Chemophobia or Math Anxiety?

An Inquiry into Building Student Confidence in Scientific and Mathematical Knowledge and Enhancing Student Achievement by Implementing Biotechnology Lessons, an Artistic Approach to Conceptual Chemistry, and Reflective Student Journals with Non-Honors Chemistry Students.

Gabrielle Powers
Honors and Regular Chemistry Teacher
West Shore Jr./Sr. High School
Brevard County Public Schools
powers.gabrielle@brevardschools.org
Abstract:

This purpose of this action research is to use biotechnology lessons, an artistic approach, and reflective journaling with Non-Honors Chemistry students to improve their confidence in their scientific and mathematical knowledge. Throughout the 2012-2013 school year, these strategies will be implemented and used to assess understanding of course material. Students’ learning gains will be analyzed using pre/post tests for each semester. Surveys will be given in August, December and May, and then compared to one another to obtain information on student confidence in scientific and mathematical knowledge and how it has changed throughout the course of the year. Quantitative and qualitative information will help determine if these teaching strategies have increased the level of confidence in scientific and mathematical knowledge of Non-Honors Chemistry students. A statistical analysis will be run to determine if there is a correlation between the level of confidence and the students’ scientific and mathematical knowledge.

Rationale:

Today, to become a teacher, one must take on many roles; teachers are educators, advisors, role models and cheerleaders for the students. A teacher’s role to educate students isn’t a simplistic one because in order to be successful, it is also a teacher’s responsibility to investigate which instructional methods have a lasting impact and are most beneficial to the students. Taking into consideration and addressing different learning styles, cultural backgrounds, and the prior knowledge or misconceptions of their students is a necessity as well.

Through action research we are able to make observations of our students and how they learn, implement new teaching strategies, and analyze these teaching strategies to determine whether or not the students learned the materials in the curriculum. Action Research is an essential component not only for assessing student’s learning gains, but it is also important for growth as a teacher. I will be actively engaging in the cyclical process of researching and implementing various teaching strategies and then analyzing the student learning and increased confidence that results from those teaching strategies. Analyzing how my students are learning best will enable me to modify the activities that are not as beneficial to my students and implement more of those that increase their understanding.

Each year several of my Non-Honors Chemistry students adopt the mentality that they “can’t do Chemistry” once they find out that high school Chemistry is essentially a math-based science course. The number of students with this lack of confidence increases as we dive deeper into the semester and deal with more conversions, equations and word problems. I often wonder if
these students are afraid of the abstract language and concepts in Chemistry, and therefore have “Chemophobia,” or if they feel that they are so incapable of being successful in math that they have Math Anxiety. In a study conducted to analyze the confidence of students as compared to their fear of chemistry and feeling of helplessness in the subject, it was found that “self-confidence prior to initial chemistry instruction among students who are high achievers in chemistry is high. Their ability self-concept is favorable and their levels of helplessness are low” (Ziegler, 2000, p. 144). In the case of my Non-Honors students, their underlying defeatist attitude could stem from their mindset that they are “not good in math.” This misconception that they are not capable of success may also be a result of the label of “Regular Chemistry” or the fact that they are only in Regular or Honors Geometry when many of their friends are in Honors Algebra II. Some of these students have always liked science, but since they are convinced that they are not good in math, they believe they cannot learn Chemistry. This poor self-conception can detrimentally affect their ability to learn the material.

It is my goal every year to change this thought process and convince these students that they can learn and understand Chemistry. I provide them with the tools and references necessary to succeed, but if the student has very little confidence that they can achieve excellence, they will convince themselves that they have to settle for just getting by. “Some students have already closed their minds to the beautiful and fascinating world chemistry has to offer them” (Danipog, 2011, p. 1610). It has been shown that students who are actively engaged in the learning process are more likely to understand the material than those who passively listen to lectures and presentations. (Frels, 2011) “Current research advocates for teaching techniques that encourage students to actively engage in the material because classroom engagement has been found to promote deeper levels of thinking and better facilitate encoding, storage and retrieval than traditional lecture” (Hackathorn, 2011, p. 40). With implementing new teaching strategies that will benefit my Non-Honors students, I hope to build their level of confidence in their own scientific and mathematical knowledge and show them that they can be successful. “Student attitudes and values are affected by class participation, and that participation also increases motivation and emphasizes a student’s responsibility for learning” (Frels, 2011, p. 72).

The purpose of this study is to determine the effectiveness of routinely utilizing biotechnology lessons, an artistic approach to conceptual chemistry and reflective student journals on building confidence and achieving scientific and mathematical knowledge of my Non-Honors Chemistry students.

**Action Research Intervention:**

By introducing my Non-Honors Chemistry students to an artistic approach to Chemistry, and reflective journaling I hope to increase their level of confidence in their own scientific and mathematical knowledge. My Action Research Interventions will start being implemented at
the beginning of the year in August. I will begin collecting baseline data using the strategies I have listed below, and compare that to the data I collect toward the end of the first semester and toward the end of the year.

**Reflective Journaling** –

“Instructors have used...journaling...to get students involved and active in the learning process” (Hackathorn, 2011, p. 41). By using a reflective journal, the students will be able to show their understanding of the material we learned in class. For example, after using the Pipetting by Design Lab kit, my students could write in their journals about how to use a micropipette, when they would be used, and how confident they feel in using the micropipettes after this activity. “Active teaching techniques change the pace of the classroom, and are a creative way to increase students’ involvement, motivation, excitement, attention, and perceived helpfulness and applicability of the class” (Hackathorn, 2011, p. 41). These journal entries the students will complete will be timed. Some of these prompts will be short “one-minute essays” where the student would be asked to write down as much information as they can about the topic they learned about that day. Some journal entries guide the students into engaging in “higher-order thinking such as analysis, synthesis, and evaluation” (Hackathorn, 2011, p. 41). The journal prompts may also ask the students to reflect on the lesson and say what worked and what didn’t work for them, or what they are still unclear about.

These journals will be a private dialogue between me and the student, therefore the student may feel more confident to say what he/she does and does not understand. “Moving from reading theory in the texts to applying the concepts through practice involves an application of concepts that is often reliant upon student writing and instructor feedback” (Frels, 2011, p. 62). I will keep the journals in the classroom, grade them and give the students feedback 1-2 times per week. Feedback is an essential element for effective learning and reflective growth.

“Detailed feedback is at the crux of an instructor’s responsibility as a professional educator, researcher and motivator. As such, formative feedback helps students reflect on their levels of performance and take a greater responsibility for their actions” (Frels, 2011, p. 72). These reflective journals will give me qualitative data as to how the students’ scientific and mathematical knowledge is improving throughout the course of the year.

**Artistic Approach** –

The students will be using an artistic approach to chemistry. Throughout the curriculum of the high school chemistry course there are various fundamental concepts at hand. Assignments that allow the students the freedom to illustrate their comprehension and creatively reflect their understanding will reveal how the students perceive conceptual chemistry. Studies of art-based Chemistry have been done, and research has found as the students are able to display
their artwork and what they know, a “sense of satisfaction stems from their correct explanations of chemistry concepts as well as the novel ways in which they applied their knowledge of chemistry to express themselves” (Danipog, 2011, p. 1613). In my class, for example, after using the Biotechnology Water Kits, I will have the students illustrate how water interacts with other molecules and how the polarity of the molecules affects the interactions. This will be a take home assignment that they will be given three days to complete. The students will be awarded the option to create this on the computer, use images from magazines, or draw it free-hand. They will need to meet the objectives of illustrating the polarity of the water molecules, and the polarity of the other molecules they are interacting with. These projects don’t have to actually represent what each molecule looks like, but they need to correctly reflect the objectives. Instead of the exact molecular models, the students will be allowed to use analogies or imagery and be creative to represent the information.

“Artistic illustration of ideas makes thinking visible through color, texture and shapes and extends the meaning of the words” (Furlan, 2007, p. 1625). In my class, after a difficult topic is introduced and we have worked through the guided-practice together, the students will be able to put the ideas and processes learned into a graphic organizer to help them visualize and make sense of concepts. For example, electron configurations are a difficult concept for student to understand. There are these abstract concepts of Principal Energy Levels, Sublevels and Orbital they need to differentiate between. A graphic organizer is used to break down those concept to make them easier to understand how they are interrelate. “Some personal and creative experiences may not only help the students enjoy chemistry but also add to their ability to learn the material” (Furlan, 2007, p. 1625). I believe this is fundamental to empowering these Non-Honors students who sometime think they are not capable of learning the material.

During and after hands-on lab activities, demonstrations, and biotechnology lessons, students will generate artistic illustrations to show their understanding and explain the key concepts that were represented in the labs, demos and lessons. While introducing the different type of chemical reactions, I do several demonstrations. One demonstration in particular I called a “Genie in a Bottle” where hydrogen peroxide is broken down into water and oxygen by using a catalyst. The students will be asked to illustrate the reaction vessel before and after, and label the reactants, products and type of reaction that took place. Integrating art and chemistry “makes the connection not only between the disciplines but also more importantly between students and the concepts of chemistry...art provides students a way to visually represent their scientific knowledge and at the same time helps teachers assess student understanding” (Danipog, 2011, 1611). Through the use of this artistic approach to Chemistry, students will be better able to visualize and understand the topics they are studying and possibly have a vested interest in being an engaged learner. As a result, their confidence in their own scientific and mathematical knowledge will increase. One of the activities I plan to incorporate is to have my students design a picture/poster to represent Ionic versus Covalent Bonds. They will be given
the criteria they need to meet (i.e. have the definitions, have at least three pictures/images, have the formation of the bond and breaking of the bond, and show at least one similarity and one difference.) Studies that have introduced students to art-based chemistry have shown that these techniques “made the students aware and realize that artistic representation could help understand chemistry concepts that give them confidence and satisfaction in explaining the concepts” (Danipog, 2011, p. 1613).

Posters, which are a common form of artistic implementation, and poster presentations will also be used to illustrate the student’s ideas in a unique way. After conducting studies that use this method to help teach chemistry, students have reflected that it “helped them review chemistry, motivated them to search for additional chemistry information on the topic, and increased their chemistry understanding” (Furlan, 2007, p. 1627). An example of an assignment that I could use would be after the students complete the Lysozyme Crystallization and GFP Chromatography activities, they would create a poster illustrating the process and be able to explain the processes at the chemical/molecular level. When these poster activities have been assigned by teachers and their student responses recorded, one student has stated, “by reviewing the material, researching for additional information from the Internet, and thinking about it more deeply, I understand the chemistry I talked about much better after the project” (Furlan, 2007, p. 1627). Conclusions have been drawn in these art-based chemistry studies that “students exposed to art-based chemistry activities have significantly higher mean scores on the chemistry concept understanding text than the students exposed to non-art based activities” (Danipog, 2011, p. 1614). By increasing the student’s knowledge in certain areas of chemistry, it will enable them to build confidence in their understanding of the course material, and hopefully believe they can be successful in my Non-Honors Chemistry class.

**Connections to Bench to Bedside Summer Institute:**

The various hands-on activities and information about the labs have been provided by the CPET Bench to Bedside Summer Program. Biotechnology lessons from the equipment lockers will be borrowed and used in my Chemistry classes. The Pipetting by Design will be reserved and used first in my classes to get the students used to working with micropipetters. Using the $200 equipment money, I will order the Water Kit Lab from [www.3dmoleculardesigns.com](http://www.3dmoleculardesigns.com) and use that in my classroom to enable the students to visualize polarity and how water molecules interact with other molecules. The Lysozyme Crystallization Lab, as well as the GFP Transformation and GFP Chromatography Labs will also be completed in my Chemistry classes. The locker materials that my students will be using will be provided by the University of Florida through the Bench to Bedside Program.
Data Collection and Analysis:

Through the process of collecting data and analyzing the results from the various sources, there will be a triangulation of data. This will hopefully indicate that these biotechnology lessons, artistic approach and student reflective journals have overall been effective strategies used to increase the confidence of students’ scientific and mathematical knowledge. I will collect and analyze data for the reflective journaling, artistic approach and pre/post test and surveys in the following ways.

Reflective Journaling –

I will keep the student journals in the classroom, grade them and give the students feedback 1-2 times per week. By reading through the student’s journal entries and coding the text, I will be able to group the data to into patterns among student responses. I will look at this data across all of the responses of my students to report my findings in a frequency table indicating the number of times a certain behavior/theme occurs. I can compare a reflective journal entry from the beginning of first semester to one completed at the end of first semester to see if there is improvement in their level of understanding and confidence in science and math.

At the conclusion of my Action Research, I will be able to put together all of the information I have collected from the reflective journals of my students to report my findings using sample quotations from students. I will also use a written narrative to summarize what I have found from these student responses. This qualitative data should represent how the student’s level of understanding and confidence has improved throughout the course of the first semester and throughout the year.

Artistic Approach –

Since the artistic ability of my students will vary greatly, their artistic representations of conceptual chemistry, labs, demonstrations or biotechnology lessons will not be graded solely on artistic talent. For the posters, the students will be given a rubric which will be a set of guidelines that they must have included in their posters. I will grade their posters based on the rubric. For example, for a given poster assignment, the student would be asked to:

- Make the message stand out – limit text (use bold letters and appropriate text size) (15 points)
- Accurately, clearly and creatively represent the chemical concept in an interesting, and eye-catching way (25 points)
- Illustrate the concept(s) using examples, pictures, flow charts, images, graphs etc. (25 points)
- Compare/contrast and/or classify information (15 points)
• Include questions for the viewer and hide the answer under a flap to lift and uncover the answer (10 points)

• Be neat (10 points)

• Be able to give a brief presentation – show your knowledge about the chemical concept you illustrated

For each class that created the posters, I am going to try to have an administrator and/or other science teachers judge the posters to help select a “class winner” based on the following criteria: overall impression of the artwork/poster, creativity and accuracy of the chemical concept illustrated, and student confidence of scientific knowledge during their presentation of the poster. Students are sometimes very motivated by competition, so hopefully this incentive will encourage them to better represent be able to understand and explain conceptual chemistry through art.

During and after biotechnology lessons, hands-on lab activities and demonstrations, students will generate artistic illustrations to show their understanding and explain the key concepts that were represented in the lessons, labs and demos. These assignments will not only be self-evaluated, but they will also be peer reviewed and evaluated by me as the teacher. The evaluation will be based on a 4-point scale:

1 = The conceptual meaning/understanding is not clear.

2 = The conceptual meaning/understanding is somewhat clear.

3 = The conceptual meaning/understanding is missing a little bit.

4 = The conceptual meaning/understanding is thorough and apparent.

The self-evaluation, peer evaluation and teacher evaluation will be recorded and that data will be reviewed during the semester to see if the students are getting better at representing conceptual chemistry pictorially. “To demonstrate understanding, a student must not only posses rudimentary knowledge, but should also be able to explain, interpret, and apply knowledge, as well as have perspectives on the information, possess self-knowledge of their own understanding, and empathize with the understanding held by others” (Danipog, 2011, p. 1611). With the students evaluating their own artwork as well as completing peer evaluations on each other’s work, this will help to demonstrate their level of understanding of these fundamental concepts. Visually, the self evaluation data and the teacher evaluation data will be represented in a bar graph. This will hopefully not only show that student understanding is increasing, as evaluated by the teacher, but that their as the level of self-confidence in their own conceptual knowledge is increasing as well. Through the use of this artistic approach to Chemistry, and the various methods of evaluation, students will be better able to visualize and
understand the topics they are studying. As a result, their confidence in their own scientific and mathematical knowledge will increase.

**Pre/Post Test and Survey Analysis**

Overall, I will be able to assess learning gains by the traditional pre and post test method. By the students completing a pre test at the beginning of the semester and a post test at the end of the semester, I will be able to statistically analyze whether or not there has been significant learning gains throughout each semester. I will be able to use this data in addition to the other sources of data collection to quantitatively analyze the efficacy of my teaching strategies. I will be able to graphically represent how student performance increased from the pre to post test using Excel bar graphs. Because I will be using my classes of Non-Honors students, I will be collecting and representing data for over 35 students. Therefore, I will take class averages and represent those class averages on the pre and post tests in the bar graphs.

At the beginning of the year, in August, the students will fill out a survey on their confidence in biotechnology, science and mathematics. They will rate their confidence in their level of knowledge in these areas on a Likert Scale as follows: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Disagree or Agree, 4 = Agree, and 5 = Strongly Agree. The student’s total score for the responses of 3’s, 2’s and 1’s will be added up and will represent the total “negative” response score. The student’s total score for the responses of 3’s, 4’s and 5’s will be added up and will represent the total “positive” response score. The student’s total “negative” score and the student’s total “positive” score will be recorded. This data will be saved for later comparison. The students will then fill out the same survey toward the end of the first semester, in December, and again, the total negative and positive response scores will be recorded and compared to the initial negative and positive response scores. These scores will be represented in a bar graph to illustrate that the student confidence in biotechnology, science and mathematics knowledge has improved as a result of these teaching strategies. The students will take the survey again toward the end of the year, in May. Once again, the process of evaluating their responses of negative versus positive responses will be recorded and compared to their initial and mid-year responses. These scores will again be represented in a bar graph to illustrate that the student confidence in their understanding of biotechnology, science and math concepts have improved through the use of biotechnology lessons, an artistic approach to chemistry and reflective student journals.

If possible, toward the beginning of the year, I would like to compare the initial student surveys with their pre-test scores to see if there is a correlation between confidence and scientific and mathematical knowledge. My hope is that toward the end of the first semester, I will not only see an increase in the level of confidence in their knowledge, but also an increase in their knowledge in general. I will compare my findings at the beginning of the year, toward the end
of first semester and toward the end of second semester and try to represent them in a graph. By entering the results in excel, I can run a correlation test to see if the level of student confidence is related to their level of understanding and if the correlation is significant.

**Literature Cited:**


---

**Budget and Budget Justification:**

<table>
<thead>
<tr>
<th>Company</th>
<th>Item #</th>
<th>Quantity</th>
<th>Description</th>
<th>Unit Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3dmoleculardesigns.com</td>
<td>WK-10</td>
<td>1</td>
<td>Water Kits</td>
<td>$385</td>
<td>$385</td>
</tr>
<tr>
<td>3dmoleculardesigns.com</td>
<td>WK-02</td>
<td>2</td>
<td>Water Kits</td>
<td>$42</td>
<td>$84</td>
</tr>
<tr>
<td>University of Florida</td>
<td>Equipment Locker</td>
<td>12 stations</td>
<td>GFP Protein Chromatography</td>
<td>No Charge</td>
<td>No Charge</td>
</tr>
<tr>
<td>University of Florida</td>
<td>Equipment Locker</td>
<td>12 stations</td>
<td>Pipetting by Design</td>
<td>No Charge</td>
<td>No Charge</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
</tbody>
</table>

**Permissions:**

Permission will be necessary to have student posters in the media center, or in the hallways for students to give their presentations. Permissions will have to be granted for administrators and/or science teachers to evaluate the posters to choose class winners. Permissions for purchase orders will need to be obtained in order to purchase some of the Water Molecular Kits.