Does Productive Struggle and Inquiry Help with Student Engagement and Motivation?

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Introduction

The **Milwaukee Master Teacher Partnership Program (MMTP**) is an NSF funded (Awards 1540840 and 1557397) collaborative project between the Milwaukee Public School District and the University of Wisconsin-Milwaukee. During this 5-year project, 25 mathematics and science teachers with a Masters degree participate in professional development to increase their content and pedagogy knowledge. Teachers complete 4 badges/micro-credentials per year which always requires the design, implementation, and assessment of a lesson targeting a certain aspect. (action research)

Classroom

This classroom study was done with two 10th grade chemistry classes at MacDowell Montessori Schools. The school is part of the Milwaukee Public School District, a large urban district serving about 74,000 students. The student demographics at MacDowell are: 2.3% American Indian, 1.7% Asian, 76% African American, 6.3% Hispanic, 1.7% Multiracial, and 12% White (all receiving free lunch) . One of the classrooms in this project, (#2) has more students with learning disabilities than class #1. It is in general more difficult to engage with students in class #2.

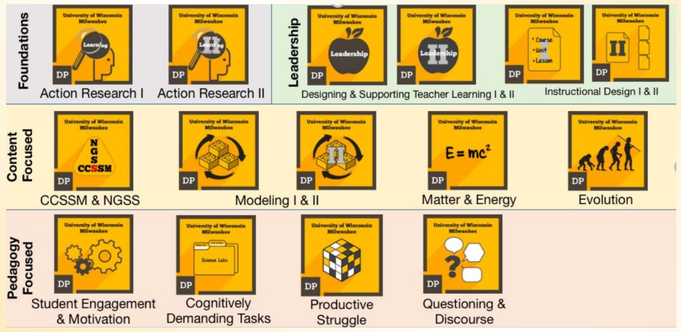
Learning Goal

This productive struggle method is used in an inquiry lesson to help engage student and students thinking. Students were asked to engage in a questions about chemical bonding. The lesson started with (for them) a rather difficult questions that was meant to initiate critical thinking. Creating sufficient challenge (Ambrose, S. A. 2010) to produce intrinsic motivation (Elliot, K. 2015) and create that moment of wonder to "draw upon the curiosity of students" (Jarvis, G. A. 2015) helps motivate children to engage in science. Inquiry is a type of discourse that triggers students' ability to solve and wonder about problems on their own. This is related to engagement because the students are doing the thinking and solving problems.

Teacher Reflection

By using substances the students are familiar with (salt and sugar), it helped with their understandings and curiosity. During prior inquiry lessons I recorded 14% verbal feedback, however this lesson had 22% and 41% verbal feedback with higher engagement on the white boards (48% and 67%) due to materials handed out to the students. This study shows engagement in a high poverty school district where not every student has a pencil or pen. Some resistance to participate may be due to using a new teaching technique the students are not familiar with. The level of thinking is difficult to document but the students did have an "ah ha" moment when the concept was explained later.

MMTP Badges (examples)

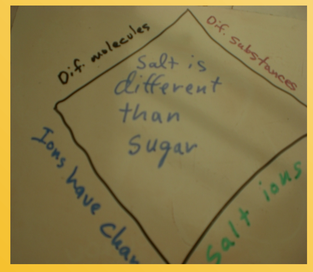


Student Engagement and Motivation Badge

Task: The educator studies factors related to student motivation and increasing student engagement through the use of tasks and instructional design, teacher-student interaction, and feedback and formative assessment. The educator selects one of the three areas to focus on, (while still learning more about and incorporating aspects of the other two areas) plans and teaches a lesson which integrates the teaching practice designed to improve student engagement, measures student engagement, and analyzes student performance outcomes as a result of implementing the teaching practice

Implemented Method

Classroom Activity	Concept	Time
Pre-test (unit test)		20 min
Opener: Critical Thinking Question	"What is the difference between ionic and covalent bonding?"	5-10 min
Demonstration: Conductivity of salt water vs sugar water	Observing, notetaking	10 min
Whiteboard/diamond group activity	Students work in groups of 4: gathering thoughts about demo, discuss observations, making sense, formulate explanations for different conductivity values	15-20 min
Modeling Activity	Connecting demonstration to particle level properties and behavior	15-20 min
Teacher Instruction: PPT covalent vs ionic bonding	Comprehensive overview of the topic, class discussions, continue to make connections	30 min
Expansion: PHET activity: Bond character and Molecular polarity + graphing activity	Introducing the bonding "spectrum"	2 x 90 min class periods
Post-test (end of unit)		20 min

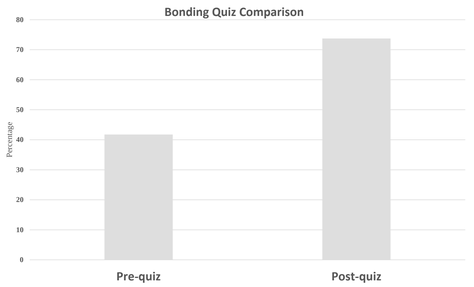


Diamond Activity

Modeling Activity

Analysis / Findings / Discussion

The significant change from a **41.8%** average in the pre-quiz results and a **73.7%** average in the post-quiz results, with a p-value of less than 0.0001, indicates that the students' scores and knowledge of bonding improved from before the unit began to after the unit was taught.



P-value ≤ 0.0001
Pre-quiz / Post-quiz
Mean 41.77 / 73.74
SD 22.23 / 20.96.

SEM 3.56 / 2.96
N 39 / 50
T = 6.9536
Df = 87

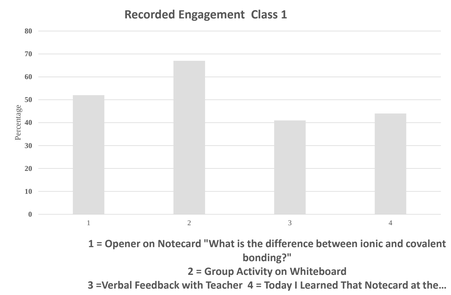
Confidence interval: The mean of Group One minus Group Two equals -31.97/ 95% confidence interval of the difference from -41.11 to -22.83

The students enjoyed the hands-on molecular water models and they enjoyed the productive struggle at the beginning of the lesson when asking them to explain why salt water is more conductive than sugar water.
I noted several students indicating an "ah ha" moment when they figured out that the bonding had an influence on the conductivity. When teaching this unit again I hope to better motivate students to complete the graphing exercise of percent ionic character vs change in electronegativity that we did after the quiz.

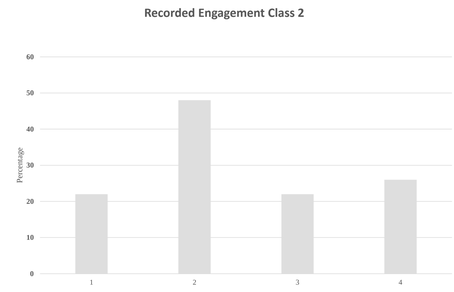
Some students refused to take the pre-quiz because they had not been taught the bonding lessons yet and did not understand that it would not lower their grade.

The connecting concepts log indicates students of different abilities engaged in the lesson ; I believe this is due to the fact that there were many opportunities to participate via opener/closure card or group activity.

Student Engagement



1 = Opener on Notecard "What is the difference between ionic and covalent bonding?"
2 = Group Activity on Whiteboard
3 =Verbal Feedback with Teacher 4 = Today I Learned That Notecard at the...



Teacher Reflection

Getting students engaged is the key to getting students learn scientific concepts. My goal is to prepare teach students the essential chemistry concepts and to prepare them for a more rigorous experience in college. My experience as a former student, teacher, and tutor told me that it is very important to understand the differences between ionic and covalent bonding before taking general chemistry courses or biology courses on the college level.
It is often expected that the students master these concepts in high school. The lesson I implemented is based on (modified) a lesson published by the American Chemical Society.

Productive struggle with inquiry was effective at reaching high risk students who are difficult to engage. The results show that the lesson had a positive impact on student learning which I believe is a result of increased student interest and engagement. Seeing and hearing students say, "Oh, I get it now" and listening to student comments and group discussions was very interesting and has impacted my classroom in a positive manner.
I plan on implementing similar strategies more in future unit lesson plans.

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References

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