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An Online Interactive Activity to Support Student Learning About Balancing Chemical Equations

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01. Introduction

A positive impact on learning outcomes through the implementation of active learning strategies has been observed, particularly in the STEM classroom (Freeman et al. 2014; Clark 2023; Beichner et al. 2007; Gaffney et al. 2008; Strelan, Osborn, and Palmer 2020; Weir et al. 2019). Evidence also suggests that students can better retain information and understand concepts when presented with information via multiple delivery modes rather than relying on words alone (Mayer 2003; Schnotz and Banners 2003).

According to the Universal Design for Learning framework, there is also a learning benefit when students are provided with various ways to receive and process information (Meyer, Rose, and Gordon 2014; Behling and Tobin 2018). To incorporate active learning and Universal Design for Learning in my classroom, I created an online, interactive activity to offer students an engaging and effective learning experience on balancing chemical equations.

Balancing chemical equations involves the application of the law of conservation of mass, which states that matter cannot be created or destroyed. Particularly for non-science majors, balancing chemical equations can be challenging because it requires analyzing molecular formulas and using ratios. This study aimed to assess the impact of this activity on student learning outcomes in two introductory chemistry courses.

02. Objective

To evaluate the impact of this online, interactive activity on student learning outcomes related to balancing chemical equations, student perceptions of the activity were also assessed

03. Acknowledgments

Heather Caprette, Senior Media Developer and Senior Instructional Designer at Cleveland State University, for the suggestion to use Articulate Storyline and her guidance in integrating this activity into the University's Learning Management System

04. Activity Design

This learning station activity consisted of two main components: the "input" stations where students received new information and "output" stations where students demonstrated their learning. This structure is based on the station labs developed by Kesler Science (Kesler).

Input Stations
- Read It
- Watch It
- Research It
- Explore It

Output Stations
- Write It
- Organize It
- Illustrate It
- Assess It

The first iteration of this activity was created using Google Forms and Google Slides. Students struggled to keep track of their progress through these activities, therefore the activity was adapted to Articulate Storyline so students could easily track their progress and receive timely feedback on each activity.

Activity Learning Objectives
- Label the parts of a chemical reaction
- Apply the Law of Conservation of Matter to balance chemical equations

IRB Approval: IRB-FY2024-50

	Survey Responses
CHM 151 Fall	25
CHM 151 Spring	53
CHM 251 Fall	91
Total	**169**

05. Try Out the Activity!

https://storage.googleapis.com/balancing_chemical_equations_learning_activity/
Balancing%20Chemical%20Equations%20FINAL%20Web/story.html

06. Experimental Approach

Introductory chemistry courses CHM 151 (non-majors) and CHM 251 (pre-nursing majors) in the Fall 2023 and Spring 2024 completed a pre-test (7 questions), the learning activity, a post-test (7 - 10 questions), and a survey about their perceptions of the activity.

	# enrolled	# pre-test	# activity	# post-test	complete data
CHM 151 Fall	48	38	43	45	31
CHM 151 Spring	59	48	53	57	43
CHM 251 Fall	127	115	102	120	94

07. Results

Figure 1. Pre-test and post-test results for CHM 151 (Fall and Spring) and CHM 251. Statistical significance was determined using a two-tailed *t*-test; *** = $p < 0.001$.

Figure 2. Percent growth for each student (each dot is 1 student), calculated by (% pre-test - % post-test) / (100 - % pre-test) x 100. 84% of all students demonstrated growth on the post-test

Student Comments About This Activity
- It was very interactive and distilled the concepts into an easy-to-learn format
- It helped me stay engaged and focused
- I liked that there were different activities, so if you were not understanding one part, another might help you
- I was able to work at my own pace
- It helped a lot to be able to visualize the equations and helped it not be so overwhelming
- The different activities held my attention and I liked the instant feedback

08. Conclusions

- Student feedback from iteration 1 requested a way to track progress on the activity and better individual feedback
- 84% of all students demonstrated growth between the pre-test and post-test
- Statistically significant improvement was observed for each class between the pre-test and the post-test
- >78% of students rated the activity positively in each of the 6 survey questions
- Student feedback from the articulate storyline format was more positive than feedback for iteration 1
- Student written feedback was generally positive, appreciating the varied format and individual feedback

09. Future Directions

- Compare the efficacy of the activity based on student demographics (e.g. race and/or gender)
- Compare the efficacy of the activity completed online vs on paper where students physically move about the classroom to engage with each activity

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13. Weir, Laura K., Megan K. Barker, Lisa M. McDonnell, Natalie G. Schimpf, Tamara M. Rodela, and Patricia M. Schulte. 2019. "Small Changes, Big Gains: A Curriculum-Wide Study of Teaching Practices and Student Learning in Undergraduate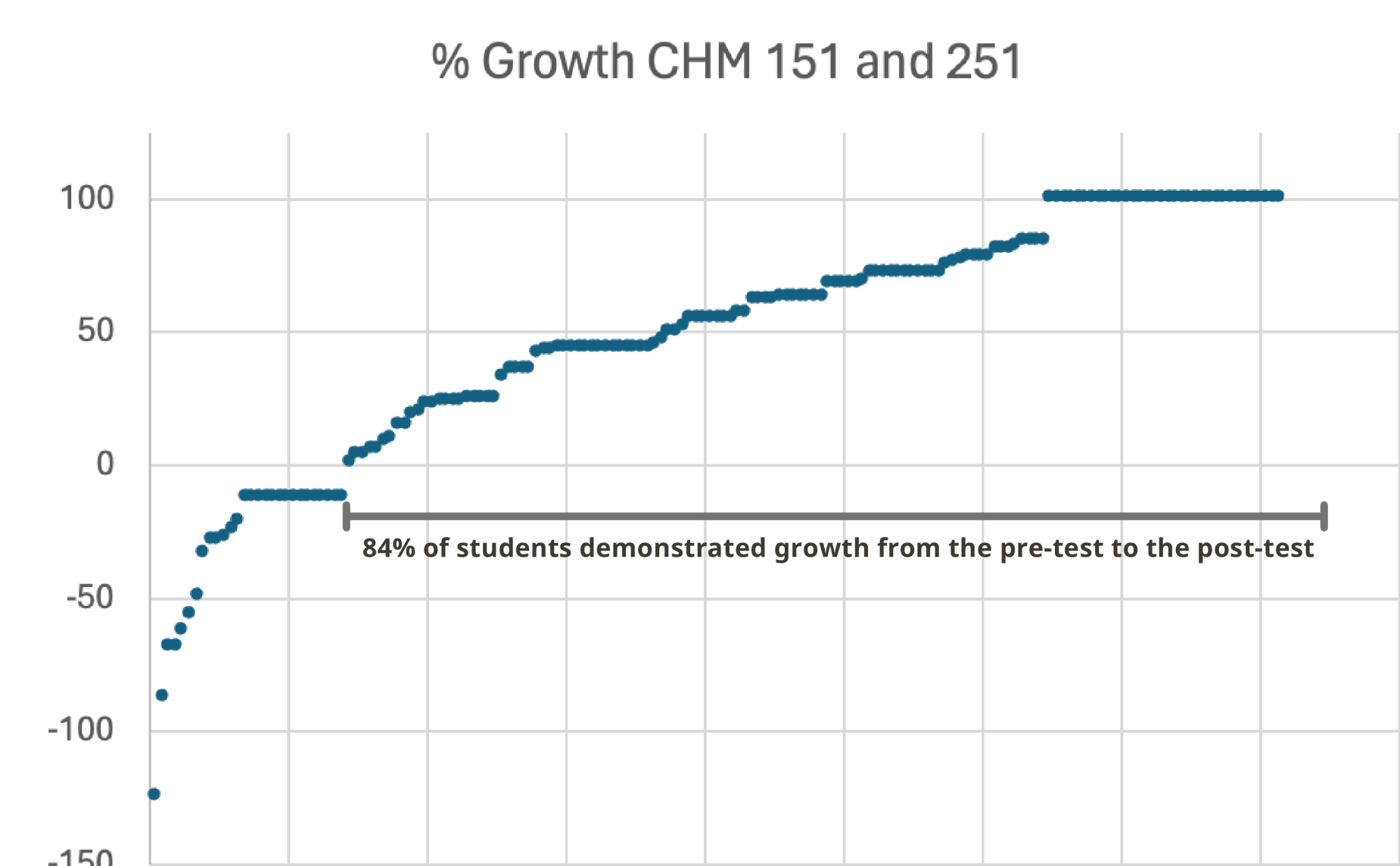 Biology." PLOS ONE 14 (8): e0220900. https://doi.org/10.1371/journal.pone.0220900.