Science and classical education in a nonclassical school: A SPN experience

by

CindyJo Fryer

B.S., Emporia State University, 1989
M.Ed., Grand Canyon University, 2021

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF EDUCATION

Department of Instruction and Curriculum
College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2024

Abstract

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The first article examines the use of classical methods to create an immersive classroom experience, including copy work, HBST, and the Progymnastmata. The second article focuses on the teaching of unit conversions through copy work, gradual release of responsibility, and model recovery. The third and final article explores the use of a document to promote metacognition through peer learning and reflection.

Overall, the study demonstrates that classical education can effectively foster a harmonious relationship between students and teachers in the classroom.

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Acknowledgements

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This dissertation is dedicated to my son, Brandon, who taught me teaching is more than transferring knowledge; it is transferring love.

Chapter 1 - Introduction

When someone uses the term classical education it elicits many images. One such image is a student sitting down and learning an ancient language such as Latin. Another image that often emerges is students reading a very thick, boring, unimportant book. Yet another image may be two people debating over two dead philosophers which no one has ever heard.

What is classical education? What use is this very old, possibly out-of-date teaching method? Does anyone teach using this method anymore? If they do, why? Why would any levelheaded parent send their child to learn a dead language and about dead philosophers?

Clark and Jain (2021) emphasize the importance of education for the whole person, stating, "Education is not merely an intellectual affair, no matter how intellect-centered it must be, because human beings are not merely minds… A full curriculum must cultivate the good of the whole person, soul, and body" (pg. 29). Education is not about standardized tests, rather it is about molding oneself into a full human able to navigate in the world with other humans. When teaching science, I strive to emphasize the importance of understanding the world and our place in the universe. The skills I want to teach are the life skills they will need throughout their lives such as critical thinking and logic. The medium I chose to use for this transfer of skills is science.

I have always loved school, learning, and researching. One of my goals in life was to homeschool my children. So, I began researching and learning how children learn. I also researched the different teaching methods and came across classical education. It came as a surprise to me how many Founding Fathers of this country were not only homeschooled but were classically educated (Cothran, 2020). Another surprise was the results of classical education on student learning. Classically educated students were outscoring their counterparts drastically (Blake, 2019). I wanted to know why.

The reasoning for limiting the amount of classical education instruction was purely due to practicality. After the Civil War, American public opinion began to shift and have less of a focus on the origin of languages and the Greek and Roman life that contributed to America. The trend of learning in schools began to concentrate on American English instead of Greek and Latin. As these languages decreased in importance, so did classical education (Howe, 2011). Colleges and universities kept the tradition longer than others, but even today, it is a rarity.

It was then I began learning about classical education. This method is not about learning a dead language, reading very thick books, or even debating dead philosophers. Rather, it is about training the mind in a way the brain works. Classical education is skill-based and focuses on exploring the true, the good, and the beautiful (Bauer & Wise, 2016).

Latin is studied because it trains the mind in a specific way. The English language is 60% Latin ("*What Percent of English",* 2015 therefore learning Latin allows the student to understand English better. Also, many original documents were written in Latin and thus can be studied in their original language by the student.

The thick, boring, unimportant books are just a stereotype of classical education. Once students sample well-written books reading becomes a habit they continue for the rest of their lives. It does not matter about the length or the age of the books, rather it is developing the love of reading that is important.

What about those dead philosophers? Classical education students are trained in logic and rhetoric. The philosophers are foundational for further endeavors of life's meaning. Again, it does not matter whether the person is living or has passed. It is the content that matters; that is, what is or did the person say or write is the conversation (Clark & Ravi, 2021).

When I homeschooled my son, I used classical techniques. The process was fun, hard, frustrating, and highly rewarding. As he matured, it was my son who suggested I teach others. I have helped other homeschool parents with teaching using the classical method and have tutored many students. The first place I taught was a private school that had classical education as its curriculum. I observed firsthand a whole school of students from kindergarten through 12th grade learn classically. It was beautiful. I wanted to research classical education and become an expert.

Some universities have doctorates in classical education. As I explored doctoral programs, I learned I had to be fluent in Latin and know about all those dead philosophers. However, I have a degree in chemistry, and I worked in commercial laboratories. Although I can read thick old books, and maybe even in Latin, I wanted to study the method of classical education with students with no background in pedagogy.

This desire drove me to the focus of this doctoral thesis. Classical education is one of my passions and I want to be an expert in the techniques. This led to many questions. Can classical education be taught anywhere at any school? Can any teacher teach classically? I currently teach in a school that does not have classical education as a curriculum. I wondered what happens when I introduce students to classical methods when the rest of the school isn't using classical techniques. This helped shape my following research questions:

1. How does a teacher experience the use of classical education techniques in a non-classical educational environment at an inner-city public charter school?
    1) What are the tensions and dilemmas that the teacher experiences between classical and non-classical education?

b. What are the synergies that the teacher experiences between classical and non-classical education?

Explanation of Classical Education

By definition, classical education is a pedagogy that uses the trivium that is, the grammar, logic, and rhetoric stages. The trivium dates to the Greek Empire and produced such graduates as Alexander the Great, Galileo, Martin Luther, and Thomas Jefferson (Cordasco, 1976). The grammar stage includes the foundation. In this stage, the students learn the basics of the concept (Bauer & Wise, 2016). Grammar stage does not necessarily mean elementary school. Rather, than learning a new skill, all students begin at the grammar stage. It is the foundational information needed to progress through mastering a skill. In chemistry, this includes the atom, subatomic particles, and the framework of the periodic table. Next in the logic stage, students use the grammar stage to place what is learned into categories to see order or lack of order (Bauer & Wise, 2016). In the chemistry example, studying the different elements of the periodic table to identify trends of the groups and periods. Finally, the rhetoric stage has the students use the basic background and order to derive concepts that can be discussed, explained, or written (Bauer & Wise, 2016). Again, in the chemistry example, this includes using the trends of the periodic table to explain chemical reactions that were observed in a lab.

There is more than the trivium in classical education. It also includes the quadrium. These include the math arts which are: arithmetic, music, geometry, and astronomy (Jain, Andreasen, & Hall, 2021). The quadrium begins after students have mastered the basics of learning. This includes having the brain developmental to the logic stage. The human brain normally begins to develop logical thinking in the preteens to early teenage years (Kwon & Lawson, 2000).

Classical methods are not only history-based but literacy-based (Bauer & Wise, 2016). This distinction allowed science class to be a good choice for research. Teaching the history of science such as the scientists and the breakthroughs was through reading and writing (Kolstø, 2008). Students must read about the scientists and how they changed science. Within this context, students learned the struggles scientists had to overcome to make a difference in the world. As they wrote (on paper) they made connections in their brains that allowed learning to take place.

In *From Wonder to Mastery*, John Mays states, "Studying the history of science is great fun and knowing the exploits of the scientific heroes of the past properly humanizes a discipline that can become sterile when divorced from the human beings who are doing the science" (Mays, 2021, p.137). Students need to know the struggles that scientists have overcome in their lives. This allows the scientists of the past to come alive in the present. Knowing Einstein struggled with mathematics can give others hope as they, too, encounter the challenges of algebra. It might be of some solace to learn Nikola Tesla was consistently ill in his early years and suffered from severe obsessive-compulsive disorder.

History-based writing, very common in classical education theory, students read about a scientist, the biography, the time, and the contribution to science. This allowed students to learn science in its context. There is a connection instead of dry facts. Students not only write about atomic theory but also about what attributes of John Dalton can they relate to and what obstacles were overcome. Learning about Marie Curie's mother not being able to touch her students because of the contagious disease she had contracted is a concept the COVID-19 students can relate to. Relating to history and science allowed the students to have another connection to learning and understanding concepts.

History-based writing allowed students to write in their voice the history connection to science. As stated before, writing instead of typing makes more connections in the brain (Rhodes, Cleary, & DeLosh, 2020). Thus, learning takes place. My study explored how the classroom environment is shaped using these techniques.

They learned what the world was like before the breakthrough or invention. What did the world think about the atom before Niels Bohr? Or Mendeleev? As the students thought about these things, they learned and reasoning about science. They become comfortable with asking questions and asking for clarification. Thinking through the PV=nRT (ideal gas law) allowed logic to replace memorizing. Memorizing is unnecessary once the logic is understood (Cotter, 2001).

Classical education techniques were used in chemistry classes and one astronomy class. What were classical education techniques? Simply, teaching students how to learn on their own. This includes increasing students' confidence, reading skills, writing skills, and logic.
If a student lacks confidence, he will not attempt things that he believes are hard. Chemistry is hard and astronomy has many Greek terminology. The subjects take effort and endurance. Not having a high school reading level decreases confidence. Increasing literacy level is the goal. Students not only have reading levels of K-3 but are at level one as described in How to Read a Book (Adler & van Doren, 2014). To be successful at chemistry or science in general, a student needs to be at least level three. This level is characterized by having the ability to understand in context what is the main theme. In chemistry, this means reading the text being able to understand concepts, and applying those concepts.

Another characteristic of classical education is the history and literature connection in each subject area (Bauer & Wise, 2016). For example, in astronomy, students will study not only

the constellations but read about their history in books such as The Odyssey (Osborne, 2010). Also, students will read about the pyramids and their connection to astronomy. In chemistry, students learn about the chemists who influenced the field. This technique gives context to the content (Mays, 2021).

In my experience, copy work (Write to learn, WTL), led to increasing brain activity, attention span, comprehension, and understanding of concepts. Students were able to write more and think in sentences instead of single words. This work was not graded on accuracy (Van Hoornbeak, 2007). Passages were chosen from the chemistry text and other sources that were unfamiliar to the students. The passages were segments the student would be studying within a few weeks. At that time, students would have heard the passage three times before seeing it in print. Copy work, in science, was from biographies of scientists, chemistry texts, or math problems not yet encountered. The students did not need to understand the copy work to complete the assignment; they needed to copy the work exactly as on the paper. This work is timed but not graded for accuracy. Initially, the students were unable to complete all the copying within the given time. Each copy work session was a different passage, never the same (Van Hoornbeak, 2007). The time allotted is the same. Soon, the students were completing copy work before time was called. At first, students' eyes will be moving from one word on paper to copying one word. Eventually, the eyes adjusted to full sentences or lines copied in one glance.

Students of classical education execute copy work throughout their educational career (Van Hoornbeak, 2007). Copy work consists of writing down exacting as the text is written. Students learn grammar, format, vocabulary, and content while copying a section of literature (Mutch, 2009). The sources of the literature students copy vary with the content. Examples

include the subject textbook, biographies, and other documents used in the class. Students need to have a variety of well-written sources to copy.

Socratic method is used throughout the class period. This method is an argumentative questioning dialogue purposely instigated by the teacher to promote critical thinking skills (Oyler & Romanelli, 2014). In this technique, the teacher asks the students to clearly state what a definition or opinion is. This helps the students to capture what they know. Next, the teacher will question the statement by offering an exception or counter-opinion. Students will then think about their previous statements through the lens of the teacher's statements. Finally, the students will rephrase or rebuttal. Not only will the students learn critical thinking, but they will also be trained in debating and the art of discussion (Oyler & Romanelli, 2014).

The last part of classical education I want to include in this section is the Progymnastmata. This is a set of exercises to promote performing well in speech and writing. Students learn proper grammar, arrange their writing in a logical order, and write for different audiences (Baxter, 2008). It is a set of twelve writing and speaking sections that range from the fable to law. Students dissect prose or speech to understand, rewrite, and recite in different ways depending on the audience the teacher assigns.

This is a very general explanation of classical education. In practice, the Socratic method is used to help the students move from one stage to another (Oyler & Romanelli, 2014). Also, the students take on most of the responsibility of learning. The teacher guides and gives the basic framework for learning to take place. This introduction will include techniques and examples of classical education and framework.

How would including classical education techniques such as copy work, and history-based writing in high school science classrooms affect literacy change? This question is out of the scope of this dissertation, but further investigation should be followed.

There are several different techniques used in classical education. In this dissertation, I will employ the Progymnastmata, writing to learn (copy work), history-based science instruction, and the Socratic method. These techniques will be further explained in the method chapter. The test high school students have not been exposed to classical learning and have low reading and writing skills. I wanted to see what I experienced as a classical teacher in a nonclassical environment. What tensions and dilemmas existed as well as the synergies in a charter school where no classical education takes place?

Purpose of Study

I taught at a private classical school for several years and learned much about this type of education. My task was to help the students with the math gaps at the school. Previous teachers had used the textbooks as the curriculum and were not secure in the content. Before the year started, I, along with other teachers, had professional development. It was during this training I learned about copy work, Progymnastmata, and the Socratic method. Hearing how these techniques helped students struck my interest in how they could be applied to math and science. Being a scientist by training, I began researching these techniques.

Within a year, students were no longer below grade level in math. By the end of the second year, pre-algebra was taken out of course study. Seventh graders were taken Algebra I with no issues. I began wondering if this type of education could help all students. The students I tutored outside the classical school also benefited. Some students were in public education while others were homeschooled. Using the same techniques had the same results.

Now at a charter school, I wanted to study how I could implement classical techniques within a public school. I originally decided to investigate the results of the students but with issues involving consent with minors, I changed my study. Instead of the results of the students, I focused on my teaching, understanding, and interactions while using classical methods in a non-classical school.

School

The school of study is a charter high school embedded in inner-city surroundings. Even though a public school, this charter like many others, has differences. One is the organizational structure. A CEO is in charge instead of a superintendent. Also, these types of schools are open to experimenting with different learning styles and techniques. Charters allow students to attend from other districts if they live within the city limits. This allows for more of a cross-section of a city's population to be present.

This school for my study has nearly 400 students from 9-12 grade. 99% of the students are of African descent with the rest being mostly Hispanic. Students are from low income which makes the school a Title I. Majority of the students are low achieving with below grade level in reading, writing, and math.

There is limited literature for teaching classical in a nonclassical school. My study could be the first. I want to determine my experience. What kind of tensions will there be between the students and me or teachers and me? What dilemmas occur during my time at the school? Also, what synergies occur during the data collection time? For this study, I have defined tension as a situation of stress that cannot be relieved. I defined a dilemma as making a difficult decision between two or more undesirable choices. Finally, my definition of synergy is combined efforts with positive outcomes.

With my study, I have the following research question:

1. How does a teacher experience the use of classical education techniques in a non-classical educational environment at an inner-city public charter school?
    a. What are the tensions and dilemmas that the teacher experiences between classical and non-classical education?
    b. What are the synergies that the teacher experiences between classical and non-classical education?

Many students in my school cannot read a paragraph at the high school level with comprehension. Mandated state test scores for science have been extremely low. The intervention involved testing the students weekly on standardized tests. This resulted in only 2% of the tested students passing (DESE, 2024). While the Covid-19 circumstances may have contributed, the percentage is still unacceptable.

There have been public schools that have adopted the classical educational model and have the state-mandated tests achieve levels that have consistently been significantly higher than their traditional pedagogy counterpoints (Blake, 2019). This led to the question of why public schools are continually using other methods that have not produced higher scores. This question was out of the realm of the scope of this research. Rather, monitor the progress of introducing classical methods in science at the high school level.

As stated at the beginning of this dissertation, most people think of classical education as Greek, Latin, and dead people. In the 1950s colleges decided that the dead languages were of no use to their undergraduates (Parker, 1957). While classical education is not the norm for public schools, this in no way means teachers cannot teach classically. My study attempted to see how

a teacher migrates through the public education system using classical education in a non-classical school.

Finally, teaching in a classical educational setting was vastly different than in an atmosphere that does not embrace this pedagogy. My perception was shaped in many ways. One is the students, and another, the teachers. Each class was different, even within the same content area. Classrooms are like organisms; alive and static. One student can change the dynamics of the room. In high school, students change rooms for each subject. Being the only classical classroom will influence the students. Thus, an effect on the teacher.

As in any job, colleagues influence each other. My school was no different. Teachers shared stories about their classrooms and students. They asked each other for advice on students and teaching. While most of my teachers did not subscribe to my type of teaching, they did have great ideas. This study explored how a nonclassical educational environment influenced my perception of teaching classically.

Why SPN

SPN is a method in social research in which the researcher's experience is the object of the study (Nash, 2004). Since the research question study was through the researcher's eyes, this allowed much flexibility. A personal narrative can be completed at any time. SPN has the exception of any time being not in the presence of the students (Porath, 2022). SPN is a new qualitative research methodology created by Dr. Richard Nash (Nash, 2004).

Personal narratives have been used throughout history for transferring information from one person or group to the next. A few examples include Anne Frank, the seven Mercury astronauts, Dr. Ben Carson, and even John, the Apostle. Scholarly personal narrative involves

this narrative from the writer's viewpoint and structures this view around scholarly data, usually peer-reviewed journals.

For example, I am writing about my experience in the classroom which is the personal narrative. I am using scholarship to ground the techniques I am using in the classroom. My results are from my observations and have scholarship to back up my rationale for the results and conclusions.

Scholarly personal narrative was the method I chose for several reasons. This method included the flexibility that I needed for this study. Since I was not able to obtain parental permission, SPN was the method of choice. I was able to see in written form the progression of my study. Also, SPN fits my personality. I love to write and normally write what happened in my classroom daily, so SPN was a little change to my routine. Lastly, SPN was very practical for my research questions.

SPN allowed me to use very few materials. The only tool needed was my journal and the only data was my memory. In my many life experiences, I realized I loved writing. It was one of my pastimes and passions. SPN is about reflection and using the medium of writing fits into my personality very well. Keeping a journal handy was part of my wardrobe. This method fits much better with my lifestyle.

Lastly, my research questions led me to SPN. I did not need to have the student's permission or their parents to complete this study. My school had very little parent participation, so the IRB requirements were hard to complete. Having the subject for the study as me, the parents' permission was not needed. I wanted to know how classical education in a non-classical school affected me as a teacher. If I could answer this question, I could show in later studies that this type of education can be implemented in any classroom setting.

Limitations

There were primary limitations that made this research question problematic in the educational context. Specifically, issues with SPN, students, and school. With these factors in mind, I wanted to determine how these affected a classical education teacher: me.

SPN

All the data was filtered through my perception. The positive side was my story. I wanted to see how I changed as a teacher. Through my eyes how did the classroom environment change and did my perception of teaching change? Self-discovery was what I wanted to discover. Through reflecting, I was able to monitor my development as a teacher. The negative side was obvious: the subjectivity of storytelling. The story was based on my observations, my interpretations, and my views. This also meant I could not generalize my findings. I could only state my change as a teacher.

It was through storytelling that civilization has thrived. Stories have been and still are handed down from generation to generation. The Diary of Anne Frank was her story. Generations for centuries will be reading the story of a teenage girl in a Nazi concentration camp. So, while storytelling is very subjective, it has its place in society. Contrary, Mein Kempf also was storytelling. Through this personal narrative, the world went to war.

Students

Students in the study school were very behind in their academics. Most students at this high school had a reading level of K-2. Another problem was the issue of background knowledge. Teachers reported repeatedly that the students did not have the basic knowledge. My students entered my classroom with very low reading, writing, and math knowledge. This was one reason for my study. It was my belief all students can benefit from classical education.

Because of the interdisciplinary nature as well as inquiry-based, classical education could help those who struggled. By implementing classical education techniques, I wanted to see how this affected teachers, students, and the administration.

The two biggest issues at the school were attendance and drug use. Some students were only present in the class once a week, others once every two weeks. This led to disruption in learning, especially in science and math. Reading fluency was also disruptive if students did not read consistently.

Drug use, marijuana, was very dominant in the school. While it was not legal for minors to consume the drug, this did not stop the usage. The student culture at the school was the biggest factor for this research. Drug use was the norm with marijuana as the drug of choice. The students used this drug throughout the day and the odor was constant in all classrooms. Although the school handbook clearly stated to report drug use, there were no consequences for such behavior. Marijuana causes the immature brain not to function properly (Weir, 2015). The students could not remember what was stated only moments before (Weir, 2015). They had no recollection of the previous day's lesson or even being present. The culture was the victim mentality. Students refused to take responsibility for their actions. This led to no learning taking place.

Charter School

The school was a charter school and thus is a public school. A local public school was a major sponsor of this school. This school in like manner of other charter schools had a CEO as its head. Also, I was able to use classical education in my classes because charters were able to adjust the curriculum if it maintained the state learning standards. The constraints of the school entailed how they wanted the school to be run. For example, high schools had extremely low

state test scores. It was mandated that teachers must test students on state tests weekly. The tests were based on the EOC standards. EOC was the end of content tests for subjects the state regarded as important. Over-testing incorrectly was considered part of the issue with low test scores (Mays, 2021). This study is about my students, me as the teacher, and the tensions, dilemmas, and synergies that are involved. Part testing at the school played a part in the study. Much time was taken away from my techniques to standardize the test for the students. The limitation was time. The study took place over only one trimester which students were tested heavily.

Instead of addressing the issue of reading, students were tested in weekly content courses. It was believed this weekly testing would increase the students' test scores on the actual EOC test. The issue was the time spent testing instead of teaching. Students were at a disadvantage in achieving learning without the reading component. Time and effort were being directed towards failure instead of time spent helping students increase reading comprehension through science, which would serve them and the stockholders better.

Summary of Section

As the researcher and teacher, I was to teach those who were present and wanted to learn. Teachers could make a difference in their students' reading and thus be more successful in life. Also, having completed the research, advice or seminars might be given to other teachers who might want to attempt this method. My goal was to teach students to be lifelong learners and that begins with reading. How this affects the classical education teacher in the classroom with these factors was the center of this study.

Conclusion

Classical education should be studied more in public schools. If taking more time to integrate subjects and teaching skills could be foundational in classrooms, teachers could see the improvement in students reading. This study explored how I, as the teacher, was shaped by teaching classical education in a public school that did not use classical education. I used this pedagogy with my students. In doing so, I reflected on how I was shaped as a teacher in a public school. Also, I studied how the classroom environment was shaped using these techniques. Again, using reflection to see how the environment changed through my time in the class. Lastly, I studied how my perception of teaching changed as I taught classically in the public school setting. The SPN served as the method throughout the study. In this dissertation's method section, I explained in depth how it will be used.

Chapter 2 - Literature Review

The research purpose is to explore how a classically trained science teacher implements classical techniques in a non-classical setting. Classical education has repeatedly produced students with high test scores in every area (Vaughan, 2018). There are several reasons for this. One reason is class education teaches the mind (Blake, 2019). Skills are taught instead of individual subjects. Another reason is how engaged the students are during school learning. This increases attention spans attitude and confidence. Once these three are increased, literacy is usually the byproduct of attitude and confidence. This section investigated the literature on classical education, copy work, and reading as it relates to science and writing.

Classical Education

Classical education is a pedagogy that uses the trivium that is, the grammar, logic, and rhetoric stages (Bauer & Wise, 2016). The trivium dates to the Greek Empire and produced such graduates as Alexander the Great, Galileo, Martin Luther, and Thomas Jefferson. This section briefly explains classical education based on the literature.

The trivium is used in every class at every age and skill teaching. To teach the periodic table, the students would first learn about atoms and subatomic particles. Drawing the hydrogen atom and then the helium atom on the board to discover the similarities and differences is one way of teaching at the grammar stage. Once the students have detected the pattern, they move on to more complex atoms. Then students are ready for the next stage of logic. They learn about the group 18 atoms, then group 17, etc. From logic, they predict some of the other groups. Finally, in the rhetoric stage, students explain their reasoning and be able to transfer their knowledge.

The Socratic method is used to help the students move from one stage to another of the trivium or even quadrium. The Socratic method is a series of questions asked by the teacher

(Garrett, 1998). These questions allow the students to come to the proper answer themselves. While this method could be used on all ages, there needs to be a progression of critical thinking on the part of the students. The end goal is for the students to begin asking the questions to themselves and others.

In the example of the periodic table, the students know how to calculate the mass of any atom. Students are then asked why some atoms do not have whole numbers for their mass. Students usually state the mass comes from the electrons. The rebuttal is electrons are not added to the mass. After the students have wrestled with the problem, students are then asked to review what they have learned about isotopes. From this review, students then realized the assumption they had accepted and changed their answers.

In the Socratic method, students sometimes entertain circular reasoning. Students need to understand not only the basics of topics, but intermediate or even higher attributes of the topic. Also, the students take on most of the responsibility for the learning. The teacher guides and gives the basic framework for learning to take place. As the name suggests, this method was developed by Socrates. He would have conversations with his students in the manner of questions. Socrates thought it was better for students to come to their conclusions, beliefs, and any changes on their own (Delić & Bećirović, 2016). At the beginning of education in the United States, students were taught using this method. When the government began to oversee education, the method all but disappeared. Then in the 1800s, law schools began to use the Socrates method as part of the court training. From there, private schools began reintroducing it and finally, public schools are slowly adding it to their toolbox (Schneider, 2013).

Science and Classical Education

For many students, science is a subject that is hard, incomprehensible, and leads to increased stress levels. Other students do not see the value in studying science as it does not seem to give them any skills for their future. This study includes how class education can change the attitude of students toward science using classical education. With changing attitudes, normally confidence level of learning can increase. If students understand skills learned in science can be applied to all parts of life, their attitude and confidence will increase. With this added attitude and confidence what would happen to the writing level of these students?

Classical education focuses not only on truth but skills. Students are encouraged to assess their abilities based on a standard and then increase their skills. This is true for science as well. Classical techniques are much aligned with inquiry-based learning. Although John Dewey is acknowledged for the term, the model goes back to the Greeks (Dewey, 1938). In this model, the students become the scientists. Teachers are the coaches, but allow the students to find the law, theory, or explanation themselves. When this model is applied, the students have a greater interest in science (Gibson & Chase, 2002).

This pedology is centered around literature and history, with many eras studied. In true classical education, the subjects are intertwined; traditionally known as interdisciplinary. Essentially, it is the ultimate cross-curriculum classroom. Students begin with the ancients. They study Samaria and the first civilization. They learn how ancient civilizations developed culture and how they lived, including the science of the time. Students read the stories the ancients read. In a sense, they go back in time to live as they did. In science, the student might have learned how archeologists found out the aspects of Samaria. During the time of the Ancient Egyptians,

how they built pyramids using levers and string for ninety-degree angles. In art, the student learns hieroglyphics. Of course, the class will mummify a chicken or other animal.

Math and Science Interdisciplinary

The concept of interdisciplinary in the classroom is becoming more popular. In classical education it is commonplace. The overlap of math and science is easy to understand. Mays (2021) states, "No one learns to solve problems by watching the teacher work through examples… but when the students began trying to work out solutions for themselves, real learning begins" (p.108). I knew the students did not have the math background to internalize the factor-label method in chemistry class fully. Giving examples upon examples on the board was not going to help my students. Therefore, I had to allow them to learn by doing. Part of the learning was to embrace imperfection. Working out solutions does not happen by chance, rather hard work and part of the hard work is accepting mistakes. It is through the mistakes; that students begin to understand. One of the biggest challenges for anyone, especially, students is the ability to recover from mistakes. A toddler falls many times before he can walk or even stand. So, it is with working through chemistry word problems.

Copy Work

Copy work is the technique of having students copy, word-for-word, a mentor text, that eventually transitions to students developing their writing from the mentor text. The source of this work is great master writings history or other great literary works. The purpose of this method is to have the students master great writing. Being exposed to great writing has been associated with increasing writing skills. The reason behind this is that students are exposed to templates that can increase their knowledge and ability to write independently (Mutch, 2009). As students write without fretting about the template, they become more at ease and can concentrate

on the context. With time, students begin to develop an internal template on how to write. Some authorities say this technique is wrong because it teaches children how to plagiarize. However, there is no indication that this is the case it has shown just the opposite (Qin & Uccelli, 2021). For example, art students learn from their masters by copying their work. This does not lead to art forgeries. Music students learn from the great masters as well. Eventually, this leads to musicians being able to create their masterpieces.

Students learn how to structure sentence sentences in a way that is new to them. They will begin to use these structures in their writing (Qin & Uccelli, 2021). It is very similar to kindergarten students learning how to trace the alphabet using templates or elementary students learning words by tracing them. When students are exposed to different writing styles from the masters, students learn how to write better themselves.

This study merged the gap in introducing copy work at the 10th-grade level in chemistry. Original documents from Master of Science such as Lord Kelvin, Robert Boyle, or Michael Faraday could be used to expose the masters to the students.

Very little data is available for copy work in terms of higher math. The copy work would be both mathematical and English. Students who must write how a problem was solved in words will have a better understanding of the concept. This technique can be adapted to chemistry math problems and to understanding the periodic table.

According to Shields (2007), learning through imitation is an effective method for students to develop critical thinking skills. Scientists that students learn via copy work, will put forth an argument and the reasons why the argument should be accepted or rejected. As the students listen, they hear good grammar, argumentation, and writing.

As students complete copying tasks, they will gradually improve their ability to paraphrase and use more effective language choices (Qin & Uccelli, 2021). Students who borrow text can improve their literary skills by using language from masters. This is not plagiarism; rather, it is gaining an understanding of a concept as the experts did and being able to explain it (Qin & Uccelli, 2021).

What has not been explored is the connection between chemistry copy work with writing better lab write-ups. Normally, high school students will only fill out reports but not complete a full lab write-up with the science process included.

Writing can be very daunting, and most students cannot write on their own very well at the beginning. This is true even for high school students. Instead of having them frustrated with trying to write proper sentences, have them copied down from their masters so they get an idea of how to write well (Shields, 2007). This instills confidence with confidence comes a better attitude in writing they will be less afraid to put words on paper. They will have the confidence to write sentences that are coherent and creative because they've been exposed to the masters. This can be attributed to writing paragraphs and papers or research papers whatever is the case needed for this topic.

Attention Span

Learning cannot take place if the child cannot pay attention. If the child is not paying attention, the child cannot be transferred to them (Kern, 2021). At a young age, the attention span is concise. As time goes on attention span increases naturally. But as the electronic world has increased our attention span has decreased (Healy, 1998). Teachers are at a disadvantage when the attention span is no longer increasing naturally. Therefore, increasing their attention span will increase their learning ability. Copy work seems to be a way to increase the attention span.

Students concentrate on the words they are copying down. At the beginning, they will write one word at a time. As time goes on, they will learn how to see the phrase and copy down that phrase instead of word for word. This activity increases their attention span from word to word two phrases. Again, as time goes on, they will be able to copy sentences at a time. Over the years, they could copy down more than one sentence at a time. This all takes attention. Thus, copy work increases attention span (Van Hoornbeak, 2007).

Confidence

Students at the school in this study had attitudes that science was hard, and they felt there was no reason to study science, and they had no skills for life. With this type of attitude, learning can be very stifling. The students did not see any reason to persevere, stay engaged, or sometimes do their homework. All of this led to decreased learning. For the study, students were told the reasons why copy work was used during the year. They were told that copy work does increase attention span and helps in writing. And why was writing important in science? It was important because knowledge was transferred from scientists to scientists. But the skill of writing is a life skill. Writing well contributes to all parts of life whether that is getting a job, keeping the job, or even getting a promotion.

Currently, there is no literature on this type of instruction. This study will close the gap in this lack of literature status. Also, there is no literature to show the effects on students who have no experience with copy work until high school. Most of the literature is based on studies for elementary to middle school. Again, this study will strive to increase the literature entries in this area.

Metacognition

Metacognition for this study is defined as understanding what you know and what you do not know (Rhodes et al., 2020). Students will have more confidence if they understand how to learn. Teaching to the test does not promote true understanding of the content. Learning how to learn is essential in helping students become life-long learners. Students need to know if they are proficient in a topic before an assessment. This must be taught. It is crucial for teachers who want their students to become self-learners to teach them metacognition. Learning to monitor and control one's metacognition is important.

Metacognition empowers students to cultivate a heightened comprehension of scientific principles, nurturing both critical thinking aptitude and self-directed learning behaviors (Perry, et al., 2019). When students understand the thinking process, they can monitor the process. Students will learn how to self-assess for their one understanding and then be able to initiate the control process of metacognition. They will begin to relearn what is needed. This skill can be taught and used throughout their lives, thus becoming life-long learners.

Reading

Reading is such a fundamental skill for learning that this skill should be continued to be taught throughout the career of the student. It is a different skill set than writing, speaking, or even listening. When students read, they are building neural systems that create specialization systems in reading (Basics, 2007). Not only does the brain create these systems during reading, but it also connects all of them to form a brain that can read. This process does not end at the elementary grades, rather it continues to adulthood. Therefore, reading should be taught at each grade level.

Bauer (2003) explains, "[Secondary schools'] task is to produce students who are reading at the so-called 10th-grade level, a fluency that allows readers to absorb newspapers and Stephen

King with ease" p. 18). This task does not consider teaching chemistry to high schoolers. It also assumes the students are at a level that can achieve the 10th-grade mark by graduation. My students came into my class with no higher than 5th-grade level of reading.

The act of reading is a skill that can be taught. All students should be taught to read regardless of limitations. Reading builds vocabulary and cognitive skills (Cunningham & Stanovich, 1998). Also, it has been documented that verbal abilities increase through reading (Cunningham & Stanovich, 1998). Not only does reading build vocabulary, but it also creates pathways to the spoken language, that is speech and listening (Schlaggar & McCandliss, 2007). Reading skills contribute more than comprehension of a text, it increases the ability of students to communicate with the outside world.

In this study, I use history as the main topic for the reading. This meant I used biographies, Great Books, and original documents. Reading is not just knowing the words on the page and what the text says. "Students [need] to have a deep encounter that makes them beyond memorizing facts and challenges them to put forth the mental effort required to understand what's going on" (Mays, 2021, p. 109). I wanted my students to go beyond memorizing facts, I wanted them to understand. This meant I needed to give them the tools for understanding. The tools I decided on were books and history. Having the students explore Egypt through literature was the first unit in astronomy. Gathering many books of different reading levels, I laid them out for a book tasting. Students gathered around a table filled with beautiful books on Egypt. The topic provided the most beautiful pictures of the pyramids and pharaohs. Capturing the students' attention, they began to skim through the books. They each picked one after looking through many other books. Every day, they read ten minutes from their chosen book. At first, they were unfamiliar with reading time. As time went on, they grew to like the ten minutes. I overheard

them talking about their books because the content interested them. This gave them a reason to put forth the mental effort to understand.

Where the Study Fits

Copy work was not just for elementary students. In this exercise, students copy exactly what was written. The easiest example is when a kindergartener traces letters to learn the alphabet. Another example is when elementary students copy words or even sentences. This technique was not used in higher grades because of the fear of plagiarism. This is a misconception (Qin & Uccelli, 2021) as stated earlier.

This study will tell the story of a teacher, me, in a charter school that did not have a classical curriculum. This teacher teaches classically. The story explains not only the experience but the tensions and dilemmas. In addition, the synergies that occurred during the data collection period.

Writing Well

Many high school students do not know how to write properly. If there was copy work for those students, they would have examples. The best way to learn how to write is to write from a masters. Schools cannot demand their students write well when they have never been exposed to practicing writing well. This becomes a vicious cycle of demanding better writing, yet not offering proper help.

Some students are naturally born good writers, but this is not the case for every student. The same parallelism can be used when stating only a certain percentage of students are naturally good at math. Math being a language, teachers give students many examples before being allowed to try math on their own. Teachers will write on the board problems and the students copy them down exactly as written. This is no different than in English language writing. It was

found that students who have used copy work in the older grades up to 8th grade tend to write better and not plagiarize (Qin & Uccelli, 2021).

There were no studies found me that studied an inner-city high school that had not experienced classical education techniques until the 10th grade. This study would report the effect on the classical education teacher with high schoolers who have not experienced any classical education.

Experiment-Based Education and Project-Based Learning

Learning chemistry can be a daunting task for students. By using experiment-based education, students learn how the invisible world of atoms can be understood. Lecturing on a concept alone is not as effective as having experiments for the students to complete (Alizadeh & Alizadeh, 2023). Not only do they learn the concepts, but they learn other skills such as graphing, data generation, results reporting, as well as the writing of science. They need to create diagrams to mirror their experiment, research the content, and even how to perform a scientific experiment.

Students who perform experiments in science learn not only the experiment but the logic of the experiment. They begin to understand the how and why of the content (Ahmadi & Khodaei, 2020). During the experiments, students increase their science literacy by conversations and in their lab writing (Hofstein, 2004).

Project-based learning revolves around a topic and does not necessarily require an experiment. For instance, it can include studying the history of man-made elements. Students are given a task such as recreating the Space Race. In these projects, students are challenged to answer a question, discover the history of an event, or create a model. This allows students to use logic as well as rhetoric skills to accomplish the assignment (Kubiatko & Vaculová, 2011).

Conclusion

Good communication skills are important to have as a lifetime achievement. If students understood that copy work increased writing skills and this skill contributed to increasing quality of life, they would be more engaged, pay more attention, and even change their attitude. It has been shown that explaining to students the reason for the work can increase their ability to be willing to do it and to be conscious of how well they do it.

Writing has been an overall challenge in schools and science is no different. This literature review examined the studies on how copy work in science affects attitude toward science the confidence in learning science and writing well.

Chapter 3 - Methodology

This chapter focused on the method of the study. I explained the study design, the study context, my positionality, the data sources, data collection, and the analysis plan. To review, the research question is:

Research Question:

1) How does a teacher experience using classical education techniques in a non-classical educational environment at an inner-city public charter school?
    a. What are the tensions and dilemmas that the teacher experiences?
    b. What are the synergies the teacher experiences?

Study Design

The method chosen to answer the research question was Scholarly Personal Narrative or SPN. This design method was developed by Robert J Nash (Nash, 2004). SPN allows the researcher's experience to be the object of the study (Heidelberger & Uecker, 2009). I was both the participant and the researcher (Porath, 2022). Scholarly personal narrative entails recounting experiences from the writer's perspective while framing this account within the realm of scholarly discourse, typically drawing upon peer-reviewed journals. Within this narrative shrouded in scholarship, a story unfolds. This story was supported by the peer-reviewed which in turn was added to the knowledge database. SPN uses social science literature to give a frame of one's own life experiences to tell a story (Heidelberger & Uecker, 2009).

Choosing SPN

Scholarly personal narrative (SPN) was selected as the research method because it aligns with my personality. I am generally an introverted person who prefers to sit back and observe.

SPN allowed me to observe and reflect. By nature, I am a scientist with a writer's twist. This allowed me to be great at teaching science. I can tell a story and teach at the same time. SPN tells a story (Nash, 2004). My research questions centered around how I teach science classically at a public high school. SPN method has the scholars "place themselves at the center of their research design" (Nash & Bradley, 2011p. 87). By placing myself at the center, I told my story. Not only did I explain classical education, but I also explained the roller coaster of teaching classically at a nonclassical school.

SPN also allowed my writing reflections to be the data. Having me be the center, I explained my growth and development as a teacher and person in the public school system.

I collected data on myself. This meant I became the personal witness of my experiences. I became the storyteller of the data collection time frame (Nash, 2015). The reflections changed throughout the year as I changed. How did my perspective change in the months within the study with students who had never experienced classical education? How did I adjust to the challenges of creating my exercises for four different preps? Each of these classical education techniques is used in traditional classical schools (Association of Classical Christian Schools, 2022). Part of the discussion was the usage of these strategies in a non-classical setting.

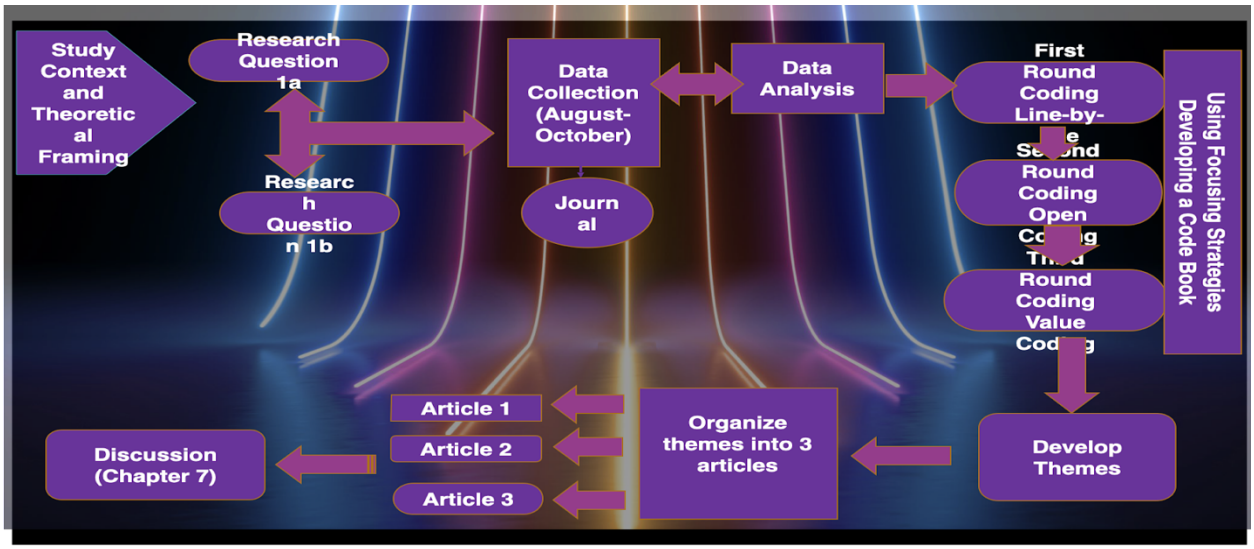
Initially, I planned on using a case study, however, parental permission became an issue; therefore, I chose SPN. Social research requires study to protect the research participants. This requires written consent from the parents of minors and the minors themselves. If the participants are of majority age, then only their written consent is required. The prospective participant's parents did not sign the consent forms. While a few majorities of age participants did sign, they eventually dropped my classes. This led to changing the method to SPN. The new method served

to document my transformation as a teacher and to see classical education considering public school.

SPN is "chosen by some [who]want to draw generous from literacy literary and artistic sources of scholarship as they examine a personal issue or professional conflict" (Nash & Bradley, 2011, p. 14). SPN uses scholarship to understand the narrative of the story for the researcher. It is how the data is explained in the context of the research questions using scholarly journals. Without the scholarship, the data is no more than a diary. With the literature, the data becomes part of the collection of knowledge in the social science realm.

Nash and Bradley continue, "Writing begins with a nagging need on the writer's part to tell some type of truth" (Nash & Bradley, 2011, p. 67). I wanted to know how the story of teaching classically in a non-classical school related to the literature known as educational research. By using the writer's pen to describe my journey of teaching at my school, I was able to tell the story of teaching students who never have experienced classical education. Scholarly literature provided the backdrop of knowledge and the lens by which I saw learning in the classroom.

Overview of Study



Study Context

This section focused on the background factors for understanding the research question, SPN, and the findings.

Background Factors

While learning the craft of classical education in my earlier years, I found myself explaining myself to parents who homeschooled using other curriculums. As I was the only parent classically teaching in my circle of friends, it became clear I was in the minority.

Later, parents began to see how my son was progressing differently than their children. They were hitting obstacles unfamiliar to them. Now the same parents who criticized me were coming for advice. It was my suggestion they try classical techniques to help their children. To their amazement, the advice helped.

By this time, I was teaching at a private classical school. The students had been classically trained since kindergarten, so they knew the regime of the learning. I began to wonder what would happen if students were not introduced to classical education until high school. The children of the parents to whom I gave advice were the only exposure I had on the topic.

When I became an inner-city high school teacher it was with the understanding I would teach classically. Since it was a charter school, it was approved. Now, I observed what happened when I was the only classical teacher in an entire high school.

Understanding the Method

Part of classical education is using original documents (Clark & Jain, 2021). Students read and study *The Double Helix* by James D. Watson and *We Seven* by Scott Carpenter (Watson, 1968; Carpenter, 1962). These two books were examples of personal accounts of history. The first was the story of finding the structure of DNA. The second was the story of the

seven Mercury astronauts. What they have in common is the story. They were personal stories. So, why not a personal story about teaching classical education? This study was my account of my time teaching in a charter school that did not teach classically. I explained the tension and situations that I faced teaching in this environment. How did I digest and reflect on the personal development days? How did I interact with my fellow teachers? What happened to my relationships in terms of give and take?

Journaling

Reflective journal writing creates the medium by which the teacher can clarify and learn from writing (Yinger & Clark, 1981). Writing involves many processes and allows learning to take place using these many processes (Emig, 1977).

Yinger and Clark argue that people learn through three modes. These modes include the enactive mode, the iconic mode, and the symbolic mode. Writing involves all three (Yinger & Clark, 1981). Not only can writing create an environment for learning, but it can also have both immediate and long-term feedback for the writer (Flower & Hayes, 1980).

By using journal writing, I, the teacher, can transform from the participant to the researcher. As Yinger and Clark so beautifully stated, "…journals are often employed as a means of talking and listening to oneself" (Yinger & Clark, 1981).

Table 1. Overview of data sources and analytic techniques by research question.

Research Questions	**Data Sources**	**Data Analysis**
RQ1 a and b	Reflective Journals	Thematic analysis using, in vivo coding, line by line, and value coding (Saldana, 2020)

Procedure

Table 2: Timeline

August 21, 2023 -November 9, 2023: Data collection period

November 10, 2023-January 1, 2024: Coding rounds

January 2, 2024 - February 29, 2024: Results and Findings

For SPN to be successful, ten guidelines were followed (Hyater-Adams, 2012). The ten include:

1. Establish clear constructs, hooks, and questions
2. Move from the particular to the general and back again...often
3. Try to draw larger implications from your personal stories
4. Draw from your vast store of formal background knowledge
5. Always try to tell a good story
6. Show some passion.
7. Tell your story in an open-ended way
8. Remember that writing is both a craft and an art
9. Use citations whenever appropriate.
10. Love and respect eloquent (i.e., clear) language

Using these guidelines, I had reflective entries using my perspective. This was done using a journal and not writing during class time, but rather, after class (Porath, 2022). I reflected on professional development activities and how I might include them in my classes. These entries served as the data for the research. How did I respond to the day's events and how that changed me as a teacher? In undergraduate and master-level education classes, pre-service teachers are asked to complete these reflections, but after the diploma or certificate, teachers do not reflect on

what is happening in the classroom. This research could demonstrate how reflecting as veteran teachers can help them prove their craft.

Table 3 Daily

Method	M	T	W	R	F
Copy Work	X		X		X
Reading/Summary	X	X	X	X	X
HBST		X		X	
Writing	X	X	X	X	X

The procedure included using classical education techniques in each class. Afterwards, I reflected on the teaching session, and then any trends that happened. The next section describes in detail how this procedure was completed.

For this study, I concentrated on two different areas. One was the classroom environment itself. The second was meetings or conversations with others. These areas allowed me to have a well-rounded viewpoint of my study.

Copy work was previously discussed. To review, copy work is a technique where the student copies exactly what is written from a text. The benefits of copy work are many. One is writing better. The act of copying from good writers helps students learn how to write with better confidence, ability, and skill.

The students completed copy work two times a week using different texts as determined by the content of the class. For example, the astronomy class would copy Johannes Kepler, *Harmonies of the World*. The students copied a section of the book for a designated time. This

work was not graded for content, but rather for completion. Grading for completion allowed the students to concentrate on the phrases and words of the good writer.

Overall Schedule

Mondays/Wednesdays

Step 1: Students completed copy work based on the content area.

Step 2: Students read a book for 10-15 minutes based on the content area.

Step 3: Part of the lesson was history based on the content area.

Step 4: All classes are written based on the content area.

Step 5: Talked with students throughout the class period.

Step 6: Reflected on copy work (Mondays)

Step 7: Reflected on Reading/summaries (Wednesdays)

Step 8: Reflected on writing (Wednesdays)

For texts and examples, refer to Appendix A.

Mondays Only (once a month)

Step 9: All staff meetings of the school.

Step 10: Conversation with a nonscience team member.

Step 11: Reflected on meeting and conversation.

Tuesdays/Thursdays

Step 12: Students read a book for 10-15 minutes based on the content area.

Step 13: Part of the lesson was history based on the content area.

Step 14: All classes are written based on the content area.

Step 15: Talked with students throughout the class period.

Step 16: Reflected on HBST (Thursdays).

For texts and examples, refer to Appendix A.

Fridays

Step 17: Students read a book for 10-15 minutes based on the content area.

Step 18: Part of the lesson was history based on the content area.

Step 19: All classes are written based on the content area.

Step 20: Talk with students throughout the class period.

Step 21: Reflected on Reading/summaries (Wednesdays)

Step 22: Reflected on writing (Wednesdays)

Step 23: Prepared lesson plan for next week based on content area and reflection.

For texts and examples, refer to Appendix A.

Fridays (Monthly)

Step 24: Professional Development for the district.

Step 25: Had a conversation with district teachers.

Step 26: Reflected on meeting and conversation(s)

Weekly

Step 27: Weekly data meeting for the science team

Step 28: Have a conversation with one or more science team member(s)

Step 29: Reflected on meeting and conversation(s)

For reflections, I wrote, describing my experiences in the classroom or with conversations with students, teachers, and other colleagues. During meetings such as data team and professional development, I reflected on my experiences and what I might be able to implement or not in my classes.

Data Collection

What happened to the journal entries? As with qualitative research, SPN codes data. My reflections were periodically copied and searched for trends (Porath, 2022). During this time, I shifted from the participant to the researcher. What trend did I observe in writing?

From the coding, I can begin to answer my research questions:

1) How does a teacher experience using classical education techniques in a non-classical educational environment at an inner-city public charter school?
    a. What are the tensions and dilemmas that the teacher experiences?
    b. What are the synergies the teacher experiences?

Not only was I using a nontraditional method for my research, but this was a nontraditional dissertation. I wrote a three-article dissertation. One journal I submitted my article was the *Principia: A Journal of Classical Education*. It is a new peer-reviewed journal for classical education. There are very few peer-reviewed articles about classical education that include SPN. I would like to be one of the first authors.

Another journal I submitted an article was the *Journal of Science and Mathematics Education.* This journal targeted not only science educators but also math educators. With science, math is the language. My second article in this journal will expose math educators to how scientists think about math.

Lastly, the *Journal of Research in Science Teaching* will be used for the third article. Science teaching journals that include research are important to keep up to date on how other teachers are implementing strategies.

Journaling/Reflection

As stated above, the data collection was not a diary. I began journaling during a time in my life when I wanted to write a science-fiction book. The place I started writing was the laboratory where I was employed. Chemists can spend many hours sitting at a chemical hood watching a reaction like watching water boil. This left me with much time to write. At first, I wrote like a scientist writing a procedure, very short and precise with no emotion. I decided to learn how to write not like a science textbook which meant I had to read genres other than scientific journals.

Reading became essential in teaching me how to write differently. I read books authored by Anna Katherine Green, Agatha Christie, Arthur Conan Doyle, and others. As I read, I highlighted portions of the text which I thought were great writing. Then, I began to expand my writing to include such texts. For example, I would write using some of the adverbs and adjectives I had highlighted. Slowly, I began to write in more journal-like phrases. Before long, I was writing differently. In the upcoming years, I was able to complete an entire sewn book every month.

For this study, I had to do more than just journaling, I had to reflect. This meant remembering details and events during class time. To properly reflect, I used a clipboard with sheets of each class attached. The sheets served as notes for lessons, communication for parents, and reminders for my data. I would write a few words to remind me of an incident or statements I overheard during class. The passing period at the school was five minutes. During this time, I would write a little more detail about what was on my sheets. I would write sticky notes during the passing period and place them in my journal for later. Another memory reminder was the

students' work. As I was grading, I would remember the context and events surrounding the completed work.

Context

Population

Students were inner-city charter high school students. None had been exposed to classical education techniques. The demographic profile of these students primarily consisted of individuals of African descent, with a notable proportion from refugee backgrounds. The academic capabilities varied significantly, with a majority performing at reading levels typical of fourth to sixth grade, and mathematical proficiency falling below grade standards. The parental involvement in their children's educational pursuits was lacking, prompting a shift in the methodological approach of this study. In addition, many students are from broken homes, and some are homeless. Students did not regard education as a priority and had discipline issues as well as the drug of choice being marijuana.

I, as the researcher, have a chemistry degree with over twenty years in the industry. Also, I hold a masters in secondary education. Being the researcher, I have five years teaching in public school four years teaching in a classical school, and twelve years homeschooling my son, classically. In addition, over ten years teaching and tutoring classically.

Sampling/Criteria

I taught using classical techniques every class period. Again, none of the students had experience in classical education and none of the teachers (other than me) had taught classically. During each class, the students had to copy work, read, and write. Copy work consisted of writing from astronomers, historical texts, or science documents. Copy work was completed two to three times a week for 10 minutes. During this time, students were given the texts to directly

copy onto their paper (Van Hoornbeak, 2008). This was also for 10 minutes. I collected all the papers and gave credit for completing the tasks.

Sources for the copy work included Galileo, Newton, von Braun, Halley, etc., and historical texts including biographies of the astronomers or accounts of observations such as witnesses to Halley's comet, moonwalk, etc. For example, Galileo's Dialogue excerpts were used for copy work (Galileo, 1978). Science documents are the laws and theories such as Newton's laws of motion. For additional sources, refer to Appendix A.

Writing included the Progymnastmata: narratives, encomiums, commonplace, comparison, and descriptive. Each unit includes one of these parts of the Progymnastmata (Fleming, 2003). This will be part of the history-based science teaching (HBST).

1. Copy work and were from the biology textbook: (*Biology*, 2017) and various chemistry texts.
2. The reading was the biography is Rosalind Franklin, The Dark Lady of DNA (Maddox, 2002).
3. Theories and laws were from biology (Cell theory, etc)

   For additional sources, refer to Appendix A.

Information Needed

To be able to answer my research questions, I needed honesty in the narratives. The information needed for SPN was the experience of the classroom. After the class, I recorded my experience and perspective. The form will be through journaling.

Lastly, I collected the students' copy work and had access to their Progymnastmata. I saw many changes that took place during the study with their work. The Progymnastmata was graded using a rubric and the students worked on them each class period. Since the students had never

been exposed to classical education, I had to teach them how to write each part of the Progymnastmata.

This method also allowed my writing to be the data. Having me be the center, I explained my growth and development as a teacher and person in the public school system. I collected data on myself. Using this method, I attempted to answer the following research questions:

1) How does a teacher experience using classical education techniques in a non-classical educational environment at an inner-city public charter school?

    a. What are the tensions and dilemmas that the teacher experiences?
    b. What are the synergies the teacher experiences?

Safeguarding Data

To safeguard the data, I had a notebook to record the reflections: any teachers or other people who have pseudonyms. The notebook was in my possession or always locked in my desk drawer.

Ethical Considerations

Trustworthiness

Trustworthiness is very important in social research. Not only do the participants need to trust the researcher, but the audience, that is, the reader needs to trust the researcher too. The definition of trustworthiness is to be worthy of confidence (Merriam-Webster, 2022). To accomplish trust, the research must be credible, transferable, and confirmable.

Transferrable

To be transferable, the method section will be detailed for the next researcher to be able to continue with the study. Description of the context, such as the method type and procedure, were discussed in previous sections.

Confirmable

Since the data is reflective, confirmability rests with the raw data of the journal. The journal was written in ink, sewn binding, and used normal practice for scientific lab book writing. That being all corrections had one line crossed out and dated with initials. No corrective tape, etc. was used.

Data Analysis Process

Coding

In addressing the research question, I engaged in the inductive process of coding. This included identifying and highlighting passages involving a careful examination. Furthermore, I emphasized recurring words and phrases, recognizing their potential to reveal patterns and insights, which will facilitate a more comprehensive, analytical exploration of the text. Upon completing this initial phase, I proceeded to transcribe the highlighted words and phrases, organizing them into twelve distinct categories using a spreadsheet. This systematic classification was guided by considerations of thematic coherence and the frequency with which certain terms and concepts recurred throughout the text. Such categorization provided a structured framework for deeper analysis and interpretation. After this categorization process, I undertook further investigation to discern broader patterns and trends within the highlighted content. I identified three overarching themes that recurred prominently and held significant relevance to the research inquiry. These themes, serving as pivotal focal points, were instrumental in shaping the foundational framework of the articles comprising this dissertation.

The initial coding process employed an inductive approach, utilizing in vivo, line-by-line coding. By using line-by-line, I reviewed my data and assigned codes (Saldana, 2021). Using my journal, I highlighted the coding which led to multiple rounds of line-by-line. Following this, I

conducted a second round of coding using open coding, that is, developing and labeling categories (Saldana, 2021). I aligned the categories with the specific questions and identified the following words and terms: events, administration, meetings, science department, students, teachers, questions, quotes, frustrations, delighted, classwork, and personal comments. Refer to Appendix B for the second round of coding results. From these results, I found three categories that were overarching of all the terms. This includes students, classwork, and the relationship between the two. This can be found in the appendix.

The third round of coding, value coding which related to my perspective. Attitude and beliefs (Saldana, 2021). Once this was employed, it resulted in the development of three primary categories: students, teaching strategies, and teacher-student relationships. It was through this coding process that I discerned the three themes for my articles: immersive environment, strategies, and metacognitive learning. My passion for teaching, coupled with my enthusiasm for the subject matter, resonated with the students. Furthermore, I aimed to convey to them the idea that learning is interdisciplinary, achievable, and a lifelong endeavor. Refer to Appendix C.

In my astronomy class, students raised questions about the relevance of studying the pyramids and ancient Egypt. To address this, I introduced the Time-Warp Classroom (TWC), an immersive learning environment. This became the focal point of the first article included in the dissertation.

In the realm of chemistry, students encountered challenges when converting units. To overcome these obstacles, I devised a strategy involving copy work, gradual release of responsibility, and the factor-label method (FLM). The second article delved into the implementation of this approach in a science classroom.

Lastly, the third article stemmed from students' lack of ownership over their learning. By creating the metacognitive peer learning document, students were empowered to take charge of their learning while benefiting from their peers. Through reflection, they could articulate their learning and plan their next steps. This article marks the third installment of the dissertation.

Delimitations

Period

For this study, I chose to focus on two semesters. With a charter school, there are no guarantees of the school being open for the next year. This current school has very low state test scores and has been rated for extreme overseeing. Another reason for the two semesters is the administration. Again, there is no promise that the current administration will continue the next year. The administration has been very open-minded about allowing me to use my classroom as the object of this study.

Class Selection

In addition to the delimitation of time, I elected to use my class specifically, one astronomy class and three chemistry classes. This led to other delimitations. I decided to use my classes that I am the teacher of record. The reason for delimiting was my experience in classical education, as I was the only teacher with such expertise. Also, since I was using only astronomy and chemistry classes, I cannot determine if my results transfer to other subjects.

Educational History

The last delimitation I selected is the education history of the students. I did not want any students who had been classically educated in the past. The reason is that I want to see how I changed with my teaching experience. I have a classical education teaching background. This

study is to see how I change with this background to a metropolitan charter school. Teaching in a private school is a different environment from a charter school.

This study will not be used to generalize any population in education. Rather, it is just the tip of what can be studied around classical education in high school students with no experience in the method. Having trustworthiness, limitations, and delimitations that are sound will be my focus for ethical considerations to be a researcher in an educational setting that can be trusted.

Positionality

I am a first-generation college graduate. Truthfully, I am a first-generation high school graduate. My family grew up in the deep south of Alabama with little or no formal education. While this might seem despairing, I did not comprehend this truth until I was an adult. To me, my parents and family were bright, wise, and successful. My mother had me reading at age 4. She read to me for hours upon hours until I read on my own. She never taught me phonics or whole words, rather she sat me in her lap and read the books while I looked on. By five years old, I was reading books my brother's sixth-grade books. My mother told me something that I have lived by my whole life. She said, "If you can read, there is nothing you can't do or learn."

My family moved to Kansas and lived in the country trailer park until I was in high school. We were not rich, but again, I did not know this until I was an adult. We always had what we needed. On Saturdays, my parents would study books to learn how to draft their dream home. If we were sick, my mom would read a medical book to learn how to make us well. Since we lived in the country the city library was too far for us to visit, but we had encyclopedias. I read all of them before I was ten.

First grade was going to be so much fun I thought. Then reality hit. I was already doing long divisions and could read at a high school level. Days I have dragged on and on. My teacher

could see I was reticent and very bored. She took me aside and gave me a reader and a math book. I was to work on my own. Once I passed a certain point, she had me complete a scavenger hunt. This hunt was not just in the classroom, but the entire hallway. The end prize was a piece of gum I got to chew the rest of the day. She made an impression on me that has never left.

I taught all my stuffed animals to read, but never thought I would be a teacher. I wanted to know everything and how everything worked. I became a scientist.

I received a degree in chemistry from Emporia State University and went into research. This was my dream job. So much to learn and to do. I helped develop the influenza test. Shortly after finding the correct substrate, I was laid off. Devastated! Next, I was in analytical chemistry. My job was testing water and soil samples for contaminants such as heavy metals. Just like in the past, I wanted to learn how to run all the instruments and the tests. I became the lead chemist and started training other chemists. This was very enjoyable. Training was easy for me, and I was good at it. This led to being transferred to St. Louis to start up my lab from scratch. I oversaw creating the layout of the lab, ordering the equipment, training, and my favorite, writing procedures. At no time did I see it as a foreshadowing of my future in teaching?

After getting pregnant, being a scientist was not my priority. Both my husband and I wanted to homeschool. What did I know about homeschooling? My mother's words came back to me, "If you can read, there is nothing you can't do or learn." During my pregnancy and two years after that, I read everything about teaching. One day when my son was three years old, he decided to become Spiderman and use his jump rope as his web to jump over the stairs. I caught him midair and said, "It is time to start school."

I never had so much fun teaching my son. All the reading and studying I had done led me to classical education. We studied ancient Egypt and the pyramids. All his stuffed animals had

been mummified with toilet paper and he learned basic math while sitting in a cardboard sarcophagus. Just like my mom, I read to him continually. We read C.S. Lewis, Jules Verne, and many more. He sat on my lap while I taught him phonics. He only had a few lessons when he took Mary Pope Osborne's book, *Tales from the Odyssey, Part 1,* and started reading it out loud (Osborne, 2010).

Other parents shared with me how hard it was for them to teach their children. This was a puzzle to me. It was hard for me to understand why was teaching so hard. Suddenly, I found myself training the parents how to homeschool. Explaining how to teach and why it works was so enjoyable.

Chapter 4 - Time-Warp Classroom

Article I: submitted to Principia Journal of Classical Education

Time-Warp Classroom: Classical Education

Pedagogy in the Secondary Science Classroom

This article introduces the concept of a teaching method called the Time-Warp Classroom, or TWC. The TWC approach aims to create a science classroom environment where the teaching methods focus on increasing student engagement, developing a lasting interest in learning through literary discussions, while closely following the institution's educational standards.

In the Time-Warp Classroom, students are metaphorically taken on a journey through different historical periods, such as the construction of the pyramids, the Renaissance era, the discovery of atoms, and the moon landing. By seamlessly combining various subjects like literature, history, math, and science, teachers in the TWC framework can provide a well-rounded education. This approach immerses students in the time and context of these significant periods, fostering a deeper understanding of the subjects and a greater appreciation for the connection between human accomplishments and the passage of time.

Keywords: science education, classical education, inquiry-based learning, holistic approach, interdisciplinary teaching, history of science

Introduction

In the context of a classical educational institution, where the major focus tends towards an emphasis on the literary and historical disciplines, the fields of science and mathematics are at times marginalized to a subordinate position. This positioning contributes to the misconception

that science is formidable and includes an insurmountable body of knowledge, accessible only to the intellectual elite. This misperception, rooted in this hierarchy, warrants consideration and reform to foster a more inclusive educational landscape.

This article is penned from the perspective of a scientist-turned-educator, compelled by a profound commitment to alleviating the challenges faced by students who harbor fear and reticence towards the field of science. In harmony with the aphorism attributed to Albert Einstein, which states "If you can't explain it simply, you don't understand it well enough."[1] Einstein emphasizes the need to demystify the complexities of science, making them accessible and comprehensible to students with a diverse range of aptitudes and aspirations. My professional background is in chemistry, with the range of medicinal, analytical, and quality assurance/control and I have been involved in the development of influenza test kits and in the examination of water and soil samples across the United States as part of Superfund projects. Furthermore, my work in quality control ensured the precise coloration of candies for a major company's desired presentation to the public. These multifaceted experiences provide me with a unique perspective on science education at the secondary level and its applications.

The objective of my teaching and the focus of this article is to bridge the schism between the domains of science and the humanities, fostering an interdisciplinary relationship within the educational environment. This goal is to foster a love for the rich tapestry of human knowledge

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[1] Ferguson, Sheila. 2008. "Challenging Disabilities Discrimination." News Gazette, Apr 20, https://er.lib.k-state.edu/login?url=https://www.proquest.com/newspapers/challenging-disabilities-discrimination/docview/332916867/se-2

and spark a passion for scientific exploration and understanding. The outcome is a group of students who are no longer separated by a gap between these two areas.

The march of science across the annals of history has occurred gradually, marked by a series of paradigm-shifting breakthroughs catalyzed by the scientists of their respective period. Importantly, numerous breakthroughs owe their genesis to the distinctive contextual backdrop against which they emerged.

Consider, for instance, the crucible of World War II, an era marked by global conflict and strife. It was within this context that the concept and creation of the atomic bomb materialized. This was driven by the necessities of wartime and the desire of governments to secure victory. Scientists too, were drawn into this endeavor, contributing to the United States' historic development and deployment of the atomic bomb. [2]

Similarly, the Space Race that characterized the mid-twentieth century catalyzed an intense rivalry between the USA and the USSR; both wanting to land on the Moon first. In the backdrop of the Cold War's geopolitical tensions, this competitive spirit spurred advancements in science and technology.

Innovations, such as Velcro, aided astronauts in zero gravity and the evolution of compact, high-capacity calculators emerged as byproducts of this technological race.[3] It is worthy to note that these advancements in miniaturization and efficiency have played pivotal roles in shaping the landscape of contemporary technology, including the existence of devices like modern smartphones.

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[2] Pappas, Charles. *One Giant Leap: Iconic and Inspiring Space Race Inventions that Shaped History*. Rowman & Littlefield, 2019

[3] Pappas, 2019.

Considering these historical events, I designed an educational framework I have entitled the Time-Warp Classroom (TWC). This pedagogical approach infuses science classrooms with the essence of classical education. Within the TWC, students are figuratively transported back in time, immersing themselves in the periods when scientific knowledge was originally discovered. This immersive approach naturally kindles student engagement while concurrently fostering a desire for life-long learning.

The foundation of TWC, rooted in the immersive environment, evokes a sense of time travel as students and instructors alike step back into history. While the focus of this article is astronomy, the concept extends seamlessly to any field of study. The unit centers on ancient astronomers and the reenactment of their tools[4] and techniques illustrates the TWC.

I started the class by having the class collectively write down questions they had about ancient Egypt and its role in astronomy. Students wrote on sticky easel pads placed on the wall for the unit's duration. As the questions were answered, the students wrote on the pads to demonstrate their new knowledge.

During a book tasting activity the students skimmed books on ancient Egypt and made selections for their personal choice reading.[5] This ignited their interest but also nurtured their autonomy in choosing what to read. This emphasis on student choice was a valuable catalyst for instilling a love for reading and self-directed learning. It empowered them to take ownership of

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[4] Kirby, Richard Shelton. *Engineering in history*. Courier Corporation, 1990.

[5] Hamilton, Buffy J. "Cultivating Reading Interest with Book Tasting." *School Library Monthly* 29, no. 3 (2012): 17-19.

their education, a practice often eclipsed by dictatorial reading assignments.[6] The books were an eclectic mix of fiction, nonfiction, picture books, science, archeology, and history.

It was during the reading time I heard the students tell each other what they learned. One student (paraphrased), “Oh my, they stored their organs in a jar in the tomb! Yuk!” This led to many students coming over to see the evidence.

Another student (paraphrased), “They pulled the brains out of their noses!” Again, students came around to see. Then some rushed back to their book to see what they would find.

What transpired in the classroom was an exchange of knowledge as students actively shared their reading experiences. This peer-to-peer sharing not only enriched their understanding but also fostered a collaborative and engaging learning environment.[7] It was a testament to the power of student-driven discussions and the way in which knowledge could be developed among a community of learners.

After the students researched the culture of the time, I asked them to pick what role they wanted to be in the time warp. By allowing each student to choose a specific role, whether it was a Pharaoh, priest, pyramid builder, worshipper, scribe, god, or goddess, it encouraged them to delve into the historical context and understand their chosen character.

By incorporating character-driven learning, students were provided with a strong connection to the past, enabling them to gain insights into the lives and perspectives of

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[6] Mason, George E., and John M. Mize. "Twenty-two sets of methods and materials for stimulating teenage reading." *Journal of Reading* 21, no. 8 (1978): 735-741.

[7] Ivey, Gay, and Peter H. Johnston. "Engaged reading as a collaborative transformative practice." *Journal of Literacy Research* 47, no. 3 (2015): 297-327.

individuals in ancient civilizations.[8] This pedagogical method, I have found, contributed to a more profound and lasting understanding of history and its influence on current society.

During this stage, students used materials and technologies available during the ancient era to create a scaled-down pyramid that aligned with celestial bodies, which was a compelling blend of hands-on experiential learning and application of the Pythagorean theorem.[9] This demonstrated how ancient cultures applied their knowledge to astronomy and mathematics.

Through these activities, students not only grasped the remarkable achievements of ancient cultures but also recognized the influence of these civilizations on the modern world. This holistic approach to education embodied the spirit of exploration, curiosity, and experiential learning, which contributed to fostering well-rounded, critical thinkers.[10]

The Teacher

The integration of my personal experiences as a scientist into the classroom setting not only humanized me as the instructor but also catalyzed fostering students' engagement in science education. This approach, encompassing the Nature of Science (NOS), not only illustrated the procedural aspects of scientific inquiry but delved deeper into the cognitive processes and motivations that drive scientific thinking.[11]

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[8] Dorion, Kirk Robert. "Science through drama: A multiple case exploration of the characteristics of drama activities used in secondary science lessons." *International journal of science education* 31, no. 16 (2009): 2247-2270.

[9] Julio, C. (1966). Hopscotch, transl. G. Rabassa.

[10] Bauer, Susan Wise, and Jessie Wise. 2009. *The Well-Trained Mind: A Guide to Classical Education at Home (Third Edition)*. W. W. Norton & Company.

[11] Jackson, Jane, Larry Dukerich, and David Hestenes. "Modeling Instruction: An Effective Model for Science Education." *Science Educator* 17, no. 1 (2008): 10-17.

Sharing stories of my own laboratory experiences, including the less glamorous moments, helped students connect with the human side of science.[12] It dispelled the perception of science as an inaccessible or flawless domain and instead portrayed it as an endeavor fraught with challenges, perseverance, and the need for adaptability.

Furthermore, the transformation of students into "scientists in training" within the Time-Warp Classroom is an effective pedagogical strategy.[13] Encouraging them to explore historical questions, such as how the ancient Egyptians constructed the Pyramids or why these monumental structures endure to this day, empowered them to embrace scientific inquiry to unravel the mysteries of the past.

Consequently, the incorporation of experiments and hands-on activities from daily life aligns with the modeling instruction method and resonates with the findings that such active learning methods can significantly enhance student engagement and comprehension.[14] This approach allows students to witness the practical applicability of scientific principles in their everyday experiences, thereby reinforcing the relevance of science in their lives.[15]

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[12] Sammel, Alison J. "Science as a human endeavour: Outlining scientific literacy and rethinking why we teach science." *Creative Education* 2014 (2014).

[13] Lawrence, Molly. "Students as scientists: Synthesizing standards-based with student-appropriate instruction." *Middle School Journal* 38, no. 4 (2007): 30-37.

[14] Jackson, Jane, Larry Dukerich, and David Hestenes. "Modeling Instruction: An Effective Model for Science Education." *Science Educator* 17, no. 1 (2008): 10-17.

[15] Schmidt, Jennifer A., Stephen S. Kafkas, Kimberly S. Maier, Lee Shumow, and Hayal Z. Kackar-Cam. "Why are we learning this? Using mixed methods to understand teachers' relevance statements and how they shape middle school students' perceptions of science utility." *Contemporary Educational Psychology* 57 (2019): 9-31.

Additionally, the role of the teacher as a passionate and enthusiastic mentor, guiding students toward critical thinking and independent experimentation, was indeed pivotal.[16] Encouraging students to design their experiments not only reinforced their understanding of scientific processes but also nurtures problem-solving skills, research acumen, and the ability to think critically and creatively.

The approach encapsulated the essence of classical education, wherein students were not passive recipients of knowledge but active seekers of truth and understanding.[17] This holistic and interdisciplinary teaching approach, encompassing history, science, literature, and critical thinking, not only enriched students' educational experiences but also equipped them with the tools and mindset to become lifelong learners and responsible stewards of their own learning journeys. Commitment to nurturing the curiosity and critical thinking skills of students exemplified the transformative potential of the Time-Warp Classroom.

Reading

I assigned my students the task of reading biographical works intertwined with the current subject matter I was teaching. I selected biographies highlighting the lives and contributions of scientists responsible for the laws of celestial bodies. Over an academic year, they read at least 300 pages. This served as a means of instilling a deep-seated appreciation for

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[16] Hestenes, David. "MODELING is the name of the game." In *A presentation at the NSF Modeling Conference*, vol. 8. 1993.

[17] McCoy, Brandon. "Classical Education: An Attractive School Choice for Parents. Issue Brief." *Manhattan Institute for Policy Research* (2021).

reading.[18] Furthermore, it was an opportunity for them to complete a task inside the crucible of the productive struggle. The significance of reading extended beyond acquiring knowledge; it also increased students' confidence. The challenge of reading a 300-page book can seem insurmountable. I observed a remarkable transformation when my students were tasked with reading a book that consists of more pages than they have ever been asked to read. The act of consistently progressing through chapters, which was not a textbook, gave them a profound sense of accomplishment. These books were not read online, rather, a physical book. Students can see their progress as the bookmark gets closer and closer to the end. This visual feedback reinforced the sense of accomplishment but also reminded them of their capacity to achieve over challenges and gave a sense of self-assurance.[19]

In addition to the development of self-confidence, students explored historical content. By immersing themselves in biographical narratives, my students were transported to the times of pioneering scientists and how they lived and worked. Such immersion enables the contextualized understanding of the scientific breakthroughs that have shaped the scientific community.[20]

This endeavor encouraged the love of reading as it exposed my students to great works of storytelling. Thus, it is my belief that this practice underlines the importance of the written word.

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[18] Wilhelm, Jeffrey D. *" You gotta be the book": teaching engaged and reflective reading with adolescents*. Teachers College Press, 2016.

[19] Halliday, Nancy. "Developing self-esteem through challenge education experiences." *Journal of Physical Education, Recreation & Dance* 70, no. 6 (1999): 51-58.

[20] McCoy, 2021.

The significance of reading may appear self-evident yet deserves explanation. but students need to be taught how reading influences a person. Reading, which is a cerebral exercise, increases creativity by using previous synapses in the brain to make new connections.[21] As individuals read literary works, they are confronted with novel ideas, perspectives, and scenarios. The act of assimilating information compels them to interlink insights with their preexisting knowledge reservoirs.[22]

In this, creativity flourishes. The reader's mind is engaged in imaginative thinking. These experiences, thoughts, and knowledge act as an intellectual symphony, birthing original ideas and unique viewpoints. Therefore, educators can inspire a lifelong commitment to the written word, empowering their students to embark upon a journey of enrichment and artistic expression.

Isaac Newton's timeless aphorism, "Standing on the shoulders of giants,"[23] resonates with the insights into the aspects of reading. When students read, the brain is not passive at all, rather, in a state of active engagement. The act of reading can develop greater content comprehension and ignite imagination. The result is a surge in self-assurance and is inspiring. I had one student ask to leave the classroom just to tell another teacher of his accomplishment. It became a badge of honor, a testament to his tenacity.

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[21] McKenzie S, Robinson NT, Herrera L, Churchill JC, Eichenbaum H. Learning causes reorganization of neuronal firing patterns to represent related experiences within a hippocampal schema. J Neurosci. 2013 Jun 19;33(25):10243-56. Doi.

[22] McKenzie, Robinson, Herrera, Churchill, & Eichenbaum, 2013.

[23] Turnbull, Herbert Westren. "The correspondence of Isaac Newton: 1661–1675, vol. 1." 1959.

Students not only obtained the treasures of knowledge and imagination but cultivated the attributes of perseverance and self-belief. These were qualities that extend beyond the classroom, equipping them with the fortitude to face life's challenges with determination.[24]

When students delved into the story of scientific discoveries, they were not merely passive spectators but active participants in the drama of human progress. Understanding the historical context of the scientific content with a human dimension showed the perseverance and struggles of the scientists.[25]

Consider the struggle and triumph of the Moon Landing. It was not merely an event but a saga of human aspiration and accomplishment. By including the students in the journey, the setbacks, and determination, the lunar landing was infused with emotional resonance. This kindled a connection between the students and the subject matter. They no longer passively assimilate facts; they engaged with the material, inspired by the human narrative.

In this manner, historical context transformed science from the abstract to concrete. It granted students the capacity to approach their studies with a deeper sense of understanding, empathy, and emotional attachment. Thus, they were not merely learners; they became custodians of human achievement, to shape the future with the wisdom gleaned from the past.[26]

One of my astronomy students, studying the Space Race, initially displayed her displeasure for the topic, however she chose to read one of the astronauts' biographies. Reading about the Apollo I incident where three astronauts lost their lives in what is known as The Fire,

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[24] Wilhelm, 2016.

[25] Du, Xu, Sheng Yuan, Ying Liu, and Xuejun Bai. "Reading struggle stories of role models can improve Students' growth mindsets." *Frontiers in Psychology* 12 (2021): 747039.

[26] McCoy, 2021.

she was confronted with an appreciation of the struggle and bravery of the astronauts. She had an emotional connection to her reading and was no longer disinterested in the topic.

This emotional connection to the sacrifices and challenges faced by the astronauts fostered a more profound appreciation of the Moon Landing. It transformed the event from the distant and abstract into a moving narrative.[27] This new connection, born of empathy, rendered the Moon Landing a symbol of human courage and determination in her eyes.

This example reinforces the idea that history is not merely a collection of facts but of lived experiences, passions, and sacrifices. By incorporating such narratives into education, we enrich the learning process, engendering a more profound and lasting understanding of the subject matter.

A commitment to an interdisciplinary approach in teaching serves as a testament to the depth and richness of the classical educational experience.[28] Including various disciplines in the study of astronomy broadens the horizons of students and underscores the interconnectedness of knowledge.

For example, incorporating the ancient astronomers, such as the Egyptians, into my astronomy curriculum provided the students with a historical foundation for the timeline of astronomy. This historical context gave the study of astronomy a sense of continuity that showed how human understanding of the universe evolved over time. Additionally, integrating art projects related to the pyramids helped the students understand the integral role of culture and architecture, bridging the gap between science and art. The pyramids were created to express the

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[27] Mason, 1978.

[28] Wall, Natasha Jean. *An interdisciplinary curriculum for classical studies*. Roosevelt University, 2004.

Egyptians' devotion to their gods through art. Another purpose of the creation of the pyramids was the position of the stars in relation to their structures.

Also in the historical timeline, in the study of constellations, an introduction of Greek and Roman gods enhances the facets of astronomy The constellations were named after the characters the stories the ancient societies created about the stars. The planets and heavenly bodies all have exciting stories behind them, and the students formed an emotional connection with the literature. It encouraged students to explore the relationship between science and literature.[29] This approach provoked a more holistic and imaginative understanding of the night sky.

Modern life draws from many of the Greek/Roman mythological stories. On more than one occasion, my students stated they saw the connection between the naming of the different projects of NASA and literary contexts. This helped them remember the names and their mission. For example, the Gemini Project of NASA included two astronauts in each mission. The students remembered the Gemini were the twins in the sky.

Having an awareness of how ancient astronomers influenced modern understandings of space, we moved to the 1950s Space Race. Including World War II and the Cold War into the context of the Space Race added a political and historical dimension to the scientific narrative. It highlighted how space exploration was profoundly shaped by global geopolitical events and the competition between superpowers. Encouraging students to examine the intricacies of different governments involved not only supported an awareness of politics but also critical thinking skills as they analyzed the motivations and consequences of these historical events.

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[29] Wilhelm, 2016.

When exploring the geocentric vs. heliocentric model during the TWC, I created a thoughtful debate by posing questions. These models represent the two theories of whether Earth or the Sun is the center of the universe. I started by asking my students what evidence they have encountered supporting each model, prompting them to evaluate the strengths and weaknesses of both. Questions I asked were "How do you determine the legitimacy of that model?" or "What observations and evidence play in the model?" This helped guide their exploration of these contrasting worldviews.

In the class discussion about our Sun, I used the debate of light as a wave or particle to provoke deep reflection. My students researched light and its behavior. Then they took sides and debated whether light was a wave or particle. I encouraged students to recreate this scientific conundrum. Scientists like Young and Einstein lived in our classroom. This approach helped my students actively grapple with the fundamental concepts, while promoting critical thinking and a deeper comprehension of the subject matter.

At the end of the debate, I asked them what scientific debates were currently being argued. The students that the issue of when life begins for a human and creation versus evolution were topics unanswered in our lives. I found it interesting the students began having discussions about these topics in a way that proved their understanding of the scientific community.[30]

The global event of the moon landing on July 20, 1969, united the world for a brief time as everyone watched in anticipation of the first step on the moon. There had not been a global experience like this one until the COVID pandemic. Students of today are decades detached from this event and space travel is no longer a novelty. Within this part of the unit, the goal was to

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[30] Rudolph, John L. "Historical writing on science education: A view of the landscape." *Studies in science education* 44, no. 1 (2008): 63-82.

help students connect to the context of the time and place. Reading stories of high school students growing up in USSR during the Cold War impacted them. I heard students gasp when reading about teenagers their age whose family members were sent away for criticizing the government. Giving them historical context allowed a more emotional and human connection to stepping onto another world for the first time in history.[31]

For one assignment, I asked students to write their view of Wernher von Braun and operation Paperclip.[32] Dr. von Braun, a World War II German Nazi scientist, developed the first long range ballistic missile. This led to the liquid stage engine of the rocket that made it to the Moon. Operation Paperclip was the name given to the operation where the US government found and gave asylum to the Nazi scientists. My students had to weigh the importance of winning the Space Race versus employing a known Nazi who designed the Saturn V.

In summary, the interdisciplinary approach in this teaching methodology not only enriched the subject matter but also equipped students with a broader and more holistic perspective on knowledge. It empowered students to view the world through a multidisciplinary lens, fostering a deeper and more understanding of the subjects studied.

Conclusion

This article demonstrates the transformative journey of integrating the perspectives of a scientist-turned-educator into the educational realm, thereby transposing scientific experiences into the classroom environment. The primary focus was to alleviate the anxiety and aversion often harbored by students towards scientific disciplines, fostering a convergence between the

[31] Rudolph, 2008.

[32] Perry, Holly R. "Operation Paperclip." (2022).

realms of science and humanities. The intent was to cultivate an enduring, affirmative rapport between students and the pursuit of knowledge in science.

Central to nurturing this rapport was the introduction of the Time-Warp Classroom (TWC), a classroom construct design to transport students back in time, enabling them to assume the roles of pioneering scientists within the epoch of groundbreaking discoveries and inventions.

The TWC experience unfolds within the classroom through an immersive engagement with scientific literature. Students partake in shared reading experiences, not only with their peers but also with the ethos and ethos of the era under study. By engaging with literature, students immerse themselves in character-driven learning, grounding theoretical knowledge in practical applications.

Crucially, beyond the realm of literature, the infusion of the scientist-educator's personal experiences from the laboratory assumes paramount importance. Sharing narratives from the laboratory serves as a conduit for instilling passion and fervor, thus empowering students to become proactive pursuers in their academic endeavors.

Integral to this mentorship dynamic is the fervent promotion of a love for reading. The educator's active participation in reading endeavors, coupled with discussions on personal literary preferences, serves as an instrumental catalyst in cultivating an appreciation for reading among students. This symbiosis between scientific content and literary exploration creates a harmonious synergy, fostering a sense of achievement and encouraging inter-student dialogue, thereby bolstering creativity and self-assurance among learners.

Chapter 5 - Factor-Label Method

Article II: submitted to *Journal of Science and Mathematics Education*

Factor-Label Method: A Triad Model

Abstract

This article delves into the practical application of three teaching methods—copy work, gradual release of responsibility, and modeling recovery—for introducing the factor-label method (FLM) to secondary science students. FLM, a problem-solving tool in science education, not only aids in mathematical comprehension but also fosters a mindset of continuous growth among learners. By blending traditional educational practices with modern pedagogical approaches, this approach aims to not only improve academic performance but also develop students' resilience and critical thinking abilities. Drawing from the firsthand experiences of a former scientist turned educator at an urban charter high school, this article employs a personal narrative to illustrate the impact of these methods on student learning. Through the scholarly personal narrative (SPN), the article provides valuable insights into the effectiveness of this triad model in enhancing student engagement and academic achievement, with implications for science education in various educational settings.

Keywords: Factor-label method, unit conversions, mathematical problem solving, chemical education, high school science

Introduction

In my experience as a chemistry educator, I devote as much time to teaching math concepts as I do chemistry principles. One area where students often struggle is in unit conversion, a concept that can be particularly confounding.

To address this challenge, I employ three key strategies in teaching chemical word problems to my students: copy work, gradual release of responsibility, and modeling recovery. These approaches are designed to give students the necessary tools to navigate mathematical concepts in chemical problems. Through a combination of these strategies, students are guided through the process of understanding and applying unit conversions effectively, enhancing their proficiency in both chemistry and mathematics.

Central to science is the Factor-Label Method (FLM), a tool that aids students in the comprehension of scientific conversions. Also recognized as dimension analysis, this method converts from one unit to another including the conversion from both metric and English systems (DeLorenzo, 1994). Scientists use this method daily.

In a classical education setting, FLM would be taught in the higher elementary grades. This allows students not yet in the logic stage to be introduced to logic steps (Cotter, 2001). With the introduction of this logic, word problems and critical thinking in general will be easier to resolve. In the test school, classical education is not practiced therefore, FLM is not introduced until high school.

Within the realm of high school science education, this skill is paramount. Despite its ideal introduction in earlier educational phases, students often encounter limited exposure to units. Bridging this instructional gap and empowering students with mastery in FLM a structured approach.

In cultivating mastery of this crucial skill, my instructional approach hinges upon a trifecta of strategies: Copy work (CW), gradual release of responsibility, and modeling recovery.

Through the orchestration of CW, gradual release of responsibility (GRR), and modeling recovery, the goal transcends mere skill acquisition. It instills not just proficiency in scientific conversions but also a mindset embracing challenges for intellectual development (McClure,1995). This union of methodologies within the instructional framework seeks to foster a culture wherein students perceive the process of learning as an ongoing journey marked by resilience, perseverance, and continual improvement.

Classical Education

Classical education follows the trivium, which includes grammar, logic, and rhetoric stages, guiding students through a structured learning journey (Bauer & Wise, 2007). Students start with mastering basics (grammar), move on to critical thinking (logic), and then persuasive communication skills (rhetoric). This section provides a brief overview of classical education explaining its core principles.

Each part of the trivium is taught for each content. For example, teaching the periodic table, students begin with basics like the parts of an atom. The teacher would have the students work through the hydrogen, helium, lithium, etc. atoms, calculating the number of neutrons.

The logic stage would include predicting some of the other elements on the periodic table, answering how the table is arranged. For rhetoric, students would write an essay explaining the next created element's (element 119) characteristics.

This educational approach prioritizes both truth and skills development. Students are encouraged to evaluate their own abilities against a standard and strive for improvement—a principle applicable to science education as well. Classical methods align closely with inquiry-based learning, a concept often associated with John Dewey but with roots tracing back to ancient Greek educational practices (Dewey, 1938).

Students take on the role of scientists, with teachers acting as guides or coaches who facilitate rather than dictate the learning process. This approach empowers students to discover scientific principles and theories on their own. Research has shown that implementing this model fosters a heightened interest in science among students (Gibson & Chase, 2002).

Factor-Label Method (FLM)

FLM, sometimes called dimensional analysis, is a technique for converting from one unit to another, including from metric to standard systems. It utilizes the Multiplicative Identity Property of 1 which states any number multiplied by 1 equals the original number. For example:

$$5 \text{ X } 1 = 5 \qquad (1)$$

Another property is any number other than zero divided by itself is 1 which is known as the Division Properties of One. Example is:

$$7/7 = 1 \qquad (2)$$

Combing both properties lead to:

If,

$$5 \text{ X } 1 = 5 \qquad (1)$$

And,

$$7/7 = 1 \qquad (2)$$

then,

$$5 \text{ X } (7/7) = 5 \qquad (3)$$

An example of FLM using these properties is:

How many mls are in 5 liters?

$$1 \text{ liter} = 1000 \text{ ml} \quad (4)$$

Therefore,

$$\frac{1 \text{ liter}}{1000 \text{ ml}} \text{ is equal to } 1 \quad (5)$$

$$5 \text{ liters} \times (1000 \text{ ml}/1 \text{ liter}) = 5000 \text{ ml} \quad (6)$$

This instructional approach empowers students to decode complex word problems through a lens of logic. By embracing logic, students are equipped with the tools necessary to dissect problem scenarios, identify relevant information, and devise systematic strategies for arriving at solutions. This departure from rote memorization cultivates a deeper understanding of mathematical principles (Navidi & Baker, 1984).

The logic of the FLM can enhance a broader comprehension of the underlying concepts. Rather than relying solely on memorized procedures, students develop the ability to discern patterns, make connections between different mathematical concepts, and apply logical reasoning to problem-solving tasks. This approach not only strengthens their mathematical skills but also nurtures their analytical thinking abilities which are necessary for chemistry instruction (Tsaparlis, 2000).

Methodology

My utilization of the Scholarly Personal Narrative (SPN) method is a deliberate and strategic choice. SPN is a methodological approach placing the researcher's own experiences at the forefront of the study (Heidelberger & Uecker, 2009). As the term suggests, it is a personal

narrative on the topic but is infiltered with academic sources of experts for knowledge and understanding.

The SPN method, renowned for its emphasis on the researcher's lived experiences, includes my narrative with a distinctive and introspective quality (Nash, 2004). By actively immersing myself in the research process as both a participant and a researcher, I bring forth a perspective that goes beyond conventional objectivity (Porath, 2022). This intentional intertwining of the subject matter acknowledges and embraces the inherent subjectivity embedded in the research.

The decision to utilize SPN in the context of classical education within the public-school system allows for a more profound exploration of the challenges and successes encountered in pedagogical differences within the school.

By weaving my own experiences into the narrative, I contribute a personalized and firsthand account that enriches the scholarly discourse and provides valuable insights into the practicalities of implementing classical education within the constraints of the public school arena.

The SPN method of written expression serves as the data and constitutes an introspective approach. By situating myself as the focal point, I manage the narrative through which I am an educator and an individual within the crucible of the public school scene. The prospect of accumulating data on my own professional and personal development, with the written medium as the record, imparts a dynamic quality. The writing of this journey is poised to capture growth throughout the academic year. This self-reflexive methodology renders the narrative a living testament to my experiences, summarizing the transformation that accompanies time.

In the Classroom

Completing Algebra I is imperative for chemistry students to be successful. The test school has a distinctive two-year course structure. Although passing algebra does not align with attaining active knowledge in my classes. The emphasis on connecting mathematical concepts to their scientific applications reveals a gap for most students. It is my vocation to transcend rote learning and instill a profound understanding of the symbiotic relationship between mathematics and science.

It is not a requirement to know the fundamentals of algebra to learn the FLM. For example, one does not need to know how the quadratic equation to convert from ounces to milliliters. Algebra is math using letters as unknowns and solving for the unknowns. Therefore, only the basic knowledge of algebra is required.

Part of the daily routine for the class is the engagement with copy work and this serves as a perceptive gauge of their existing level of mathematical proficiency. This strategic approach not only facilitates an assessment of their comprehension but also provides a foundation upon which I can tailor my guidance in advancing their skills in unit conversion.

Copy work, or CW, is a way to acquaint students with FLM. It involves the meticulous replication of complex problems utilizing the method (DeLorenzo, 1994). Emphasizing exact replication without delving into comprehension, this approach enables students to familiarize themselves with the method's structure and mathematical arrangement. Concentrating on format rather than comprehension, this method serves to focus on the organizational intricacies of the FLM (Van Hoornbeak, 2007).

Utilizing (CW) as an initial introduction to the FLM serves as a deliberate strategy in my instructional methodology. This pedagogical approach involves presenting students with

intricately structured FLM problems and instructing them to transcribe these without delving into comprehension. The primary objective is to familiarize students with the visual layout and formatting inherent in the method, encouraging them to concentrate on the method's structure rather than its intricate details (Van Hoornbeak, 2007).

Each instructional session I present students with a distinctive and complex FLM problem to copy onto paper. This consistent exposure aims to acclimatize them to the method's formatting intricacies, emphasizing unit spacing and mathematical organization (Qin & Uccelli, 2021).

During my data collection, i.e., journaling, I noted, on September 18, the students did not understand why they had to just copy. Many thought they had to solve for a unit. Others had never seen units. I had several students who refused to comply. For those students, I only stated they would not receive the points. During the silent time of copying, many who refused decided it was better to copy than receive zero points.

In introducing the concept of copy work to my students, it becomes imperative to provide explicit guidance on the procedural aspects of this academic exercise. Initial perceptions often misconstrue it as a conventional worksheet, leading to a sense of panic among students who grapple with the unfamiliarity of the task.

The ensuing panic, induced by a perceived lack of understanding, underscores the necessity of explaining the true nature of copy work. It is upon me to emphasize the directive to replicate the provided material with precision, regardless of the extent to which students' progress. The emphasis squarely placed on the meticulous reproduction of the written content.

As this exercise is continued, students become accustomed to copy work. Invariably, students will tell me they understand why copy work is important. Even to state copy work helped them better understand how to approach problems logically.

Simultaneously, I complement this practice with a simplified problem-solving demonstration on the board, explaining the step-by-step process involved in executing the Factor-Label Method. This is part of the gradual release of responsibility (GRR) (Fisher & Frey, 2013). Additionally, I supplement this in-class instruction with a PowerPoint presentation that expounds upon the method for understanding through its availability on the digital platform, specifically Google Classroom for student reference (Google, 2024; Power Point, 2024).

As the GRR strategy suggests, I do not have the students complete the steps at the beginning. Rather, I start out by walking through the first three steps. I ask them to state the steps together as they look at their notes and I talk them through a problem. This is repeated with several problems until they are comfortable with telling me what to write.

I have the three steps as:

1. *Write what you want on the far right*
2. *Write what you know on the far left as a fraction include units*
3. *Write a large multiplication sign to the right of the known*

I use these steps to offer confidence to the students. These steps serve to understand what is being asked of the students. As our previous example:

How many mls are in 5 liters?

1. What is the question asking? How many mls.
2. What is known? 5 liters

Therefore:

$$\frac{5 \text{ Liters}}{1} \quad X \quad = \_\_\_\_ \text{mls} \qquad (7)$$

I noticed my students began approaching all questions in the same manner. They learned to understand what was being asked before answering. Next, they began to see what they knew. I overheard one student going through these steps when answering questions in another subject.

Then it is their turn. I have a student go to the board and complete one of the steps as another states the step. Again, once everyone has a turn, I then have the students use their own boards to complete the first three steps. It is common for students to hesitate to display their abilities in public. It is imperative to have the students understand it is part of the process. Normally, a student who believes they understand the skill goes first.

Lastly, they perform the three steps by themselves. This can take several days as I only teach FLM in fifteen-minute intervals. Do Nows and exit slips are used to gauge the week's duration.

As part of the requirement per teacher handbook, Do Nows must be present at the beginning of each class period. Do Nows are short, less than seven-minute mini assignments. These have multiple purposes.

One is to have the students transition from one class to another. With students having up to six different subjects per day, Do Nows allows their minds to focus on the given subject. Another purpose is to assess the students for the day's work. This permits teachers to decide if any summarizing, reteaching, or other discussion needs to be in place. Still another function is to set up the daily lesson. Students will understand what the lesson may entail.

Patience and constructive teaching atmosphere are of the utmost importance since immediate mastery is not expected. By expressing my commitment to supporting them through

this journey over the forthcoming class periods, I demonstrate a dedication to nurturing a gradual and comprehensive understanding of the skill.

This approach is characterized by an awareness of the educational landscape, a commitment to fostering active knowledge, and a strategic utilization of student feedback to tailor the learning experience. This not only contributes to the advancement of mathematical proficiency but also underscores a broader commitment to cultivating a holistic understanding of the interplay between mathematics and science among students.

It is noteworthy that points are allocated not based on the culmination of the task but rather on active participation in the exercise. This intentional approach aligns with the cultivation of commendable work habits, as students are encouraged to engage in the process of exact replication without the burden of completion expectations. Consequently, this pedagogical methodology contributes to fostering an environment wherein participation is esteemed, and work habits are duly recognized (Van Hoornbeak, 2007).

As the students acclimate to this practice, a shift occurs in their perspective and approach. Once the realization crystallizes that copy work entails the replication of written content, a stress reduction ensues, paving the way for an almost therapeutic engagement with the task.

This positive behavior is particularly instrumental in the seamless transition between classes. The acquisition of this skill not only serves as a practical means of transitioning but also empowers the students. The gradual release of cognitive load, facilitated by the clarity of understanding the content, becomes manifest. The students embark on a journey wherein the act of copying transforms into a conduit for comprehending the subject matter.

The relationship between the mechanical act of replication and the cognitive absorption of content underscores the efficacy of copy work as an educational tool. This dual functionality

not only streamlines the educational experience but also is a supplement to the students' sense of empowerment as they traverse the academic landscape with a newfound grasp of the material.

Conscious of time, I reserve approximately fifteen minutes daily dedicated to teaching the FLM. Initially utilizing Do Nows for CW during the initial week, I gradually transitioned to employing the first few moments of class for engaging students in discussions pertaining to the fundamental steps inherent in the method. This incremental approach ensures consistent exposure and gradual assimilation of FLM principles without overwhelming students.

By intertwining CW practice sessions with simplified problem demonstrations, and concise yet consistent class time allocation, the instructional design aims to engender a foundational comprehension of the FLM (Mutch, 2009). This scaffolded approach not only familiarizes students with the method's visual structure but also incrementally immerses them in the rudimentary steps essential for grasping the essence of FLM, fostering a trajectory toward comprehensive proficiency.

Modeling recovery embodies a core tenet of my instructional framework, aiming to alleviate students' stress in confronting challenges. Within the classroom setting, I engage in real-time problem-solving, abstaining from pre-prepared exercises. I do this by not having the answers nor the step-by-step format completed beforehand. By navigating through problems alongside students and openly rectifying my mistakes, I exemplify the acceptance of errors as an inherent part of the learning process. This approach cultivates a learning environment where mistakes are perceived as opportunities for growth, encouraging students to embrace their fallibilities as steppingstones toward mastery.

In addressing the challenges faced by students prone to shutting down. I employ a strategy during class sessions. Instead of presenting pre-written practice problems, I generate

exercises in real-time, crafting questions on the spot. This deliberate approach allows me to engage alongside students in problem-solving exercises, enabling me to encounter and rectify mistakes just as they do (McClure, 1995). This inclusive method fosters an environment where mistakes are not only accepted but openly acknowledged and corrected.

Should students arrive at different solutions than mine, I refrain from presuming my correctness. Rather, I conduct a transparent review of my work in their presence, validating their answers and correcting my errors when necessary. This practice of openly acknowledging and rectifying mistakes, whether computational or conceptual, demonstrates to students the intrinsic nature of errors as integral facets of the learning process (Meijer, Korthagen & Vasalos, 2009).

In the gradual release of responsibility model, the deliberate inclusion of instruction on error recovery within the FLM domain is pivotal. This deliberate emphasis on the recoverability of mistakes resonates with the forgiving nature of FLM, particularly when units are employed. It is an integral tenet of the philosophy that errors need not signal a complete reset; rather, they serve as catalysts for additional steps in the problem-solving continuum (Tsaparlis, 2000).

The interactive exchange wherein students articulate the steps provides a dynamic platform for the encounter of errors, both by the students themselves and occasionally by the instructor. This revelation becomes an opportunity to unveil the art of recovery from mistakes. Transparency in acknowledging and rectifying errors is a pedagogical asset that not only demystifies the learning process but also instills resilience in the students (McClure, 1995). I heard one of my students speaking with another cohort, not to worry about how messy it looks, and that I (the teacher) would help fix it.

The demonstrated recovery process, coupled with the acknowledgment that mistakes are inherent in the learning journey, fosters a growth mindset within the academic setting. Students,

when confronted with errors, no longer perceive them as insurmountable obstacles but rather as integral components of the educational track. The instructor's willingness to model fallibility further normalizes the concept of learning through trial and error, contributing to a classroom culture where mistakes are not stigmatized but embraced as steppingstones to understanding.

The inclusion of error recovery as a pivotal component of the gradual release model not only fortifies students with practical problem-solving skills but also assists in them with the resilience and adaptability necessary for navigating the intricacies of FLM. This holistic approach to learning underscores the transformative potential embedded within the acknowledgment and rectification of mistakes.

By exhibiting the process of recognizing and rectifying mistakes without reservation, I convey to students that errors are inherent in learning and are not indicative of failure. This approach instills in them the understanding that errors serve learning and growth, fostering a classroom culture where inquiry and clarification regarding problem-solving steps are encouraged. Emphasizing the value of making mistakes as a pathway to learning, I encourage students to embrace errors as opportunities for acquiring deeper comprehension (Jackson, Dukerich & Hestenes 2008).

Through this approach, students are empowered to view mistakes not as setbacks but as steppingstones toward understanding. The classroom thus nurtures a mindset that perceives errors as integral components of the learning journey, fostering a culture of resilience, curiosity, and a relentless pursuit of knowledge (O'Reilley, 1998).

My journal entry from September 29 provides a compelling insight into this pedagogical approach during a session on the FLM with the 4th-hour class. The strategic utilization of

repetition, engagement with whiteboards, and a constructive response to mistakes showcases a thoughtful and effective teaching methodology.

Beginning with a review of the FLM steps, which the students had been writing for Do Nows, exemplifies the importance of reinforcing those steps. I decided to have them repeat the steps on their whiteboards which serves as a dynamic and participatory method to assess their familiarity with the process.

The exercise involving a problem on the BenQ, where students completed step 1 on their whiteboards, gave me the observation of behavior among those who made mistakes and provided insights into the students' collaborative dynamics and learning processes.

At a pivotal moment I intervened and directed everyone to their lab books, writing down the three crucial steps—Must make mistakes, must keep writing, Must multiply by one. This intervention not only addresses the immediate challenge but also instills a mindset that embraces mistakes as integral to the learning journey.

I spoke on the importance of mistakes as opportunities for progress resonates with a growth-oriented perspective. The assurance I will not abandon them in their mistakes fosters a sense of security and encourages a risk-taking attitude among students.

The connection between writing, synapse formation, and learning underscores a neuroscientific dimension to teaching philosophy (Rhodes, Cleary & DeLosh, 2020). Encouraging students to persist in writing, even if uncertain, until the "light bulb" moment occurs reflects a commitment to the cognitive processes that underpin learning.

Finally, incorporation of the multiplication by one theorem in the context of the FLM provides a conceptual bridge between algebraic principles and practical applications in unit

conversion. This interdisciplinary approach enhances students' understanding by relating mathematical concepts to real-world scenarios.

The acquisition of a new skill necessitates a profound acknowledgment of the inevitability of making mistakes. Embracing and even encouraging mistakes become pivotal elements in the learning process, providing ground for growth and improvement. Importantly, the teacher plays a central role in shaping the students' response to errors by fostering an environment where mistakes are not only accepted but also viewed as opportunities for learning.

Encouraging a positive attitude towards mistakes involves not only acknowledging their occurrence but also demonstrating how to recover from them. This approach underscores the importance of resilience and problem-solving in the face of errors. By openly addressing and exploring mistakes together with the students, the teacher cultivates a collaborative and supportive learning atmosphere.

The transparency of the teacher, refusing to conceal mistakes, contributes to an authentic learning experience. Instead of creating a façade of infallibility, the teacher becomes a model of continuous learning and improvement. This authenticity fosters trust and rapport between the teacher and students, creating a safe space where learners feel comfortable admitting and addressing their own errors.

Crucially, the teacher's response to mistakes becomes a pivotal factor in determining how well students recover from errors. A constructive and supportive response, along with guidance on rectifying mistakes, propels the learning process forward. The teacher's role shifts to a facilitator of exploration and understanding.

The recognition and acceptance of mistakes, coupled with a teacher's transparent and supportive response, create a conducive learning environment. This approach not only instills

resilience in students but also nurtures a mindset that perceives mistakes as integral components of the learning journey. The teacher's guidance in navigating and recovering from mistakes becomes a cornerstone in shaping the overall effectiveness of the learning process.

Conclusion

In summary, the FLM emerges as an accessible skill for students, even those unfamiliar with it, through a carefully designed pedagogical approach. The introduction of the method through copy work proves instrumental in acquainting students with its format, allowing them to visually grasp the procedure. This initial exposure sets the stage for the subsequent phase – the gradual release of responsibility.

Within the Gradual Release of Responsibility (GRR) framework, students incrementally acquire mastery of the FLM and its associated steps. The GRR methodology facilitates a dynamic learning process wherein students not only grasp the technicalities but also internalize the underlying logic essential for skill mastery. This approach fosters individual confidence, giving students the opportunity to collaborate in groups while benefiting from the teacher's guidance.

The recognition that mistakes are an inherent part of the learning process is emphasized. This acknowledgment creates an environment where errors are viewed as essential steppingstones toward perfecting the method. By instilling the notion that mistakes are not only acceptable but necessary, students develop a more positive and open attitude towards learning how to proficiently convert units.

The FLM is demystified and rendered approachable through a sequence of intentional pedagogical steps. The combination of copy work, the Gradual Release of Responsibility, and the acceptance of mistakes as part of the learning journey collectively contributes to a conducive

learning environment. This comprehensive approach not only equips students with the necessary skills but also fosters a resilient and confident mindset in their scientific endeavors.

Chapter 6 - Metacognitive Learning

Article III: to be submitted to *Journal of Research in Science Teaching*

Metacognitive Learning in Science Education

Worksheets have been used in classrooms for a long time. A worksheet as defined for this article is a paper for recording work completed (Oxford Online Dictionary, n.d.). Often worksheets are static records of tasks completed. Worksheets are useful for a few reasons including the ease of distribution portability, and the paper trail of tracking the completion of tasks. While this is true, there are drawbacks to worksheets which can be easily copied from, typically worksheets cover rote knowledge and can be considered busy work. Having the evidence of growth of knowledge is more informative to the student and teacher than a worksheet which typically only displays work that was completed A document provides information or evidence of something (Oxford Online Dictionary, n.d.); which in education would be evidence of learning. Intentionally designing dynamic documents to demonstrate evidence of growth in learning positions learning as a process, not knowledge as acquisition. Therefore, I use dynamic documents of learning instead of the static worksheet in my chemistry class.

As a teacher of science, I have found that students will write down notes and even work equations but still do not understand the concept. To address this issue, I developed a document that I call a metacognitive peer learning document or the MPLD. Although it may look like a typical worksheet on the surface, I used this document to introduce metacognitive strategies that helped students understand what they already knew and what they needed to learn. Using a classical education approach, this document extended beyond merely cultivating proficiency in chemistry. The work on the MPLD instilled a mindset for students that perceived challenges as the channel for growth. This synthesis of classical educational precepts with contemporary

pedagogical methodologies endeavored not solely to impart academic acuity but also to equip students with the fortitude and problem-solving imperative for their cognitive journey. Through scholarly personal narrative, this article demonstrates the development, implementation, and assessment of the MPLD with a reflection on the strengths and weaknesses utilizing it as a pedagogical technique. Finally, I will consider the implications of both this research and the document itself on teaching and learning.

Metacognition

Metacognition can be defined as the understanding of the capability to govern one's thinking process (Flavell, 1979). Practically, students understand how they think and what they know about certain topics.

By cultivating these cognitive control skills, students can enhance their ability to manage tasks, regulate emotions, and achieve their goals more efficiently and proficiently. Metacognition empowers individuals to reflect on their thinking patterns, monitor their understanding, and adapt their strategies as needed (Flavell, 1981). This reflective practice not only improves academic performance but also fosters lifelong learning and personal development.

Integrating metacognition with learning core chemistry ideas and scientific practices is essential for science education. Metacognition enables students to develop a deeper understanding of scientific concepts while fostering critical thinking skills and self-regulated learning habits (Perry, et al., 2019).

By intertwining metacognition with science education, students gain the ability to reflect on their thinking processes, monitor their understanding of scientific concepts, and adapt their learning strategies accordingly (Avargil, et al. 2018). This reflective practice helps students

recognize misconceptions, identify gaps in their knowledge, and develop effective problem-solving skills essential for scientific inquiry.

Through these processes, students become more adept at recognizing when they encounter challenges and identifying effective strategies to overcome them. This self-awareness empowers students to take ownership of their learning journey, advocating for their needs and seeking out resources and support when necessary (Bada, & Olusegun, 2015). By equipping them with the tools to regulate their learning, students gain confidence in their ability to navigate academic tasks and achieve their goals. They learn to set realistic expectations, manage their time effectively, and persevere in the face of obstacles, cultivating resilience and determination. By encouraging reflection, monitoring, and evaluation of their learning experiences, students develop the skills and mindset necessary to take control of their learning journey and achieve success in school and beyond.

Metacognitive Peer-Learning Document

Documents of Learning serve as a pragmatic vehicle for introducing and reinforcing the intricacies of science education. Through deliberately designed questions, students are exposed to a gamut of scenarios, enabling them to assess their learning. This deliberate exposure, coupled with guided instruction, cultivates a visual acuity for applying the method and fosters incremental comprehension.

Constructivist theory consists of believing the student learns by their experiences (Bada, & Olusegun, 2015). Classical education involves this theory through inquiry-based learning. This type of learning allows the students to learn as they study content for themselves.

In crafting instructional materials, I made a deliberate choice to not utilize the term "worksheet." This decision was rooted in the recognition that the term inherently conveyed the

notion of presenting questions or tasks for students to complete. Instead, I elected to refer to these materials as "documents," a term that suggested a broader scope beyond mere tasks, highlighting the role as comprehensive records intended to provide valuable information to students.

Documents of Learning served as platforms through which students engaged with content, explored concepts, and navigated their own cognitive situations. Within these documents, students encountered a wealth of information that enabled them to assess their current understanding, identify gaps in their knowledge, and chart pathways for further learning and growth.

Moreover, these documents function not only as repositories of information but also as dynamic tools for fostering effective communication and facilitating the exchange of ideas. By framing them as documents, I encouraged students to view them not just as static resources to be consumed, but as interactive mediums for collaboration, inquiry, and critical thinking. The Document of Learning served as a springboard or dialogue, enabling students to articulate their thoughts, pose questions, and engage in meaningful discussions with peers.

The "Metacognitive Peer Learning Document" (MPLD) was a resource I have developed to aid students in understanding the contents of a lesson. It is divided into three key phases: Content Area, Peer Learning, and Reflection.

Self-Assessment/Self-Reflection

Encouraging students to partake in self-assessment cultivates accountability and self-awareness, both crucial attributes for fostering effective learning environments (Fouche, 2013). By assuming responsibility for evaluating their comprehension levels, students are prompted to actively engage with the material and reflect on their understanding (Muskita & Subali, 2020).

This process not only instills a sense of ownership in their learning journey but also facilitates the identification of strengths and areas requiring improvement.

In addition, guiding students through purposeful engagement with the learning material enhances their study skills and strategies (Fouche, 2013). Techniques such as summarization, questioning, and synthesizing information enable students to extract meaningful insights from the material. By actively participating in these activities, students develop effective study habits that are transferable across various academic disciplines (Bauer & Wise, 2007).

By encouraging self-assessment and reflection, students are equipped with the tools to identify areas of weakness and take proactive steps to address them (Clarà, 2015). This process not only enhances academic performance but also promotes a sense of agency and control over one's learning journey, thereby mitigating feelings of anxiety and apprehension.

Methodology

Context

Navigating the education landscape within a state-controlled school that diverges from conventional pedagogical norms, such as classical education, poses inherent challenges. The complexity is particularly pronounced for students who do not meet grade level expectations in mathematics and reading when confronted with the responsibility to maintain learning standards, especially regarding teaching science.

In such a complex undertaking, pedagogical strategies necessitate an adaptive approach. Addressing the fundamental gap between math and reading is a critical component of effective science education. Tailoring instructional methods to accommodate gaps and employing differentiated techniques could bridge the existing educational disparities.

The commitment to fostering an inclusive and supportive learning environment, coupled with a creative and flexible instructional methodology, stands as a formidable response to the challenges presented in this distinctive educational setting.

Conversely, a charter school, while still a public school, reveals a distinct advantage through its business-like organizational structure and flexibility in teaching methodologies. Freed from traditional public-school curricula, administrators in charter schools offer educators the latitude to explore innovative approaches to pedagogy. This newfound freedom has allowed me to seamlessly integrate classical education pedology into my instructional practices.

In this school, I place a deliberate emphasis on basic skills, which could provide a more effective way of addressing the differences between students' math and reading skills which are important in learning science, especially chemistry. The classical education paradigm, with its time-tested focus on the trivium of grammar, logic, and rhetoric, provides a framework for cultivating critical thinking skills and academic excellence.

Metacognition is a valuable tool in classical education. Helping students to understand how they think and learn is important to teach for lifelong learning (Gogh & Kovari, 2018). Students should be encouraged to explore their interests and given the tools to do so using their K12 subjects. This article I examine how metacognitive peer learning documents can assist students in lifelong learning and success in their future endeavors.

Within the flexible confines of the charter school environment, I can tailor my teaching methods to cater to the unique needs of my students. This adaptability, rooted in classical education principles, prompts a more holistic and integrated approach to learning. The result is an enriched educational experience that not only meets mandated standards but also nurtures a deeper and more meaningful engagement with the subject matter.

The integration of classical education pedology within the charter school framework has afforded me a more adaptable and responsive approach. This not only addresses the intricacies posed by students with varying levels of proficiency in math and reading but also exemplifies the potential impact of my teaching methods in enriching the educational experience within a given educational setting.

Methods

I deliberately selected the Scholarly Personal Narrative (SPN) method to illuminate the incorporation of classical education within the public-school sphere. Placing my own experiences at the forefront of the study, this methodological approach reflects a commitment to an exploration of the intersection between classical education principles and the dynamics of the public-school setting (Heidelberger & Uecker, 2009).

Recognized for its emphasis on the researcher's lived experiences, the SPN method imparts a distinctive and introspective quality to my narrative (Nash, 2004). By actively engaging in the research process as both a participant and a researcher, I brought forth a perspective that transcends conventional objectivity (Porath, 2022). This intentional intertwining of the subject matter acknowledges and embraces the inherent subjectivity embedded in the research process.

The decision to employ the SPN method in the context of navigating classical education within the public-school system signifies an acknowledgment of the complex interplay between personal experiences and broader educational paradigms. This method enables a more profound exploration of the challenges and successes encountered in integrating classical education principles, offering a deeper understanding of the practical implications.

The recognition of the subjective nature inherent in the SPN method underscores a commitment to authenticity and transparency. By weaving my own experiences into the narrative,

I contribute a personalized and firsthand account that enriches the scholarly discourse and provides valuable insights into the practicalities of implementing classical education within the constraints of the public-school arena.

In summary, the adoption of the SPN method reflects a deliberate and intentional approach to research, elevating the significance of my own experiences in navigating the complexities of introducing classical education principles in the public-school context. This methodological choice aligns with a broader commitment to a holistic exploration of the intricate relationship between personal experiences and the broader educational landscape.

This methodological approach, where my written expression becomes the data, embodies an introspective paradigm. By placing myself as the central focus, I shape the narrative as both an educator and an individual navigating the complexities of the public-school environment. The systematic gathering of data concerning my professional and personal development, utilizing the written medium as the primary record, introduces a dynamic quality to the study.

To adhere to SPN, I journaled throughout the trimester about my teaching and my impressions on the students using the MPLD. As the name suggests, I used. My journal as data throughout the trimester. The trimester was twelve weeks in length with seventy minutes for each class. I had three classes in which I implemented the document. To code my data, I used line-by-line (Saldana, 2021). Using the results of the line-by-line, I used open coding to decide the categories (Saldana, 2021). Finally, using value coding, I was able to narrow down the categories to determine how to improve on the MPLD (Saldana, 2021).

The flexibility of writing, mirroring the fluctuation of this educational journey, captures my experiences and serves as a comprehensive summary of the progression that unfolds over time.

Development of the Document

The development of this document will be discussed in this section. MPLD was created to have a proactive approach to addressing the challenges posed by irregular student attendance, discipline issues, and frequent field trips in my teaching environment. The implementation of Metacognitive Peer learning documents (MPLD) with a well-structured format was a thoughtful strategy to foster independent learning and assess students' understanding effectively.

First, it was important not to overload the document or the students with too much content. This would lead to widening the gaps in knowledge and frustration among students (Cushman, 1994). Therefore, I assessed the students throughout the unit to decide which information to include. Some assessments included activities like Do Nows, exit tickets, and other forms of assessments to guide the document's content (refer to the appendix for examples of the document).

To illustrate how I included the design, I chose to concentrate on the units of pH, acids, and bases. Students need to understand what pH includes and what constitutes an acid or base. Overall, they need to know why understanding these concepts is important. When deciding what content to use for the MPLD, I looked back and the purpose of the unit and aligned the document to the learning standard. The standard I used was:

HS-PS1-11: Acids and Bases	Plan and investigate to compare properties and behaviors of acids and bases. Examples of properties could include pH values (concentration), neutralization capability and conductivity. Observations of behaviors could include the effects on indicators, reactions with other

	substances, and efficacy in performing titrations. (NGSS, 2024)

Some questions on the MPLD included the following:

1. Create a chart that displays the differences between acids and bases.
2. Explain the following equation: pH= -log [OH^-]
3. Given the following elements, list them in decreasing activity:
   - Lithium
   - Gold
   - Aluminum
   - Zinc
4. What determines if an aqueous solution is an acid, base, or neutral?
5. Write a balanced equation of MgO in acid-base chemistry.

Typically, I will write ten questions for the document. Refer to the appendix D for a complete document. The questions are derived from the learning standard as well as what the purpose of the unit. I start very basic on the first MPLD of the unit. As from the above example, the questions are very simplistic. This type of MPLD could be used as a pre-test. During the peer interaction, I discern how well they understand the concepts. The speed of completing the document and the communication tells a lot about the content knowledge. An example would be the vocabulary the peers use with each other. One student I overheard spoke in terms of the proton donor. This type of terminology demonstrated the student understood the concept of acid and base.

Student Use of the Document

I gave the students the document at the beginning of the week so they could work on it consistently throughout the week. Students did not work on the document the entire class time, rather I set aside time for the work, then continued with the rest of my lesson plan. I was still teaching on acids and bases, but they would work on their lab or lab write-up. Part of the lesson

was spent performing problems in acids and bases using the equations associated with acids and bases. During this time, it is not unusual for students to begin making connections from the MPLD and the other parts of the lesson. One student commented during the lab write-up that he began to understand the equation of the above question 5. Also, students do not work on the document as homework. Students tend to find the answer and write it down without understanding. If they complete the document in class, they will have the group experience of being in the "same boat." Also, I, as the teacher, want to observe the learning taking place. By this observation, I can better assess the class.

When I gave the students the MPLD, they a color-coded the questions for themselves using a three-color system:

- **Green** signified questions students were confident of the correctness of their answers, harboring no doubts.
- **Yellow** was designated for questions where uncertainty persisted regarding the correctness of the answers or when there were queries about the content.
- **Red** highlighted questions where students anticipated their answers might be incorrect. While attempting these questions was not mandatory, students were welcome to try.

Students were to answer all the green and yellow questions. For the red, they were to explain why the question was colored red. The rubric for this portion of the document was as follows:

Were all questions colored-coded? _/4
Were all the green questions answered? _/2
Were all the yellow questions answered? _/2
Were there explanations for red questions? _/2

_/10

The graded evaluation during this phase considered the color code used, the completion of questions marked in green and yellow, and the students' accountable explanation for the red-coded sections. This explanation was not an excuse but a candid acknowledgment of responsibility. For instance, stating absence without obtaining notes was not an explanation, while “I did not make up work for when I was absent,” was not an explanation. The explanation needed to be in the first person to show ownership. This is a skill that must be taught. On September 25th in my journal, I recorded many of my students who did not explain why they could not answer some of the questions. Some wrote they missed class. I had to prompt them to take ownership of missing content during absences.

Using the Socratic Method, I spoke to each of them about their reasonings. I asked,

“Why did you not know how to answer the question?”

“Why do you think you do not know?”

“What would allow you to answer the question?’

“How could you get that information?”

“What do you need to do to get that information?”

I did not assume a perfect understanding when no red was present; instead, at this stage, evaluation centered on the color-coded system, completed questions, and the honesty of self-reflection.

The structured approach outlined encourages students to undertake a self-assessment of their comprehension of the content presented in the document, thereby fostering accountability and self-awareness. This method guides students through a purposeful engagement with the learning material, promoting a deeper understanding of the subject matter (Fouche, 2013).

On the same day as the above entry, my students were admitting to themselves they needed to be present in class. Also, they admitted to not understanding but did not ask for help. While others confessed, they did not take notes and needed to start and obtain notes from classmates. It was at that moment, that I reassured them of my agreement and looked forward to seeing their renewed dedication to learning.

Peer Learning

Following the document's initial grading, the classroom dynamic shifted as students gathered into groups to review their answers. During this phase, I actively positioned myself to facilitate and monitor peer discussions.

Engaging in comprehensive discussions, students debated and dissected each question, ensuring active participation from all peer members. To encourage everyone to take part, I included the participation as a grade. I would be watching and listening to the conversations and inform them of my intentions. The use of notes was permitted, encouraging students to rely on their understanding rather than external resources like textbooks or computers. Notably, red-coded questions received the most attention, allowing students with potential answers to demonstrate their methods to the group. This stage fostered extensive discourse, encouraging questions, debates, and clarifications among peers.

I assumed an attentive role, listening intently to each peer's discussions. This meant keenly observing instances where students believed they understood the concepts but stumbled due to miscalculations or content misunderstandings. Admittedly, this is one of my favorite parts of the MPLD. My students, who have been together in the district for years, show their sibling-like behavior. I also have a log which I use to list my notes for each class. The list consists of questions students asked the most, concepts I need to reteach, which students had a hard time

with, and those who did well. This log came into existence through my many years in industry. Creating personal logs became essential when working with instruments that consistently needed troubleshooting. Each instrument had its own lab book. During this phase, I have heard students argue over an answer in chemistry. One group of peers grabbed white boards and markers to have what mounted to be a heated discussion over whether a certain solution was more acidic than another solution. Still another set of peers were debating what happens when sodium hydroxide and water are mixed. I overheard one peer comment about how he/she thought that when the sodium hydroxide and water are mixed, the concentration of OH^- ions increase. This comment let me know the student understood the concept of acids and bases.

There were times when I overheard peers discuss misinformation. One such common misconception I overheard was the pH of an acid was seven to fourteen. I came around to my peers and softly asked if they were sure of that comment. They looked it up and found out they were wrong. These observations serve as invaluable cues for addressing common misconceptions or clarifying misunderstood concepts to the entire class.

Once the peer learning stage has been completed, the document undergoes a secondary grading process, considering factors such as the completion of all questions, the participation, and the accuracy of responses. The following rubric is applied:

Are all the questions answered?	_/2
Did the document holder participate in peer learning?	_/3
Are the answers accurate?	_/5
	_/10

The red questions needed to be answered in peer learning. Peer learning can increase self-confidence in the student for the content (Cooper, 2002). Also, it was important to note that if

completed correctly, peer learning allowed all participants to learn more than if they were separated (Keerthirathne, 2020).

Incorporating peer learning within the framework of the MPLDs enriched the educational experience for my students and afforded me, as the instructor, valuable insights into their comprehension levels and communication dynamics. The enjoyment derived by students from highlighting their knowledge fostered an engaging learning environment (Bauer & Wise, 2016).

Integrating peer learning into the MPLDs framework represented deliberate effort to enhance the educational journey for students. By collaborating with their peers, students were exposed to diverse perspectives and collective problem-solving, fostering deeper understanding and critical thinking skills (Melander, 2012). Moreover, peer activities provided opportunities for students to actively participate in discussions, share insights, and receive feedback from their peers, thus enriching their learning experience (Melander, 2012).

From the instructor's perspective, peer learning within the MPLDs framework offered invaluable insights into students' comprehension levels and communication dynamics. By observing peer interactions, I gauged the extent to which students grasped the material and identified areas where further clarification was needed. Additionally, I gained a deeper understanding of students' communication styles, collaborative skills, and ability to articulate their thoughts—an asset in tailoring instruction to meet their diverse learning needs.

Furthermore, the enjoyment students derived from participating in peer activities contributed to a vibrant and engaging learning environment (Riese et al. 2012). The opportunity to collaborate with peers, share knowledge, and collectively solve problems fostered a sense of camaraderie and intellectual curiosity among students. This positive atmosphere not only enhances motivation and participation but also cultivates a lifelong love for learning.

In conclusion, the integration of peer learning within the MPLDs framework enriched the educational experience for students while providing me with valuable insights into their comprehension levels and communication dynamics. By fostering collaborative learning environments where students could actively engage with the material and each other, I created opportunities for growth, discovery, and enjoyment in the pursuit of knowledge.

This stage of collaborative learning and evaluation encouraged students to actively participate in articulating concepts and fostered an environment conducive to shared understanding, clarification, and peer learning. The assessment post-peer discussions evaluated the accuracy of responses the depth of comprehension and the impact of collaborative learning on individual student insights.

Art of Discussion

The art of discussion was a skill I needed to teach. This training was delivered in several sessions. At first, I thought high school students would be schooled in the discussion. Therefore, I gave them directions to gather into their peer groups and discuss the questions. No one moved. After taking the MPLD from several students from around the room and placing the papers on a central table, students reluctantly moved. Still no discussion.

Next, I gathered my MPLD and sat down at the table with the students. I noted in my journal the reactions of the students; their facial expressions were of confusion and fear. Smiling, I began to ask their answer to the first question. Disappointed, they handed me their papers. To which I gave back to them and asked the questions once again. A little more hopeful, one student read their answer. At this point, I role-played as a student and stated my answer which was similar, but not complete. The question:

1. *Create a chart that displays the differences between acids and bases.*

We compared our charts, and I asked questions about how his was different than mine and for him to explain it. Then, I asked the next person in the group the same question. The student who had been observing the last conversation did not just hand me his paper, rather, stated his was like my chart. Again, modeling the desired behavior, I asked how his was like mine and asked if it was different than the first person. I must be clear, I had to travel around to each peer group and model discussion. The first time of teaching this skill, I had to model how to discuss each question to each peer group. While this was very laborious and took sizable time, this is the most important time. The skill of discussion is useful in all of life. It must be taught and nurtured.

Journaling was immensely helpful during this time. I was able to remember some of the more enjoyable moments. One student remarked she needed to speak with her peer more often because of how he took notes. Another student stated he began to understand better once he had to explain his answer to another peer.

One more note to clarify. Once students have good conversations, it continues for the rest of the school year. Two students decided to become lab partners because they found out they communicated very well with each other. An observation I had during this time was a student who displayed above-average skill in communicating. I asked the student if he ever considered being a teacher. His comment was memorable. He said until now he had never known what he might do after graduation. The student said he was considering going into teaching.

Individual Student Reflection

In the final phase of the document process, I engaged in a reteaching session, offering students the opportunity to voice queries or comments arising from peer discussions. This phase culminated in the assignment of a comprehensive final reflection, requiring students to articulate

their insights about the content and their personal growth as learners (Clarà, 2015). The reteaching took place while I was walking around during peer learning and whole class instruction. This all depended on who needed to be retaught as well as what was retaught. For example, acid has a pH of seven to fourteen. I overheard and saw on the documents several students; thus, I retaught the entire class. An example of instructing a few students was the mathematical error that was reflected in only one peer group. This reteaching session allowed the students to write any notes needed to advance their learning once though no attention was needed. I, as the teacher, took note of what was asked and what needed to be retaught. This note served as future Do Nows and exit slips and if needed, a few questions on the next MPLD.

During this session, I noticed some students who had not asked questions before, began to raise their hands and be more engaged. Also, some of my shy students raised their hands to answer questions since they had gained confidence through the process. It was also during this time I had students high-five each because they had worked on one of the questions in the document and their answer was correct.

After the reteaching, the students undertook the last section of the MPLD: the reflection. This reflection prompted students to compose a detailed paragraph encompassing their newfound knowledge about the subject matter and self-discoveries as learners. They were encouraged to delineate their intentions regarding changes in their approach to the class after the document and peer work. Additionally, students were invited to offer constructive suggestions to enhance the teaching approach. The rubric is as follows:

What did you learn?	_/3
What surprised you during the process?	_/3
What questions do you still need answering?	_/1
Paragraph form (intro/conc)	_/3

/10

This reflective exercise served as a conduit for students to express their revelations about the content and insights into their learning journey. Some students acknowledged the necessity for additional similar documents to reinforce understanding. Others recognized the importance of improving note-taking practices or identifying reliable sources for notes in case of absences. Some students unveiled newfound confidence in their understanding, feeling more at ease with asking questions and reducing stress associated with incomprehension.

The reflection not only consolidated the students' comprehension of the content but also unveiled their evolving self-awareness as learners (Clarà, 2015). It enabled them to contemplate adjustments in their learning strategies while offering valuable feedback to the teacher. This reflective closure encapsulated the iterative learning process, fostered Metacognitive Peer learning and facilitated an ongoing dialogue between students and teachers for continuous improvement in the classroom environment.

In my journal, I recorded a student reflecting he did not know he knew some of the answers as he was feeling like he was struggling in class. He concluded by stating he thought he might make it through chemistry. Another entry, I summarized a student saying she thought she knew the answer only to find out she did not and was glad she found out what she got wrong.

The inclusion of a reflection component in the MPLD not only served as a valuable tool for student self-awareness but also provided me with crucial feedback to enhance and adapt instructional approach (Rogers, 2020). My multi-faceted rationale for incorporating reflection demonstrates a thoughtful consideration of both student needs and pedagogical goals.

I learned my students liked the format because it felt more like an exercise rather than a test. Also, they commented they felt more comfortable in making mistakes which led to them to understanding. One student stated having to write down the explanation on the red coded

questions allowed her to express she felt intimidated asking others for notes, and now that she discussed it with me and we found a solution, she felt more at ease in asking a particular student.

By gaining insights into what students have learned about the content and themselves, I can make informed adjustments to the MPLDs. The modifications based on student reflections exemplify a responsive and adaptive teaching approach, ensuring that the instructional materials align closely with the students' learning preferences and needs.

Discussion

The MPLD guided students towards a deeper understanding of their own learning processes. This was particularly beneficial for students who may lack awareness of how to study efficiently, providing them with a means to self-assess and improve their study skills.

The positive outcomes reported by students, including finding the unit assessment easier, feeling better prepared, and experiencing reduced stress, underscored the effectiveness of the MPLD approach. Additionally, the observed increase in students' confidence, attributed to the confirmation or identification of gaps in understanding through reflection, further highlights the impact of this pedagogical strategy on student well-being and academic performance.

The reported ease of unit assessments suggests that the MPLD approach effectively equips students with the necessary knowledge and skills to navigate academic challenges successfully. By engaging with the learning material in a structured and purposeful manner, students develop a deeper understanding of the subject matter, enabling them to approach assessments with greater confidence and proficiency.

The observed increase in students' confidence is a testament to the transformative impact of the MPLD approach on student well-being and academic success. Through reflective practices and collaborative learning experiences, students gain a deeper understanding of their strengths

and areas for improvement, bolstering their self-esteem and self-efficacy. This newfound confidence serves as a catalyst for continued growth and achievement, empowering students to overcome challenges and pursue excellence in their academic endeavors.

Additionally, I paraphrased several reflections from the week of September 26. Some students recognized that they possessed a greater understanding of chemistry than they had initially believed, resulting in increased confidence. Others acknowledged gaps in their comprehension of certain concepts that they had previously assumed they understood. In general, students expressed a desire for more MPLD activities in the future, because of productivity and effectiveness in enhancing their learning experiences.

Lastly, the positive outcomes reported by students, including enhanced performance on assessments, reduced stress levels, and increased confidence, underscore the effectiveness of the MPLD approach in promoting student well-being and academic success. By providing a supportive and empowering learning environment that emphasizes reflection, collaboration, and self-assessment, the MPLD approach equips students with the skills and mindset necessary to thrive in today's complex and dynamic educational landscape.

Conclusion

In conclusion, the adoption of the MPLD approach represented a significant step forward in enhancing the quality of education and promoting student success in my chemistry class. Through its emphasis on structured self-assessment, purposeful engagement with learning material, and peer learning, the MPLD framework has demonstrated its effectiveness in equipping students with the skills, knowledge, and confidence needed to excel academically.

The positive outcomes reported by students, including increased preparedness, reduced stress levels, and heightened confidence, underscore the transformative impact of the MPLD

approach on student well-being and academic performance. As educators continue to embrace innovative pedagogical strategies like the MPLD framework, we can anticipate further advancements in fostering a supportive and empowering learning environment that prepares students for success in an ever-evolving world.

Although this was a mostly positive experience for me, there were challenges. The MPLD did not follow the standard model of teaching chemistry. While this was true, it was my belief that if I slowed down and allowed the students to absorb and reflect on learning, students would benefit in the future. Just as in mathematics, if a fundamental concept was not learned, the student becomes frustrated. Learning a skill used as the building block not learned cannot be overcome.

Another challenge was the time spent on the MPLD. While I did not devote all the class time to the document, time was dedicated to it across multiple classes. In my school, the class time was seventy minutes. Not all educators have the luxury of that time per day. Time restraints must be considered when desiring to use MPLD.

One more challenge was the teacher's knowledge. I have been a teacher for several years and a chemist for even longer in the field. It takes time to develop the skills to perform the Socratic Method or to have a quick turnaround for reteaching. New chemistry teachers might not find this strategy helpful. This is not to say a first-year teacher could not use MPLD. It is cautionary to use this strategy. One compromise would be to co-teach this method.

When teachers can step back and observe students, then reflect on that observation, lesson plans and more effective use of time can be implemented. Lessons are not just transferring information; they are teaching students how to teach and learn about themselves. By providing students the opportunity to take more responsibility in learning and helping students understand how to learn from others, it can help in the frustrations face by students. By teaching students

how to step back and reflect on their work including successes as well as failure, we as teachers can help students with the life skills needed to be a life-long learner.

I can attest that using MPLD left me with a greater understanding of my students and a better relationship with them.

Chapter 7 - Discussion

This dissertation explored the use of classical education techniques in a non-classical school setting. I wanted to explore the tensions and conflicts that arise between the principles of classical education and those of non-classical schools. The non-classical school I chose was a charter school in an urban inner city. By choosing a charter school, there were allowable freedoms that were absent in a traditional public school. All charter schools are public with a different organizational set-up. For one, charters have CEOs instead of superintendents. Another difference is the curriculum. While all public schools, including charters, must submit to the state-regulated standards for education, charters have the freedom to explore different avenues to adhere to the standards. I utilized traditional educational methods to instruct students on the standards mandated by the state. Initially, I wanted to examine the synergies that occurred during my experiences between the students, staff, and administration. But what became clear was the importance of the dynamics between the students and me. This led me to narrow my focus to just my classroom.

This was intended to be a qualitative case study, but unfortunately, when families and students refused to provide informed consent, I had to switch to a scholarly personal narrative (SPN) method. This allowed me to explore the research questions related to how reflecting during the school year influenced my teaching. After analyzing the data, I decided to write the three articles based on my classical education techniques that affected classroom behavior and the student's perceptions of learning, content, and themselves.

To review, the research questions included:

1) How does a teacher experience using classical education techniques in a non-classical educational environment at an inner-city public charter school?

a. What are the tensions and dilemmas that the teacher experiences?

b. What are the synergies the teacher experiences?

Addressing the first part of the research:

1) How does a teacher experience using classical education techniques in a non-classical educational environment at an inner-city public charter school?

a. What are the tensions and dilemmas that the teacher experiences?

The data became apparent the tensions and dilemmas that I experienced were not between my fellow peers or superiors. Rather, the tensions and dilemmas came from the students' frustrations with content. They had much tension in the classroom due to not understanding basic material. Many voiced the tension of feeling helpless in chemistry. One student commented she did not think she would ever understand and burst into tears. Other students decided not to show up to class. When confronted, many thought if absent, then no grade would be given.

I wanted to help my students with these issues. Knowing they were not on grade level in reading, math, and writing, I decided to integrate math, science, and reading using the Factor-Label Method (FLM). From my reflections, I realized part of the issue was how the content was dispersed. I created a triad for the FLM which included, copy work, GRR, and modeling recovery.

1. How does a teacher experience using classical education techniques in a non-classical educational environment at an inner-city public charter school?

b. What are the synergies the teacher experiences?

As before, the data revealed a surprising synergy for me. Again, synergy for this study is the result of collaborating with positive outcomes. From the data, I discovered the students were not engaged in the science classroom. I overheard many students saying it was boring and had added no importance to their lives. Therefore, I developed an educational model called the Time-Warp Classroom (TWC), aimed at integrating the principles of classical education into science classrooms. In the TWC, students are metaphorically taken on a journey back in time, delving into historical scientific discoveries. This immersive method not only sparked student interest but also cultivated a passion for continuous learning.

Through the implementation of character-driven learning, students established meaningful connections to the past, allowing them to glean insights into the lives and viewpoints of individuals from ancient civilizations (Bauer & Wise, 2016). I observed that this educational approach enhanced students' comprehension of history and its impact on contemporary society, fostering a deeper and enduring understanding. In paraphrasing student conversations, I discovered that they did not know until they began reading that they were the same color as the pyramid builders. The school population was 98% black and having the realization that it was their race that was able to not just build, but to have the Great Pyramid being the only full-standing wonder of the ancient world was a source of pride. Still, another student decided to make a life goal of visiting Greece to see what Odyssey might have seen if he was a real person. The TWC enabled students to comprehend not only the remarkable accomplishments of ancient cultures but also the enduring influence of these civilizations on contemporary society.

Embracing exploration, curiosity, and experiential learning, this comprehensive educational approach nurtured well-rounded, critical thinkers (Mays, 2021).

Secondly, I discovered the benefits of copy work, gradual release of responsibility (GRR), and modeling mistake recovery. Students lacked the format for logical thinking which led to not being able to complete math-related problems as well as fear of making mistakes. These three obstacles may have contributed to them not being successful in science content. I created the second article explaining how I unfold the factor-label method (FLM). FLM, also known as dimensional analysis, served as a method for converting between different units, such as from metric to standard systems. This technique relied on the fundamental mathematical principle known as the Multiplicative Identity Property of 1, which dictated that any number multiplied by 1 remains unchanged.

Using FLM can help students grasp core concepts more effectively. Rather than just memorizing steps, they learned to spot patterns, connect different math ideas, and use logical thinking to solve problems (Cotter, 2001). This not only boosted their math skills but also improved their ability to think analytically, which is important for learning chemistry (Tsaparlis, 2000).

I broke down the FLM to make it easier to understand through a series of intentional teaching methods. By incorporating activities like copy work, gradually releasing responsibility to students, and embracing mistakes as part of learning, a supportive learning environment is created. This comprehensive approach not only gave students important skills but also helped them develop resilience and confidence in their scientific studies (Jackson, et. al., 2008).

Lastly, the third article resulted from my observations that my students were not understanding concepts without being constantly given the answers. MPLD was born out of the

need for a proactive solution to tackle issues like irregular student attendance, discipline problems, and frequent field trips in my teaching setting. Introducing Metacognitive Peer Learning Documents (MPLD) with a clear structure was a deliberate move to promote not only self-learning but peer learning while at the same time assessing students' comprehension more efficiently. Implementing the MPLD approach marked a significant step forward in improving educational quality and enhancing my students' success. By emphasizing structured self-assessment, active engagement with learning materials, and collaborative peer work, the MPLD framework was effective in equipping students with the skills, knowledge, and confidence needed for academic excellence (Bruney, 2012). The positive outcomes reported by students, such as increased preparedness, reduced stress levels, and boosted confidence, highlight the transformative impact of the MPLD approach on student well-being and academic performance (Cooper, 2002). As educators continue to embrace innovative teaching methodologies like the MPLD framework, we can expect further progress in creating a supportive and empowering educational environment that prepares students for success in an ever-changing world.

Impact of SPN

During this study, my perspective changed through using SPN. I had the initial impression the students did not like my subjects. By writing down my experience, I realized the students had a connection with me.

I came to understand that students had tensions and dilemmas. They burst into tears and even communicated very verbally their frustrations. During these outbursts of emotions, I came and sat with them and allowed them to vent. Then I began to speak to them in a soft voice that I would not allow them to quit. I said to them, "I know it is hard and I am not going to leave you behind. You will master this and I am going to remind you of this day when you do master it."

Then I would make them a promise. I would not allow them to fall behind if they would do what I asked of them. Each student agreed. I was able to help them relieve some of their tension.

Other students would refuse to get out of their seats to write on the QBoard. I would coax them up by reminding them of the mistake I had made earlier. One lesson I learned was to never hide my mistakes from my students. I would forget to hit save for their grade, write the wrong assignment on the board, mispronounce a word, and even make mistakes in the math. Another lesson I learned was to make mistakes during every class period. This way, I can coax them by my mistakes. They had a dilemma: stay in their seat and not learn or go up to the front and be embarrassed by not knowing. As they came up to the QBoard, I would help them through their fear.

I found it interesting the synergy was not from the staff and me, rather, it was from the students and me. During the MPLD, students did not want to discuss with each other for the peer-learning portion. I would sit with them and help them with discussion. Once they began to understand how to discuss, the students would help others who had trouble discussing. I overheard students say, “Let me show you how to do it, Mrs. Fryer showed me so I will show you.” The next time MPLD was assigned, it took much less time to complete. They began to have fun with the fact they had the correct answer. If they did not know the answer, I noticed they were not as upset as the first MPLD. Again, I overheard, “Well, that’s why we do these.”

Another tension was the reading for the students. Many could not read at grade level, so the required daily reading was very upsetting. Again, I came beside them with my book and explained I only expected them to read during the assigned time. No number of pages or paragraphs were required, just read. This helped, but I could see that some students would just hold the book up and pretend to read. I knew why, their reading level was below the book level.

Still beside them, I would highlight a word in my book. Then, write it on the front page. As I wrote down the definition from a dictionary, I said, “I had no idea what that would mean, and now I can understand the sentence.” The students looked at me in surprise. I added, “Did you think I would know all the words in this book?” I turned the front page of the book so they could see I had it filled with words. “These are just the words from the first few chapters!” I watched as a few students began to read their books and underline some words. They looked up and asked if they could underline. Smiling, I gave permission.

Once they began reading, they were interested in finishing the book. Recording the overheard conversations of the students proved to me they had an investment in the book. While writing, I overheard a student warn another about an upcoming sad event in the book, which reminded me of that moment. Recording in my journal the progress of the student’s behavior getting better allowed me to understand they had changed for the better.

The most significant impact of SPN was the intentionality of monitoring the student's progress in learning the skills I was teaching. A student asked me if I remembered her frustration with FLM in the previous weeks. Because I had recorded it in my journal I did remember. She then stated she now understands and is glad she persevered. After she left class, I returned to the passage and relived that moment when she was in tears. Turning the pages of my journal, I was able to see her progression and realized she had made great strides in her pursuit of excellence.

SPN being reflective as well as scholarly impacted by teaching systematically in the ability to be flexible in my teaching and the empowerment of articulation of my teaching. The method allowed me to see how I could change how I was teaching. By listening to my students, I could monitor how I was impacting the students in a positive direction. Reflecting is normally accomplished during the education stage of the teacher. Once the certification is complete, some

teachers do not see the need for reflection. Also, unless in professional development, teachers are not exposed to updated data-driven instruction. SPN allowed me to experience flexibility, articulation, and reflection all of which impacted me greatly in many ways (Clara, 2015).

SPN impacted me in the flexibility of my teaching. Being able to look back at my reflection gave me the outlook to teach closer to my full potential. I could see from my writing that the students were struggling with what I overheard. Paraphrasing in writing led me to see the students' perceptions. Also, I was better at asking questions to draw out the issues. Articulating both the positive and areas for growth was important for my teaching to be effective. The areas were able to be expressed in writing, thus allowing me to see my impact of teaching.

In my considered view, engaging in periodic reflection yields benefits within the realm of education Maintaining a meticulous record of my instruction and their corresponding effects on student learning proves invaluable. Being able to look back at lessons from reflective viewpoints allowed me to change what was needed as well as keep what worked. Such reflective exercises became particularly apparent during the staff meetings. Beyond presenting statistical insights in graphical form, I could provide accounts of student responses and ongoing pedagogical challenges. I facilitated a more comprehensive dialogue aimed at optimizing student learning outcomes.

Furthermore, I was not expecting my ability to present my teaching at the weekly department meetings. During my turn of presenting data to the team, I was able to not only demonstrate how the students were progressing in learning, but I could present using peer-reviewed references for my conclusions. Not only was the confidence I experienced unexpected but the reactions of the members in the meeting. The administration and the teachers were intrigued by the results. Having my peers and my superiors take an interest in my teaching

techniques was impressive to me. One teacher decided to incorporate the MPLD into her class routine. She came back to say it was very successful. Having the curriculum and instruction coordinator announce the instruction strategy I used was what the students needed was the most astonishing to me.

Throughout this study, I taught classically, and formative assessments were commonplace. These assessments took the form of discussions, exit slips, Nows, quizzes, reports, and written tests. The school required all teachers to record at least one assessment per week per class. Some of these were to be included in the departmental meetings where data was presented. By using formative assessments, I was able to guide the students by reteaching if necessary. At times, I was able to assess the students were understanding and ready to move to the next level of skill. It was from these assessments that I created the MPLD. Using the discussion, exit slips, and quizzes, I used the data to drive the content of the document.

Managing Expectations

At the beginning of this study, I expected the tensions and dilemmas to originate from the administration or the staff. Because of this assumption, I began to reflect on my interactions with the administration and staff. At the same time, I was writing about my time in the classroom with the students. Since the purpose of reflection is to contemplate, I reread my entries and began to discover the students were the story I needed to tell and not the adults in the building.

My entries were about the frustrations and obstacles of my students. I wrote how I wanted to help them through their productive struggles. Through conversations with my fellow department colleagues, I began to articulate what I was implementing in my class and the results. It was the required presentation of data at these meetings did I understand that I was creating synergies to help with the tensions and dilemmas of my students. As the study progressed, the

faculty noticed students were obtaining the proficient stage. My presentations became the story I wanted to tell using SPN. During the conversations in the meetings, I was able to articulate using my SPN journal the progress made with my students.

Limitations

As with all qualitative studies, including the specific context of SPN, this study inherently carries certain limitations, particularly in terms of the extent to which its findings can be generalized (Nash, 2004). While the results of this study suggest that students in my science classes were able to engage with elements of classical education within a school environment where such practices are not conventionally employed, it is crucial to approach the extrapolation of these findings with caution. The applicability of the study's conclusions to broader educational contexts may be constrained by factors such as the unique characteristics of the participant group and the specific instructional approaches utilized.

Moreover, while the study findings indicate that the introduction of classical education techniques did not yield any discernible negative consequences from the school administration, teachers, or students, it's important to acknowledge the potential existence of unanticipated limitations or adverse outcomes that may not have been captured within the scope of this investigation.

I had the advantage of being in the field of chemistry for many years. This led to having significant knowledge, skills, and experience that other teachers might not possess. Knowing chemistry from the standpoint of industry brings a different perspective to teaching. Suggestions for this limitation for teachers could be using the summer for working in the industry. There is a great need for those who know science. Having a teaching background is an added access. Teachers have the unique ability to explain hard concepts to others and have the skill to work in

different environments. The skill of teaching in the field of science industry is skill businesses are lacking. Explaining the complication to others is not a skill everyone can have on their resume. Another suggestion would be to bring scientists to the classroom. Not just to speak to your class, but to have conversations with them, for a relationship that both can benefit. This is a resource that is very underused in our culture.

Still, another limitation was my own biases. I had my interpretation of the data. The data was from my perspective only. It was my experience which cannot be reproduced (Nash & Bradley, 2011). This limitation is not to say the study was invalid, rather, caution must be observed and recognize the interpretations and experiences were from one person, one teacher, and one classroom in one school. As in all science, the results should not be considered a scientific or educational law, rather the results hopefully launch more study into the issues this study covered.

The method used in this study was not the traditional method. SPN is new and relatively unknown to many researchers. This method in its conclusiveness is new, but the parts of which is it made are not. Scholarship has been used in science and the social sciences for a long time. The narrative has been used for even longer. What this method uses is the combination of the two. By using the narrative to tell a story that includes scholarship, this study was able to show my experiences in the classroom which could lead to another study. With more SPN studies appearing in the field, this one day will not be a limitation. Until then, SPN remains to be new and under investigation. This can only allow SPN to become a better method in the future.

Further Research

Expanding the scope of this study to include a broader array of classes within the same school setting would provide valuable insights into the potential applicability and effectiveness

of techniques such as TWC, FLM, and MPLD across diverse subject areas. Gathering feedback from both educators and students regarding their experiences with classical education practices, as outlined in this study, could offer deeper insights into the impact of these methodologies on teaching and learning dynamics.

Furthermore, conducting quantitative research to examine the relationship between the implementation of classical education strategies and students' performance on state standardized science tests, as well as their reading proficiency scores, would offer empirical evidence of the efficacy of these approaches. Additionally, exploring changes in students' college entrance exam scores before and after the introduction of classical education practices could provide valuable insights into their long-term academic impact.

Lastly, conducting qualitative research focused on teachers who have integrated TWC, FLM, and MPLD strategies into their instructional practices would illuminate their perceptions and experiences, thus offering valuable insights into the effects of these methodologies on teaching approaches and classroom dynamics (Alder & Flihan, 1997). It would be an interesting study to see how scalable the perceptions and experiences of teachers as well as students.

In addition, science education is a field that needs further study on implanting classical education into the science classroom. Having more professional development in the education of science is an area that could be explored more in-depth. While this study did not concentrate on the professional development of teachers, it would be a worthwhile exploration of assisting science teachers in not just teaching strategies, but at least refreshing their content knowledge.

Finally, what were the findings? Being able to add to the knowledge base in general was very daunting. The thought of having my findings given to all those who are experts in classical education was very intimidating. That said, not locating one document on teaching classically in

a non-classical setting could be of benefit to someone else like me. It would have been to my benefit to have read what awaited me at the charter school. Just knowing it can be done is very reassuring. After all, the education of students is at the center of all educational materials.

While this study is now over, I will continue to use SPN in my teaching to give my students the best possible instruction to my ability. Also, the amount of learning in both my content area and my teaching I consumed was such a blessing, that I want to experience more of this blessing in years to come. SPN allowed me to use my love of writing, research, teaching, and most important, learning to become a better teacher and in some small way, help others do the same.

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Appendix A - Suggestions for Copy Work

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Appendix B - 2nd Round Coding

Events	Admin	Meetings	Students	Teachers	Questions	Quotes	Classwork	Personal Comments			
Science pacing p1	assumes 150 students fail p9	PD Week p12	Liked Book tasting p 29	Anxious about phones p13	What can I do to have them trust me p55	There is not reason to teach or have kids write by hand p 17	1st week waste of time p 26	more consistant than other teachers p 5			
PD Week p12	435 students p12	CPI training p19	Gryffren Fries p43	Do not have kids read p 29	Why do we have meetings about things we should already know p63	Being cussed out is part of jour job p 20	study hall misnamed p 26	teachers have anxiety due to not being detached p 13			
Named Science Hall p15	No content allows first week p 26	Department meeting p 39	Kids enjoyed Odyssey p58	Guided notes p 37	Why so many field trips p64	Your greatest asset is your relationship with your students p 44	books for students and book tasting p29	week 1 waste of time p 26			
CERCA p 16	Do not count AMI work p34	Obs results p44	No context of Odyssey p61	full credit for turning in paper p5	Why do admin refuse to treat us like professionals p91	Why are you taking quizzes? Because we suck p46	10 min read p 26	study hall waste of time p 26			
CPI Training p19	EOC gets all the attention p 41	Data Team p50	Transfer said no labs p79	Do not know HS content p62		We suck part II p 51	chem kids bad behavior, gave quizzes until behavior changed p 46	use of drugs part of why kids do poorly p 69			
First Day of School p 26	Admin obs p 44	Meeting on what we know p62	Called racist p90	Do the same as kids p 118		We should never get a lab p 84	names of groups of elements p 48	no consequences for students p 108			
AC Broken p27	Teach to test p 50	All energy for EOC p72	Laughed at admin p105	Cries on the way home p 125		I have never read a book p 14	createad paragraph for them to follow p 49	**Frustration**			
AMI P 32-24	no spanish chem book p 60	DT cannot attendance p 91	did not know where to begin reading p 114	**Science Department**		I have never seen a book this size p 14	reflections about science laws p 50	Chem not EOC so second rate p 1			
Obs on teaching p 41	admin cannot do hs work p 62	DT downplayed teachers p122	Bullies teacher p125	Dept cannot ask the real questions p40		Impressed with your teachign and how you get the kids engaged, thinking , and working p146	Greek and Roman gods and constellations p 52	Have to teach all subjects p 2			
Results of Obs p44 5/5	no respect for teachers p 103	FM discipline p123	give me rocks p160	Meetings are frustrating p63			FLM Zonarian units p 53	attendance p 4			
Sponsor Obs p75	policies not enforced p 118	DT treated like we are not pro p132	think they will pass because they are enrolled p162	Lunch with team p 63			Gradual release for FLM p 53	writing is not imporant p 16			
PD Day p97-99	downplays frustrations p 132	FM classroom management p 150		Texts outside of school p 87			constellatioins - Odyssey p 54	put up with verbal abuse p 19			
IC obs p109	field trips trump classes p 147	PD Trauma based p166		Chip gone due to stress p93			CW for FLM p 55	no content allowed first week p 26			
IC results p 111	finals are not counted p 147			Impromptu meetings p105			powerpoint for FLM p 56	no reading p 29			
				Mike had to leave p133			Reading Odyssey p 58	AMI not graded p 34			
				Mike lost it again p 163			Winston p 61	guided notes p 37			
							10 question worksheet (MPLD) p 65	teach on grade level but reading way below p 39			
							Behavior correct before allowed lab p 85	cannot speak on real issues p 40			
							Heavenly bodies poster for self learning p 86	teach to the test p 50			
							metals lab p 115	reading not a priority p54			
							relaxed learning p 120	guided notes p56			
							reflection about learning p 124	phones p59			
							student created study guide for finals p149	field trips p64			
							finals questions form characters in my books p 158	starting from scratch p 69			
							quesitons for answering the questions p 158	rewarding bad behavior p 74			

Appendix C - 3rd Round Coding

Events	Admin	Meetings	Science Department	Students	Teachers	Questions	Quotes	Frustration	Delighted	Classwork	Personal Comments
Science pacing p1	assumes 150 students fail p9	PD Week p12	Dept cannot ask the real questions p40	Liked Book tasting p 29	Anxious about phones p13	What can I do to have them trust me p55	There is not reason to teach or have kids write by hand p 17	Chem not EOC so second rate p 1	CERCA p 16	1st week waste of time p 26	more consistant than other teachers p 5
PD Week p12	435 students p12	CPI training p19	Meetings are frustrating p63	Gryffren Fries p43	Do not have kids read p 29	Why do we have meetings about things we should already know p63	Being cussed out is part of jour job p 20	Have to teach all subjects p 2	Scored high on obs p 44	study hall misnamed p 26	teachers have anxiety due to not being detached p 13
Named Science Hall p15	No content allows first week p 26	Department meeting p 39	Lunch with team p 63	Kids enjoyed Odyssey p58	Guided notes p 37	Why so many field trips p64	Your greatest assset is your relationship with your students p 44	attendance p 4	IC stated I have the type of relationships all teachers want p 111	books for students and book tasting p29	week 1 waste of time p 26
CERCA p 16	Do not count AMI work p34	Obs results p44	Texts outside of school p 87	No context of Odyssey p61	full credit for turning in paper p55	Why do admin refuse to treat us like professionals p91	Why are you taking quizzes? Because we suck p46	writing is not imporant p 16	Impressed with my teaching p 146	10 min read p 26	study hall waste of time p 26
CPI Training p19	EOC gets all the attention p 41	Data Team p50	Chip gone due to stress p93	Transfer said no labs p79	Do not know HS content p62		We suck part II p 51	put up with verbal abuse p 19	gave me rocks p 160	chem kids bad behavior, gave quizzes until behavior changed p 46	use of drugs part of why kids do poorly p 69
First Day of School p 26	Admin obs p 44	Meeting on what we know p62	Impromptu meetings p105	Called racist p90	Do the same as kids p 118		We should never get a lab p 84	no content allowed first week p 26		names of groups of elements p 48	no consequences for students p 108
AC Broken p27	Teach to test p 50	All energy for EOC p72	Mike had to leave p133	Laughed at admin p105	Cries on the way home p 125		I have never read a book p 14	no reading p 29		createad paragraph for them to follow p 49	
AMI P 32-24	no spanish chem book p 60	DT cannot attendance p 91	Mike lost it again p 163	did not know where to begin reading p 114			I have never seen a book this size p 14	AMI not graded p 34		reflections about science laws p 50	
Obs on teaching p 41	admin cannot do hs work p 62	DT downplayed teachers p122		Bullies teacher p125			Impressed with your teaching and how you get the kids engaged, thinking , and working p146	guided notes p 37		Greek and Roman gods and constellations p 52	
Results of Obs p44 5/5	no respect for teachers p 103	FM discipline p123		give me rocks p160				teach on grade level but reading way below p 39		FLM Zonarian units p 53	
Sponsor Obs p75	policies not enforced p 118	DT treated like we are not pro p132		think they will pass because they are enrolled p162				cannot speak on real issues p 40		Gradual release for FLM p 53	
PD Day p97-99	downplays frustrations p 132	FM classroom management p 150						teach to the test p 50		constellatioins - Odyssey p 54	
IC obs p109	field trips trump classes p 147	PD Trauma based p166						reading not a priority p54		CW for FLM p 55	
IC results p 111	finals are not counted p 147							guided notes p56		powerpoint for FLM p 56	
								phones p59		Reading Odyssey p 58	
								field trips p64		Winston p 61	
								starting from scratch p 69		10 question worksheet (MPLD) p 65	
								rewarding bad behavior p 74		Behavior correct before allowed lab p 85	
								no respect for teachers p 101		Heavenly bodies poster for self learning p 86	
								not believed by admin p135		metals lab p 115	
								stood up on meeting p 139		relaxed learning p 120	
								Not believed, taken seriously, not respected p 144		reflection about learning p 124	
								field trips allowed on days of finals p 147		student created study guide for finals p149	
										finals questions form characters in my books p 158	
										quesitons for answering the questions p 158	

Events

PD Week p12

Named Science Hall p15

CERCA p 16

CPI Training p19

First Day of School p 26

AC Broken p27

AMI P 32-24

Obs on teaching p 41

Results of Obs p44 5/5

Sponsor Obs p75

PD Day p97-99

IC obs p109

IC results p 111

Admin

435 students p12

No content allows first w

Do not count AMI work

EOC gets all the attentio

Admin obs p 44

Teach to test p 50

no spanish chem book p

admin cannot do hs wor

no respect for teachers p

policies not enforced p 1

downplays frustrations p

field trips trump classes

finals are not counted p 147

Meetings

CPI training p19

Department meeting p 39

Obs results p44

Data Team p50

Meeting on what we knov

All energy for EOC p72

DT cannot attendance p 9

DT downplayed teachers

FM discipline p123

FM classroom management p 150

PD Trauma based p166

Students

Gryffren Fries p43

Kids enjoyed Odyssey p58

No context of Odyssey p61

Transfer said no labs p79

Called racist p90

Laughed at admin p105

did not know where to begin reading p 114

Bullies teacher p125

give me rocks p160

think they will pass because they are enrolled p162

Teachers

Do not have t

Guided notes

full credit for

Do not know HS content p62

Do the same as kids p 118

Cries on the way home p 125

Science Department

Dept cannot ask the real questions p40

Meetings are frustrating p63

Lunch with team p 63

Texts outside of school p 87

Chip gone due to stress p93

Impromptu meetings p105

Mike had to leave p133

Mike lost it again p 163

Questions

meetings about things we should already know p63

Why so many field trips p64

Why do admin refuse to treat us like professionals p91

Frustration

Have to teach all subjects p 2

attendance p 4

writing is not imporant p 16

put up with verbal abuse p 19

no content allowed first week p 26

no reading p 29

AMI not graded p 34

guided notes p 37

teach on grade level but reading way below p 39

cannot speak on real issues p 40

teach to the test p 50

reading not a priority p54

guided notes p56

phones p59

field trips p64

starting from scratch p 69

rewarding bad behavior p 74

no respect for teachers p 101

not believed by admin p135

stood up on meeting p 139

Not believed, taken seriously, not respected p 144

field trips allowed on days of finals p 147

Classwork

study hall misnamed p 26

books for students and book tasting p29

10 min read p 26

behavior, gave quizzes until behavior changed p 46

names of groups of elements p 48

createad paragraph for them to follow p 49

reflections about science laws p 50

Greek and Roman gods and constellations p 52

FLM Zonarian units p 53

Gradual release for FLM p 53

constellatioins - Odyssey p 54

CW for FLM p 55

powerpoint for FLM p 56

Reading Odyssey p 58

Winston p 61

10 question worksheet (MPLD) p 65

Behavior correct before allowed lab p 85

Heavenly bodies poster for self learning p 86

metals lab p 115

relaxed learning p 120

reflection about learning p 124

student created study guide for finals p149

finals questions form characters in my books p 158

quesitons for answering the questions p 158

Personal Comments

teachers have anxiety due to not being detached p 13

week 1 waste of time p 26

study hall waste of time p 26

use of drugs part of why kids do poorly p 69

no consequences for students p 108

Quotes

There is not reason to teach or have kids write by hand p 17

Being cussed out is part of jour job p 20

Your greatest assset is your relationship with your students p 44

Why are you taking quizzes? Because we suck p46

We suck part II p 51

We should never get a lab p 84

I have never read a book p 14

I have never seen a book this size p 14

Impressed with your teaching and how you get the kids engaged, thinking , and working p146

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First Day of School p 26	Admin obs p 44	Meeting on what we know p62	Impromptu meetings p105	Called racist p90	Do the same as kids p 118		We should never get a lab p 84	no content allowed first week p 26		names of groups of elements p 48	no consequences for students p 108
AC Broken p27	Teach to test p 50	All energy for EOC p72	Mike had to leave p133	Laughed at admin p105	Cries on the way home p 125		I have never read a book p 14	no reading p 29		createad paragraph for them to follow p 49	
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Results of Obs p44 5/5	no respect for teachers p 103	FM discipline p123		give me rocks p160				teach on grade level but reading way below p 39		FLM Zonarian units p 53	
Sponsor Obs p95	policies not enforced p 118	DT treated like we are not pro p132		think they will pass because they are enrolled p162				cannot speak on real issues p 40		Gradual release for FLM p 53	
PD Day p97-99	downplays frustrations p 132	FM classroom management p 150						teach to the test p 50		constellations- Odyssey p 54	
IC obs p109	field trips trump classes p 147	PD Trauma based p166						reading not a priority p54		CW for FLM p 55	
IC results p 111	finals are not counted p 147							guided notes p56		powerpoint for FLM p 56	
								phones p59		Reading Odyssey p 58	
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								not believed by admin p135		metals lab p 115	
								stood up on meeting p 139		relaxed learning p 120	
								Not believed, taken seriously, not respected p 144		reflection about learning p 124	
								field trips allowed on days of finals p 147		student created study guide for finals p149	
										finals questions form characters in my books p 158	
										questons for answering the questions p 138	

Appendix D - MPLD Example

Chemistry MPLD 1.A

Instructions:

Part 1: Color each question if you know the answer in green: if you are unsure of the answer in Yellow:
Red: if you do not know the answer
Answer all green and yellow
Give your reason for having red questions

1. Create a chart the displays the differences between acids and bases.
2. Explain the following equation: pH= -log [OH^-]
3. Given the following elements, list them in decreasing activity:
   - Lithium
   - Gold
   - Aluminum
   - Zinc

4. What determines if an aqueous solution is an acid, base, or neutral?
5. Write a balanced equation of MgO in acid-base chemistry.
6. Predict whether the aqueous solutions of these compounds are acidic, basic, or neutral.
   - KI
   - NaHS
   - KNO_3
7. Calculate the pH of a solution with an equilibrium concentration of the hydronium ion 9.8 X 10^{-3}M. Show all work.
8. Explain the difference in the following terms involving acids and bases:
   - Bronsted-Lowry
   - Lewis
   - Arrhenius
9. Give three examples of a conjugate acid-base pair.
10. Which of the following will produce the lowest pH in solution?
    - 2.0M NaOH
    - 0.5 HF
    - 0.3 HI

Part 2: Gather with your peers and discuss all the questions. Answer all the questions. You must participate.

Part 3: Write a reflection on your experience with this MPLD. Include:
What you learned
What surprised you
What questions you still have

What did you learn about yourself and learning that you will implement

Appendix E - IRB

KANSAS STATE UNIVERSITY | University Research Compliance Office

TO: J. Spencer Clark
Curriculum and Instruction
Manhattan, KS 66506

Protocol Number: IRB-10781

FROM: Lisa Rubin, Chair
Committee on Research Involving Human Subjects

DATE: 10/13/2023

RE: Approval of Your Proposal Entitled, "10/11th grade Reading levels in Science - EDCI 991 Internship in C & I."

Federal regulations stipulate that human subjects protocols can be approved by IRB's for only one year, and require "continuing review" and approval to continue past the expiration date. On the basis of the IRB "continuing review," your project is classified as follows:

Active. The activity is pending or in progress, and there have been no changes that have occurred or are contemplated that would affect the status of human subjects.
EXPIRATION DATE: 10/28/2024

If the activity persists, it will be eligible for continuing review several months prior to the new expiration date.

Electronically signed by Lisa Rubin on 10/13/2023 7:01 PM ET