cite Orton and Forbisher (2004) as evidence that these aspects are common issues for students to overcome. Additionally, in working with the students in this exercise, there was feedback that the students did indeed have difficulty understanding the concept of stable isotope values as a ratio of ratios, as well as how to interpret values that are lower (“more negative”) or higher (“less negative”). We will incorporate discussion of this feedback into Section 4.2 and 4.5. This will also contribute to addressing the issue with “informal, qualitative feedback” that this reviewer also pointed out (see above).

COMMENT: Page 12, lines 11 and 12: Do you believe that the study was limited because you did not track individuals? What would you recommend for future research?

RESPONSE: I think this comment refers to Page 8, Lines 11 and 12. I don't think tracking individuals would add significantly to the evaluation of the effectiveness of the teaching activities, especially in the context of a one day session. However, this section could benefit from additional detail and further discussion later in Section 4.4, which we will add. We could also add some discussion of what we could improve in future iterations, as well as some discussion of what further research avenues our results suggest would be worthwhile to pursue. If these activities were expanded beyond a one day exercise, then tracking individual participants could be beneficial.

COMMENT: Page 10, line 18 refers to 'newly-learned vocabulary terms [used] in nonsensical ways'. Line 19 refers to this as a 'strategy'. Are you sure this is a strategy and not a mistake? Lines 20, 21 state that 'This outcomes implies that the instructor or discussion leader should focus on core concepts over details or implications'. On what basis do you make this conclusion? I would conclude rather that the students need more experience hearing, reading, and using the new concepts and terms. Threshold concept theory explains that when students develop understanding of troublesome concepts they start to speak like someone in the discipline. These students have not yet achieved this.

RESPONSE: This is very useful input, and we appreciate the reviewer's thoughts on different interpretations of this observation. We were not familiar with Threshold Concept Theory, and we thank the reviewer for pointing this out to us. We will include some discussion of alternative interpretations.

COMMENT: In section 4.4. mean test results are reported. Please describe the test scale. What does a mean of 2.6 indicate? Please give some examples of the test questions? Are they multiple choice, open, calculations,...?

RESPONSE: We will add details of the test questions and how they were scored, perhaps in another table, or by modifying Table 2.

COMMENT: Page 10, line 30: How do you know the lecture and demos were received uniformly well?

**RESPONSE:** This sentence is vague and will be clarified and substantiated.

**COMMENT:** Overall, the initiative is exciting and could inspire many extensions. I suggest considering future possibilities for expanding the teaching modules. Beyond identifying the origins of food, students could design improvements to current practices. For example, students might consider the distances that food is transported and whether these distances could be shortened.

**RESPONSE:** We will incorporate some discussion of potential extensions of the teaching activities, as suggested.

Reviewer #2:

General Comment: This was a really interesting approach to teaching about stable isotopes and the water cycle. The exercises and supplemental materials were sufficiently detailed and of high quality and I would consider using some of the prepared slides myself if they were available. I tried to be more critical than I am below considering that I took longer than I should have to complete this review. With that being said, I only have some minor comments that I hope are helpful to the authors.

Specific Comments:

COMMENT: The authors write that the exercise is designed to promote "experiential learning" (page 7, line 11), and I'm curious about the motivation the students and teachers had to complete the exercises. Based on my reading of the literature, this is not experiential learning, and I would be interested to see some citations or some elaboration on why the authors think it is. Beyond that, it would be informative to know how motivated the students and teachers were to engage in the exercise. After all, as you stated, the origin of fruits and vegetables is often indicated in the grocery store, and the isotope method does not necessarily yield a single result. In fact, the underlying question is whether or not isotopes create a "fingerprint" of origin (page 7, lines 5-6), but the answers will often be inconclusive (page 9, lines 22-27). I would caution against overselling this as experiential learning, and would suggest that this otherwise well-designed exercise could use a better framing for student engagement. For example, the isotopic fingerprint could be a method for revealing dishonest labeling practices (perhaps unscrupulous tomato vendors at a farmer's market).

RESPONSE: We will reevaluate our assessment of these activities as experiential learning by exploring the relevant literature. We will also elaborate on the student's reactions to the research outcomes, in our discussion of student feedback. We do emphasize in the manuscript that the non-unique geographical solution is an important aspect, as the results are not a "Silver Bullet", as is often the case in real research. We do take the suggestion that different aspects of the results and different applications could be more interesting and effective, and we will incorporate discussion of this in the section that will pertain to future improvements and extensions (as also suggested by Reviewer #1).

COMMENT: On page 2, line 20, it states that revealing the geographic origin through isotope analysis makes "the distance to the point of purchase and consumption becomes more apparent." I don't know what is meant by this. Is it more apparent than looking up the origin on the sticker and then looking at a map?

RESPONSE: Yes, the fruits we selected to test were all labelled with origin, but many fruits in other stores are not. Yes, comparing the fruit labels to a map would provide a similar first-order result. A main point to these activities is to have the students discover something they didn't know previously, through their own research. This is a central concept in science, and is more thrilling than reading a label. A goal in these activities is to capture student interest and attention in a way that will be more memorable than reading a label. However, we take the suggestion to clarify these goals and our rationale for designing the activities as we did, and will include discussion of these aspects in the introduction to frame the study's goals better.

COMMENT: Also, in the same paragraph (line 23), what is the magnitude of the water flux via “trucks and trains” relative to other fluxes?

RESPONSE: We will develop quantitative estimates of these fluxes and include them in the revision.

COMMENT: After reading the title, I thought this would be more focused on apples than it was. For example, Figure 2 is a tomato, Figs. 3 has data for oranges, apricots, bananas and tomatoes. Fig. 5 if about the geographic origin of a tomato. Apples only appear in Table 1. The title seems like a bit of false advertising.

RESPONSE: We respectfully disagree, and assert that the running lead of a compound title is often short and memorable, while the subtitle provides more detail in support. “Every Tomato Has a Voice,” just doesn’t have the same memorability as “Every Apple Has a Voice,” though this may be a cultural difference. Besides, we do include data for two separate sets of apple samples. We decline to change the title, though if the Editor feels strongly about this issue, we may reconsider.

Technical Corrections:

COMMENT: The MWL line in Fig. 1 should be labeled as GMWL because that’s how you refer to it throughout the manuscript. In Fig. 3 it’s labeled as the “Global Meteoric Water Line” and in Fig. 4 it’s labeled as the GMWL. You should be consistent. Even in the legend of Fig. 1, you use both MWL and GMWL to refer to the same line.

RESPONSE: This is indeed inconsistent and will be changed as suggested.

COMMENT: The sentence on line 23-25 of page 3 is an incomplete sentence.

RESPONSE: This sentence will be corrected.

COMMENT: So is this one on page 4 “These  $\delta^{2}\text{H}_{\text{vap}}$  and  $\delta^{18}\text{O}_{\text{vap}}$  values were then plotted in  $\delta^{2}\text{H}$  and  $\delta^{18}\text{O}$  space and fitting a least-squares regression line through the fruit water  $\delta^{2}\text{H}_{\text{liq}}$  and  $\delta^{18}\text{O}_{\text{liq}}$  values (Figure 4).”

RESPONSE: This sentence will be corrected.

COMMENT: page 4, line 13: delete the second "method" page 4, line 31: delete the "it" prior to C2 "the GMWL" page 6, line 11: it may not be "intuitive" to many that heavier molecules will evaporate less easily page 10, line 9-10: that last sentence is poorly phrased or incomplete. Is there a phrase missing after "largely"?

RESPONSE: These changes and clarifications will be made.