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Learning to Teach

Language Arts, Mathematics,
Science, and Social Studies
Through Research and Practice

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A publication of the Department of Curriculum and Instruction
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Language Arts, Mathematics, Science, and Social Studies *Through Research and Practice*

Learning to Teach Language Arts, Mathematics, Science, and Social Studies Through Research and Practice publishes manuscripts that address curricular innovations, thoughtful discussion of current issues for practice, or essays that inform, advocate for a position or persuade. Manuscripts must address subject-matter specific interactions of teachers and learners.

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Volume 3 Issue 1 August 2014

Section on Language Arts

Section on Mathematics

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Section on Social Studies

Language Arts

Valuing the Mockingbirds: Allowing Diversity to Sing in a Language Arts Classroom

Emily Shellabarger

Abstract: New secondary language arts educators may find themselves paralyzed by the amount of diversity in their classroom and how this diversity impacts student understanding of texts. Hermeneutic phenomenology provides insight into how students begin to develop their understandings and identities through experiences with others. The diversity of experiences among the students can be utilized through the method of Socratic seminars. Through this method, student engagement increases while the teacher's desire to meet the diverse needs of his/her students is achieved. This article will show that using the Socratic method in a secondary language arts classroom is an effective way to understand and utilize the lived experiences of students as they use these lived experiences in the process of interpreting texts.

Introduction

> *Imagine yourself in a language arts classroom. You are in a high school, and you are about to begin a unit on Harper Lee's, To Kill a Mockingbird, with your freshmen. Robert sits in the corner of the classroom. Both of his parents are high school drop-outs, and he rides the city bus for forty-five minutes every morning just to get to school. Chandra sits in the front row; her mother is a professor at the local university, and her father is a local police officer who drops her off in front of the school every morning as you are walking in. Michael sits beside Chandra. His single-mother works three jobs while he watches his siblings before and after school. All of your students are extremely different; however, the moment you pass out Lee's classic novel, they are all thinking, and some are saying, the same phrases that echo in language arts classrooms everywhere: "I don't want to read this. Why do we have to read this old novel? What does it have to do with me?"*

As beginning educators, we will enter classrooms with diversity, which is beyond what we could have imagined. Each student who walks through our classroom doors every morning has encountered experiences and people who have shaped life as they know it. There will clearly be overt diversity – race, gender, socioeconomic status, etc. However, what I will focus on is the more covert diversity – the diversity of lived experiences. It is much more difficult to access this diversity; however, it is imperative that this diversity be embraced in a language arts classroom because it is this diversity which impacts the way in which students perceive the texts we will place in front of them. There are many ways this diversity can be accessed. Using the Socratic method in a secondary language arts classroom is an effective way to understand and utilize the lived experiences of students as they use these lived experiences in the process of interpreting texts.

Hermeneutic phenomenology is a tradition, which was pioneered by Hans-Georg Gadamer (Hyde, 2005). This tradition rests on the idea that "knowledge is realized in the interpretation and understanding of the expressions of human life" (p. 33). In order to understand these expressions, hermeneutic phenomenology "attempts to be attentive to the way in which things (phenomena) appear to be, and to be interpretive, since all phenomena are encountered meaningfully through lived experience and can be described in human language" (Hyde, 2005, p. 33). Hermeneutic phenomenology is not as complicated as it sounds; this tradition merely places a significant emphasis on the lived experiences each of us encounters in our lives and how these lived experiences shape our perception of phenomena in the present moments.

Within hermeneutic phenomenology, there is a clear emphasis on interaction with others. There is an important notion within hermeneutic phenomenology, the Absolute Other, which has a major impact on the way in which a language arts classroom should function. The concept of the absolute other stresses that "the self only comes to know itself in relationship with the other," and "[w]ithout a personified 'absolute other' the self lacks a sense of identity, definition and form" (Hyde, 2005, p. 41). In our new journey as educators, we will be given a classroom full of absolute others, each with his/her own diverse lived experiences. It may be in our nature to stifle these lived experiences both because in our own educational experiences we were encouraged to ignore our preconceptions and because, truthfully, it may seem easier to keep our instruction on a more objectively planned path. However, utilizing our classroom full of absolute others is essential because our students cannot fully understand what they know until they understand what they know in correlation with the understandings of their peers.

Interactions with the Absolute Other Through the Provocation of Student Thought and Analysis

Discourse is imperative in a language arts classroom not only because it gives the students a chance to understand their ideas in association with the ideas of others, but also because it has a direct effect on motivation and engagement. Often times, students in language arts classrooms are overwhelmed and unmotivated because they are given a novel, asked to read the novel, given general recall questions, and then assessed on how well they understood the novel. This cycle of read, recall, and assess not only creates motivational issues for students, but it also creates a student body that becomes apprehensive and hostile towards reading and interpretation. A study on motivation by Kelly (2007) showed "when teachers focus on provoking student thought and analysis, and postpone evaluation of students, they set the stage for widespread student engagement by relinquishing authority to students, taking students seriously, and reducing the risks of negative evaluation" (p. 350).

This focus on the provocation of student thought and analysis not only makes the students feel as if their thoughts are welcomed and appreciated, but it gives them an opportunity to understand the thoughts and ideas of their peers and to evaluate their own thoughts and analysis. Students begin to interact with the absolute others within their classroom, and through these interactions, the students more fully understand their own ideas and perceptions – they develop a sense of identity in relation to the text. When students simply read and then recall what they have read, without engaging in discourse with the absolute others, they miss an opportunity to synthesize their thoughts and analysis through conversation with others. The lack of this conversation keeps students from being able to fully develop their own ideas and identities.

This idea of allowing student thought and analysis to drive a lesson can be terrifying for beginning educators as it requires us to give up a sense of control in our classroom. When teachers give up that sense of control, they are not simply succumbing to the chaotic possibilities of a high school classroom left to its own devices. Rather, the teacher is giving up the control of being the sole-determiner of the direction of the lesson. He/she still has control of the management of the classroom and how the students are expected to act, but he/she gives student thought and analysis the opportunity to drive the lesson in a direction that is most beneficial for the students as they perceive it. He/she does not know where student thought will take the lesson, and the idea of this practice can be terrifying for beginning educators.

Yet, the benefits of the emphasis on student conversation in class are abundant in that "[s]peaking up in class helps alleviate boredom, is an opportunity for sociable appreciation by one's peers," and "helps [students] hone oratory skills" (Kelly, 2007, p. 350). Giving students the opportunity to speak in class about what they believe texts mean involves the educator relinquishing some of the control of where the content is directed, and this can be a paralyzing idea for first year teachers. As beginning teachers, however, we will also be fighting a battle for engagement, and giving up a bit of control of the direction of the content will benefit the classroom exponentially in that student engagement will increase; thus, giving up some of our control as educators may actually make our job easier.

How Do These Interactions Effectively Occur?

In order to alleviate the stress of giving up some of our control in the classroom, beginning educators must have a method for discussion that is both effective and efficient. There is a method in which student thought and analysis takes control of the classroom, and this method is commonly known as the Socratic seminar or immersion circles (Ludy & Plumb, 2000). Prior to a Socratic seminar, students are given the guidelines for the seminar: "Refer to the text when needed during discussion. A seminar is not a test of memory," "Ask for clarification if you are confused," "Stick to the point," "Don't raise your hand. Wait patiently for your turn," "Talk to each other not just the facilitator," and "Accept responsibility for the seminar. It is whatever we make it" (Ludy & Plumb, 2000, p. 26). As the students become more familiar with the seminar process throughout the year, they simply need to be reminded to keep the guidelines in mind.

Ludy and Plumb explain the following components of the Socratic seminar process, which begins once the students have been introduced to or reminded of the guidelines and given a text to read. As the students read the text, the teacher/facilitator then breaks the class into an inner and outer circle. The inner circle will be discussing the text; each person in the outer circle will have a member of the inner circle to assess. The teacher/facilitator has some freedom in regards to how the outer circle assesses the inner circle. He/she can provide actual assessment sheets, or he/she can simply ask the students to keep notes depending on the atmosphere of the class. The students within the inner circle then discuss the text as the students in the outer circle listen quietly.

Like the assessments for the outer circle, the teacher/facilitator has some choice in how the conversation of the inner circle goes. Depending on the class, the teacher/facilitator can choose to provide guiding questions, or he/she can let the group move at its own pace. Once the inner circle is finished with its discussion, the teacher/facilitator can then open the floor for comments or questions from the outer circle or him/herself.

The benefits of the Socratic seminar have been found in a study conducted by Polite and Adams (1997). This study found "seminar discussions were effective in engaging students in tasks that called on their metacognitive and thinking abilities, while simultaneously developing both conflict resolution skills and an increased respect for the opinions and feelings of their peers" (p. 275). Students who engage in Socratic seminars learn skills that transcend the language arts classroom. While they are given a chance to exercise their metacognitive and thinking abilities, they also learn crucial communication skills that they are able to utilize in other content areas and their lives outside of the classroom. The idea of the Socratic seminar directly correlates with Gadamer's idea of the absolute other. The students who engage in the Socratic seminar both better understand the text, and they better understand their own ideas and identity as they are in conversation with their peers.

Some beginning teachers, however, may fear that when the students are given the autonomy to discuss what they choose in regards to a text, the students will not be able to fully comprehend the details of the text. However, a study by Fall (2000), which compared the results of an assessment for a group of students who were able to collaborate after reading a text and a group of students who were not given an opportunity to collaborate after reading a text, showed "[s]tudents who had an opportunity to discuss the story…showed an increase in the number of correct facts… whereas students who did not have an opportunity to discuss the story…showed a decrease in correct facts" (p. 926). In this study, the students who were able to collaborate after reading a text scored higher on the post-reading assessment than students who were not able to collaborate. Therefore, an effective Socratic seminar does not decrease student understanding of the text, but rather, the seminar allows students to more deeply connect with the text and develop an understanding beyond what they would have developed on their own.

What do we do now?

In the previously mentioned vignette, we were introduced to students whose perceptions, which they brought into their language arts classroom, were a product of their varying lived experiences. As beginning educators, we can ignore these past experiences and continue the cycle of read, recall, and assess, or we can utilize these past experiences and give our students an opportunity to generate a deeper meaning of the text and themselves through discourse in the classroom. In a Socratic seminar, Robert, who finds a way to generate the bus money he needs to get to school every day, would be able to share his ideas on the dignity Walter Cunningham had when he refused anything he could not pay back in *To Kill a Mockingbird.* Michael could verbally communicate his ability to relate to Mayella Ewell – the young woman in the novel who is often responsible for taking care of her siblings. Chandra could share her ideas on the importance of a powerful father figure, and the rest of her peers would also have their own unique ways of relating to the text. As the students better understand each other, they will better understand themselves and the text, as they are able to make connections through the absolute other. The dreaded, "What does this book have to do with me," is eliminated as students are able to make meaning of the text through their own eyes while also refining their understanding of the details of the text.

The idea of giving up some of the control in the classroom in regards to the direction of the lesson, as a beginning educator, is absolutely terrifying. However, the Socratic seminar is a form of organized chaos that allows the students to engage in a more meaningful experience with the text. As the control of the educator decreases, the engagement of students increases. As the engagement increases, the students are more eager to participate, and their understanding of the text deepens through conversation with the absolute other. Though it may take some adjustment for both the students and the educator, the Socratic seminar is an effective way for beginning language arts educators to assist their students with better understanding the texts and themselves.

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About the Author

Emily Shellabarger received her Master of Education Degree from the University of Toledo and her Bachelor of Arts in English and Writing from Bluffton University. Her passion is to assist students in utilizing their individual experiences in the language arts classroom. In August 2014, she will be teaching high school language arts in Toledo Public Schools.

All the Cool Teachers Aren't Doing It
An Argument on the Uselessness of Writing

Zakary Alan Kidd

Abstract: Many teachers who are not of the English Language Arts content area feel it is not their duty to include writing as a part of their curriculum; however, it has been proven that students who write about a topic, regardless of the specific content area, develop a stronger and more analytical thought process about what they are learning. This satirical essay takes an unusual stance on the issue at hand and offers a ridiculous solution, while presenting strong viewpoints promoting the use of writing in other content areas. The solution presented is an often detrimental approach affecting student engagement and learning within other content areas.

The Problem at Hand

Today's language arts classroom is a place run by slave drivers who rival those from the darkest depths of history. Teachers in this dark field are requiring students to write, sometimes on a daily basis. Children in today's schools are producing an *incredulous* amount of 1.6 pages of handwritten work in their language arts classes and an insane 2.1 pages in all other classes combined in the average week (Jago, 2014). Now don't light your torches and reach for your pitchforks just yet. There is a light at the end of the tunnel, but first we must delve further into this cruel and unusual punishment we are inflicting upon America's youth.

According to Harris, Graham, Friedlander, Laud and Dougherty (2013), only a third of students within the United States have acquired the skills necessary to deem them as proficient, or at grade level, in writing. This is preposterous! One-third of our students are having their time wasted learning a useless skill that only teaches them to effectively communicate their ideas. Writing has also become extremely neglected in classrooms, as mathematics and reading have been receiving the majority of the research and funding for studies (Harris et al., 2013). The fact that research in writing is receiving any funding is ridiculous! Nobody needs to be able write proficiently, much less discover new techniques that teach this ancient and outdated skill. All the funding should be going to subject areas that are actually worthwhile.

The writing plague that has stricken America's schools has long had its roots in the traditional language arts or English classroom. Teachers in this subject area generally require students in their classes to respond to prompts in a manner that requires written communication. Some of these in class writing assignments require students to write *multiple* paragraphs, while other assignments that might require work outside of class often force the students to create multiple drafts, and sometimes require multiple pages. The amount of writing done in today's classroom often leaves students ill prepared to express their thoughts and ideas in a college classroom, but why risk our students' well being for a little extra learning?

Students who are forced to create pieces of writing suffer tremendously from the strenuous workload that is placed upon them. The physical harm that falls upon students from these forced writing endeavors should not go unnoticed in schools.

Writing requires repeated movement of the hand and students who engage in this task for even a short amount of time often complain that this task hurts their wrists and squishes their fingers. Although there has been no expert documentation that writing has ever caused any permanent damage to the wrist and/or fingers, why should we risk it with our own children?

Although finger squishing is not to be taken lightly, this is nothing compared to the damage that is being dealt to the spines of our children. Students who are assigned lengthy writing assignments often have to visit the school's library to conduct research on the topics they are going to be writing about. The fact that these dungeons of antiquity exist, when it has been years since the invention of the internet, is an entirely different problem due for a separate discussion at a later time. However, to complete these lengthy and torturous assignments of writing, students often have to bring a book home to read and on really bold occasions of writing inflicted punishment, sometimes they have to bring home more than one book! This places an undue burden on the spines of the children who have to carry these texts in their backpacks. The development of lifelong research and citation abilities is trivial when one realizes the unpleasantness of having to cart around even one extra book. Take a look into any nursing home and you will surely see the hunched over elderly who are now paying in their old age for the years of teacher abuse. One might suggest that we inflict similar punishment on the backs of those who are doing this to our children, but there would be no effect because only the spineless would produce such inhumane forms of torture.

Perhaps, the only plus side of this terrible aspect of the educational system is that the teachers have to read the material the students produce. It warms my heart to imagine those cruel educators staying awake to the wee hours of the morning, skimming across the texts that our students poured their souls into, checking for every period and comma that was out of place. I wish the task of reading upon no one, but at least it is some justice for the sore wrists and squished fingers inflicted upon today's youth!

Some teachers of content, other than those language arts devils previously mentioned, have long understood the value of an education that produces the smallest amount of hand written material as possible. They have even begun to develop ways to entirely remove the need for writing from the classroom, if there was ever a need for it in the first place. Behold the Scantron! Such an incredible gift from the heavens above! Although it has been shown that writing across the curriculum has been proven to increase analytical thinking skills and disciplinary knowledge, this glorious machine virtually erases the need for our students to learn the outdated and torturous craft of writing (Jago, 2014).

The inventors of the Scantron have taken on the sacred mission of purging our educational system of this senseless writing. The elite class of educators who endorse the use of this beautiful tool are a breath of fresh air in the putrid atmosphere of traditional writing classrooms.

The Scantron has taken the stress of writing from our students almost entirely. In most cases, students only have to be able to reproduce the letters that are in their names and the most elite educators have even been able to bypass this. Students who are assessed using these Scantron forms only need to be able to create dots! Such wonderful dots! Oh, how truly splendid a world we will live in when all we need to know how to do is create dots! Imagine walking into a doctor's office and being able to fill out all of your paperwork with dots!

A Portrait of Writing Used Against Student to Cause Unnecessary Learning

Let's take a look at how a teacher, who once employed writing in his classroom to strengthen student learning and understanding, has been able to adjust his curriculum to allow for the use of the wondrous Scantron and lessons free of engagement. Last year John was a first year teacher. Fresh out of his collegiate days, he had an entire arsenal of pedagogical torture techniques sharpened and ready to go. In his sophomore biology class, John's students had terrible trouble mastering the cell cycle. John saw this as an opportunity to inflict the sadistic strategies that he had learned from his professors upon his students. He began to realize the problem his students were having was that they were not able to analytically think about the steps that lead from prophase to the eventual cytokinesis. They could not see how one step led to another.

John decided to take an unusual and torturous approach to his students learning. It was stressed in his college education courses that writing projects should be administered to help students develop both writing skills and disciplinary knowledge in specific subjects like social studies, art and science. He remembered reading in studies that students who write about a topic are eventually able to develop more analytical and complex thoughts about a topic, so John developed an eventual goal of having his students write a short story about the cell cycle from the cells point of view (Jago, 2014).

He decided to try and model his prompts after an example given in a text that he had read where a social studies teacher asked his students, "What role does work play in your life?" The teacher then reinforced this prompt by exposing the students to a painting by Van Gogh that portrays potato farmers and asked them about the effects work has had on the bodies of the farmers. The prompt was then expanded by a reading from a Seamus Heaney poem that compares the work of Heaney to the hard physical labor of his grandfather. Students were able to make inferences about these two forms of representation and then related them to their own writing and class discussion (Jago, 2014).

From his previous research, John knew first hand that there is a direct correlation in a Vygotskian perspective between drawing and the ability to create a complex text. In order to engage *his* students in their learning, much like the teacher he had read about, John had them sit down and draw each step of the cell cycle. Somewhere in his graduate research, it had become apparent to him that drawing and writing require many of the same motor skills. Since many students begin to draw to tell stories before they can write, drawing can be used as an aid in building a complex text. John allowed his students to be as creative as possible using supplies he had borrowed from the art teacher and provided ample class time to assist them and guide them in the correct direction using models on the board (Mackenzie, Veresov, 2011). This seems like a ridiculous amount of effort on his end for a little extra learning. The amount of work and thinking he was requiring from his students caused them to be quite tired after the school day and his students annoyed their parents at the end of the day with all the information they were learning from his class.

John then developed a multi-layered writing prompt that prepared students to reach his final goal of being able to describe the entire cell division process in short story format. John understood that in order for students to write well, they had to write often (Jago, 2014). At this point, silly John still believed that being able to express your ideas coherently in writing was important to understanding the material. His first set of prompts was created to give the students the ability to address the differences between the various phases of the cell cycle. For example, his first prompt was, "Describe the difference between meiosis and mitosis." This only required about a paragraph in response, but it definitely caused quite a bit of finger squishing amongst his pupils. Now once more, John recalled the importance of multiple modes of representation in the ability to develop complex reasoning and analytical thought, so after each prompt there was a space for the students to redraw the corresponding picture from the cell cycle.

After answering several short prompts like this, his students had begun to grasp the necessary disciplinary knowledge to complete their short story but now there was a great deal of writing that needed to be read in order for John to be sure his students were fully accomplishing their learning. Poor John, he really only wanted to kick his feet back and drink coffee while reading his fantasy football stats, but he was still idealistic and committed to having his students learn the material he was teaching.

After he felt his students had successfully developed an understanding of each individual phase, he then provided them with a creative writing prompt that required the students show how each phase of the cell cycle leads into another from the cell's point of view. John wished that his students would elaborate upon each phase of the cycle; so in order to create the maximum amount of punishment possible, he mandated that his students have a minimum of two and half pages, double spaced and typed. In doing this, he did a great injustice to his students. Not only were they drawing connections between the previously learned phases of the cell cycle, but they also had to write about it! And once they had written, he had required they type it on a keyboard that is not attached to an iPhone!

Once John's students had completed this ridiculous writing assignment and he had subjected himself to the outrageous hours of reading and grading, he was quite sure that his students had developed a full understanding of the cell cycle. He was quite happy with the displeasure he had caused amongst his students via the writing process. Poor John …

The Bright Future of Writing-less Classroom

Now that John is in his second year of teaching, he has grown much wiser as a result of some advice given to him by seasoned veterans in his building. John' s cell cycle unit now looks much different. John now provides all of his cell cycle information on PowerPoint slides. He then gives his students the slides on handouts that require no student engagement or participation. His lessons require no energy put forth by the student so that they have plenty of energy for other things, and don't waste their parents' evening telling them about all the things they learned in his class. His assessments now solely take place on Scantron forms and are full of simple true and false questions that require no extra analytical skills from the students. He has virtually eradicated writing from his curriculum. John now agrees that writing is only a skill that is important in language arts classrooms and serves no purpose in his own classroom.

Imagine if we could effectively eradicate writing from all aspects of life! As it is only beneficial to the liberal arts educator in their respective classrooms, it surely serves no purpose in life other than to punish those who are still of school age. If, as a human race, we could take the necessary steps to remove this antique aspect of our life, than we will truly be making strides in our educational system and brighten our future as the world's leading illiterate country.

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About the Author

Zakary Kidd graduated from the University of Toledo with a Bachelor of Arts in English with a concentration in creative writing. From there, he immediately enrolled in the Licensure and Alternative Masters Program at the University of Toledo and received his Master of Education and license in secondary education. His passion in the field of Language Arts is inspiring a love for writing among his students using non-traditional and unique strategies.

Mathematics

Mastery Learning: An Effective Means of Increasing Achievement While Tailoring Instruction in an Informed Data Driven Way

Samuel M. Y. Östling

Abstract: We are living in an age of high teacher accountability. Teachers are embedded in classes that serve a wide array of students and are expected to differentiate their instruction to meet the needs of each individual student. To address these expectations, this article will discuss the framework of mastery learning, assessments that inform both students and teachers, as well as reasons why the mastery learning framework should be implemented. The mastery learning framework, together with quality assessments, is an effective means of increasing achievement while tailoring instruction to individual students in an informed, data driven way.

Introduction

"Most students (perhaps over 90 percent) can master what we have to teach them, and it is the task of instruction to find the means which will enable our students to master the subject under consideration" (Bloom, 1968, p. 1). I, like many other new secondary mathematics instructors, believe the vast majority of students can learn mathematics in excess of the common expectation. We are living in an age of high teacher accountability. Teachers are embedded in classes that serve a wide array of students and are expected to differentiate their instruction to the needs of each individual student. This is a daunting task that all too often remains incomplete. On top of that, some teacher evaluation systems (like the new Ohio teacher evaluation system) expect us to have solid data to back up all of our instructional decisions and be able to present it upon request. These are challenging tasks for a veteran instructor, so how are we as new teachers going to do this? Teaching your classes within the mastery learning framework has the potential to address these concerns. The mastery learning framework, together with quality assessments, is an effective means of increasing achievement while tailoring instruction to individual students in an informed, data driven way.

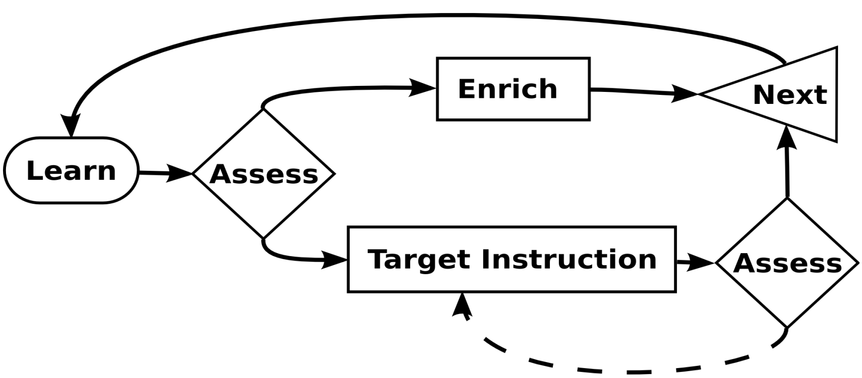
What is Mastery Learning?

Mastery learning is a framework for instruction and assessment that aims to increase the student's mastery of a topic by means of targeted instruction and reassessment. The mastery learning framework, illustrated in Figure 1, was initially proposed by Bloom in the 1960's when it was common for teachers to use the normal curve to determine appropriate grades for sorting students, long before there was a common set of mathematics standards (Bloom, 1968). Bloom advocated for a set of "absolute standards and the use of grades or marks which will reflect these standards" (Bloom, 1968, p. 8). A set of standards was needed to determine if the students were able to master the content. What do we mean by "master?" Mastery can be determined by achieving a score above a certain threshold on a criterion referenced assessment that contains several questions that require higher forms of thinking (Bloom, 1968; Mevarech & Amiran, 1982; Whiting, Wright Van Burgh, & Render, 1995).

The mastery leaning framework was developed to incorporate the instructional patterns of a private tutor into the structure of public education in America. Bloom did this in response to research that indicated student achievement was not just a function of aptitude but also largely depended on instructional time among other variables, including a student's aptitude for particular kinds of learning, quality of instruction, a student's ability to understand instruction, and a student's perseverance in the subject (Bloom, 1968). With many of those other variables outside the control of the instructor, the mastery learning framework is designed to provide more instructional time where it is needed. As we all know, instructional time is at a premium and cannot be squandered. Thus, it is important to make informed decisions about how to use the instructional time we have.

This framework (see Figure 1) was proposed by Bloom (1968) for exactly that. The framework is rather simple. First, present your lesson. There are no special requirements for the lesson, just teach it however you think is best. Then give an assessment that allows you to determine which parts of the lesson were mastered and which parts still need work. The students can now be broken up into groups based on what each student still needs to work on. You then give targeted instruction to these groups, while the students that demonstrated mastery are engaged in an enrichment activity that supports or extends their knowledge. The students that received further instruction are assessed again and the class moves on to the next lesson. It is conceivable that some students may need to repeat the targeted instruction stage more than once, though the vast majority of students attain mastery within one cycle of reassessment, at least in the field of mathematics (Armacost & Pet-Armacost, 2003; Kuruganti, Needham, & Zundel, 2012).

Figure 1.
The mastery learning framework.



The targeted instruction must be different from the initial instruction and preferably tailored to the specific needs and styles of the student (Bloom, 1968; Whiting et al., 1995). Simply regurgitating the previous instruction louder, harder, and longer is not effective. The target for instruction is found by giving assessments that are informative, not just to the instructor but to the students as well. These assessments should be well-aligned formative assessments that tell the instructor exactly what the student knows and doesn't know. The enrichment activity should extend or reinforce the knowledge the student was able to demonstrate on the assessment.

What does this look like in practice? Imagine an instructor is giving a lesson on finding the area of parallelogram. This is at the beginning of a unit on area and the students have just mastered finding the area of rectangle. The instructor used a think-pair-share activity for initial instruction. During the discussion the students derived the formula by cutting the parallelogram in half and rearranging the pieces to form a rectangle. A simple two-question assessment was given at the end of the class period. The assessment showed that some students grasped the core concept of the lesson, which was rearranging a given shape into a familiar shape, while others were only able to apply the formula derived in the lesson. The next day the students were divided into two groups. The enrichment group worked on applying the idea of rearranging figures into familiar shapes to a set of practical area problems including finding the crop yield of an oddly shaped field and the amount of paint needed for a house. If the students finished the problem set they could play a game of Quintillions or work on a jigsaw puzzle. Both activities tap into this core idea about area.

The targeted instruction group did not demonstrate mastery of the concept of rearranging figures. They watched a series of animations where figures were cut and rearranged into other shapes. Each student was then given a collection of paper shapes and a pair of scissors with the task of rearranging each shape into a different one. When a student was comfortable rearranging shapes he or she could then take the second version of the assessment. Upon passing the second assessment the student could join the other students working on applications of this concept, if time permitted. The next day the students came together again to learn about the area of triangles and trapezoids. Since the students already have a firm grasp of rearranging figures into known shapes, this lesson goes smoothly.

As the mastery learning framework was presented by Bloom (1968), only students that master the content the first time around get to the enrichment activity. Though it is clear that many of the students who failed to master the content would not have the necessary knowledge to succeed in the enrichment activity, it may be the case that the students who were close to reaching mastery would benefit more from the enrichment activity than the targeted instruction for the rest of the class. Thus, it may be beneficial to add a second threshold for not quite mastery but close. The students that fit into this category have shown enough knowledge that they will likely be able to do the enrichment activity (perhaps with some help) and learn from it. Since they still haven't demonstrated mastery it makes sense to reassess them with the students that received targeted instruction.

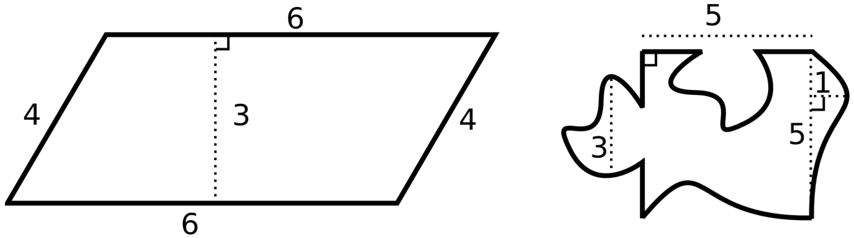
Assessments that Inform

When immersed in a mastery learning environment, with its repetitive and small formative assessments, it would be all to easy to stop at acquiring just enough procedural knowledge to get through the second round of assessments if traditional assessment practices are used. Knowledge of mathematics that stops at procedures is almost totally useless outside a familiar setting (Bransford et al., 2000). We need students to be able to transfer what we teach them to real problems beyond the school setting if education is to be worthwhile. "Transfer is affected by the degree to which people learn with understanding rather than merely memorize sets of facts or follow a fixed set of procedures" (Bransford et al., 2000, p. 55). Thus our assessments must reflect the need for understanding. With mastery of the standards for understanding as the goal, assessment takes on a form different from the norm.

In order to assess mastery, assessments must be criterion referenced and contain problems from all levels of Bloom's taxonomy (Mevarech & Amiran, 1982). Furthermore, "difficulties can arise when students learn strategies that apply only in limited contexts and do not realize that they are inadequate elsewhere" (Black, Harrison, Lee, Marshall, & William, 2004, p. 17). Thus, questions need to be designed to shine light on these inadequate strategies if they exist "and to explore problems in understanding the concepts so that students can grasp the need to change their thinking" (Black et al., 2004. p. 17).

Recall the previous example regarding the area of a parallelogram. An assessment in that lesson that probes understanding might look something like Figure 2 with the instructions "find the area of each shape." The shape on the left follows directly from the lesson, whereas the shape on the right is not familiar and requires the student to make multiple cuts and rearrangements to get to a shape they can find the area of. A student can procedurally use the formula for a parallelogram to find the area of the shape on the left but must use the core concept behind that formula to find the area of the shape on the right. Thus, this assessment probes understanding of the concept not just comprehension of a procedure.

Figure 2.
Shapes that probe for understanding of area.



Note: Iinspired by Bransford et al., 2000, p. 57.

Effective assessments for mastery need to clearly indicate the student's strengths and weaknesses on each assessed standard (Knaack, Kreuz, & Zawlocki, 2012). This can be done by being diligent about alignment between questions and standards and providing specific feedback on the student's level of mastery on each standard. By doing so, students become less focused on the test score and more focused on learning the content. It is important that students not be given a cumulative grade on the formative assessments. Research suggests that when students receive a grade on an assessment they are less likely to read the comments and implement suggestions (Black et al., 2004). Furthermore, repeated poor grades can have a negative effect on student self-efficacy and thus diminish learning rather than enhance it (Bloom, 1968). The evaluation of the assessment needs to be transparent so the grade has meaning to the student and they know what is required to demonstrate mastery (Jönsson, 2008).

It doesn't matter what level the instructor sets as mastery, students will rise to the challenge (Whiting et al., 1995). What does matter is allowing the student a chance to reassess in order to demonstrate mastery (Armacost & Pet-Armacost, 2003).

Why Implement Mastery Learning?

The current shift in teacher evaluation has provided a strong incentive for teachers to get students to perform well on tests, particularly end of year, standardized tests. The mastery learning framework has a proven track record of increasing student achievement (Anderson et al., 1992; Bloom, 1984; Mevarech & Kramarski, 1997; Reddy et al., 2013; Whiting et al., 1995), but there are more benefits to implementing this framework that have also been proven by research. The ability for students to demonstrate their improvement on a reassessment allows them to get a sense of accomplishment and increases their self-efficacy (Anderson et al., 1992). This may contribute to the tendency of students to demonstrate higher achievement in other courses even after leaving a mastery learning environment (Whiting et al., 1995).

Learning in a mastery learning environment increases students' long term retention of the content (Mevarech & Kramarski, 1997). Students spend more time on task (Bloom, 1984) and need less time to learn more advanced topics (Whiting et al., 1995) when learning for mastery. There is also evidence to suggest that the mastery learning framework, together with adequate assessments, increases mathematical reasoning skills (Mevarech & Kramarski, 1997). Bloom (1984) demonstrated that the mastery learning framework allowed students to outperform their aptitude. This means that math is not something you "just get" or not. With this framework, everyone can learn mathematics regardless of their aptitude. The mastery learning framework is a valuable tool for producing higher achieving, more capable, and confident students.

Conclusion

Implementing the mastery learning model can take more time initially. There may be more work upfront, preparing assessments and planning several approaches to a concept, but it doesn't take long for the investment to pay off (Whiting et al., 1995). With an understanding of mastery, and the limitation placed on secondary educators by the dominant structure of education in this country, the mastery learning framework, as proposed by Bloom (1968), is a crucial part of the best frameworks of education (Bloom, 1984). The key aspects of this model are formative assessments that inform individually targeted corrections and enrichments followed by further assessment until mastery is reached.

The specifics of initial instruction, targeted instruction, and enrichments are not the focus of this article. For that, I refer you to the work of others (DeWeese & Randolph, 2011; Khan, 2012; Mevarech & Kramarski, 1997; Whiting et al., 1995). It is important to note, however, that the choice in targeted instruction matters. Targeted instruction must be suitably different from initial instruction (Bloom, 1968) and tailored to the learning needs of the individual student (Whiting et al., 1995). Furthermore, many, though not all, of the implementations of mastery learning take advantage of the gains in understanding afforded by the kinds of communication found when students work together in small groups (Bloom, 1968; Mevarech & Kramarski, 1997; Slavin & Karweit, 1984).

The new focus on the Common Core State Standards for Mathematics (CC-SSM) and the Partnership for Assessment of Readiness for College and Careers (PARCC) assessments in mathematics presents a move toward mastery learning principles by the US government and an opportunity for educators to implement mastery learning principles in their classrooms. It was found that the PARCC assessments "are likely to represent important goals for deeper learning, particularly those related to mastering and being able to apply core academic content and cognitive strategies related to complex thinking, communication, and problem solving" (Herman & Linn, 2013 p. 4). Aside from the noble goal in increasing human capability, without a change in instructional organization and practice toward concept mastery, students will not be prepared for the new demands of standardized testing in a curriculum of understanding. In the end, the mastery learning framework, together with quality assessments, is an effective means of increasing achievement while tailoring instruction to individual students in an informed, data driven way.

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The Role of Technology in Mathematics Classrooms

Noah Bleckner

Abstract: The different forms of technology available to educators have dramatically increased over the years and technology is more prevalent in classrooms now than ever before. Educators must be made aware of the different technologies available and how to appropriately use them. Only then can technology be integrated effectively into the classroom setting. This manuscript outlines the different roles technology can play in the classroom. Using technology as a partner or extension of self will best enhance student learning, motivation, and engagement. In mathematics classrooms, using technology in these two roles will also aid in developing conceptual understanding by students.

Introduction

Today's society is constantly changing, and every year a new form of technology comes out. As mathematics educators, we have heard the term technology on a regular basis through our continuing education. We are told we need to use technology in our classrooms as much as possible to help students develop better conceptual understandings, to keep up with the times, and to appeal to our students. We are expected to learn about all the new forms of technology as they come out and how to use them. There is one key component that is continually missing from the content given to educators regarding the use of technology. This main component is vital to the application and integration of technology in the classroom setting. This main factor needs to be addressed before technology can begin to be used appropriately in the classroom. To address this factor I pose the question; what is the role that technology plays in the classroom to help students best learn mathematics?

Technology can play various roles in a classroom. As educators, it is up to us to choose the role we want technology to play and integrate it into our lessons and classroom accordingly. The integration of technology into these specific roles in mathematics classrooms will increase student engagement and motivation (Godzicki, Godzicki, Krofel, & Michaels, 2013). It is our duty to become familiar with all of the different forms of technology and what technology our students are comfortable using. We must then appropriately integrate them into our lesson plans. In this paper I will show examples of the different roles technology can play in a mathematics classroom. I will then argue that technology as a *partner* and an *extension of self* will have the most benefit to student learning.

The Roles of Technology in Mathematics Classroom

There has been a great deal of research done on the different roles technology can play in mathematics classrooms and the effect it has on student learning, engagement, and motivation. Goos, Galbraith, Renshaw, and Geiger (2003) outline four roles technology can play in the classroom: *master, servant, partner* and an *extension* *of self*. When technology plays the role of either *master* or *servant* it does not help students to develop a conceptual understanding of mathematic topics and can even hinder the learning process. When technology plays the role of a *partner* or an *extension of self* it facilitates student learning.

Technology is playing the role of a *master* in the classroom when a teacher is unfamiliar with the specific technology they are trying to incorporate. This creates chaos in the classroom for both the teacher and the students. The use of technology becomes the focus of both the teacher and students instead of the content. This takes valuable classroom time away from the students, which can impede their ability to fully understand the topic at hand. The second role technology can play is as a *servant*, in which it is used as a supplement to instruction, such as a calculator used to multiply while doing a math problem. In this way the technology is not the focus and stays in the background, allowing the content to be the emphasis. While this may be a suitable role for technology to play in some instances, it is not aiding in the students understanding of the concept.

Technology's role as a *partner* occurs when students rely on some form of technology to better develop their conceptual understanding of the mathematical concept they are studying. An example of the use of technology in this role was presented in a study conducted by Gonzalez and Herbst (2009) investigating how dynamic geometry software (DGS) affects student learning. Using DGS, the authors discovered that students could better investigate the concept of congruency than they could without the software. Students could examine more geometric relationships that related to congruency when using the DGS than when only using a pencil and paper. They also found when students were using the DGS they were more motivated to learn and more engaged in the content. This software, functioning in the role of a partner, allowed students the capability to explore the content in a more in-depth fashion than they would if the technology had not been present.

The final role in which technology can be incorporated is as an *extension of self,* which is described as occurring when technology is used as a natural part of a teacher's repertoire. In this role, technology becomes commonplace in the classroom and is continuously a part of the lesson plans. An example of using technology as an extension of self may be found in Kay and Edwards (2012) study in which they examined whether learning performances changed as a result of using video podcasts. The role of technology in this mathematics classroom was an extension of self because the podcasts were used on a daily basis in the classroom as the form of instruction. Students could watch the videos at their own pace, rewind, re-watch, and follow along in their books as they watched. Technology in this role extended the classroom and the educator's ability to reach students. As a result, students were more engaged in watching the podcasts. Students took advantage of the ability to watch the podcasts at their own pace. This also led to better test results over the material that was covered in the podcasts. The effectiveness of these podcasts, as well as other forms of technology, was also dependent on how comfortable the teacher and the students felt while using the technology.

Comfort Level Matters

The students' and teachers' perceptions on the form of technology being used can determine whether it is effective in the classroom setting. It is important that teachers demonstrate competency with the use of technology and that this competency is observable by the students. If the educator is not comfortable with the technology being used, the technology will play a negative role in the classroom (Goos, et al., 2003). If the teacher is not comfortable, they will put more focus on the incorporation of the technology rather than using the technology to address a concept.

If technology is used appropriately, students generally like using it and feel comfortable using it. This is the goal teachers need to have when creating lessons and incorporating technology into the classroom. The teacher must know their students and their backgrounds in order to be knowledgeable about the students' perceptions on the different forms of technology available. Godzicki et al. (2013) surveyed four different junior high mathematics classrooms regarding the use of technology in the classroom and motivation levels. It was found that 75% of students were motivated and engaged in learning when using technology in the classroom. This was only applicable to technology the students had used before and self-reported they had enjoyed using in the past.

To integrate technology effectively, the teacher must be comfortable with their ability to use it and show the students how to use the technology in the intended way. New technology is being introduced at a rapid rate, and as educators, we must continue our training on the use of these new technologies. Teacher education on the use of technology will lead to teachers being more comfortable using technology in their mathematics classrooms (Lin, 2008). Lin (2008) performed a study in which 47 pre-service teachers participated in a five week training program on how to integrate computers and websites into their mathematics classrooms. As a result of the workshop they found that the pre-service teachers had more positive attitudes towards using computers and websites in their classroom. If a teacher does not have the training or does not feel comfortable using technology they will not take full advantage of its potential. When this happens, it is likely technology will play the *master* role. This leads to the technology becoming the central focus and takes the attention away from the concept. To avoid situations where technology becomes the *master*, teacher training programs should be provided to educate teachers on how to properly use specific forms of technology.

Integration of Technologies that Help Students Learn Mathematics

Technology in a mathematics classroom can take on many forms. Some examples include a computer, graphing calculator, interactive white board, etc. As teachers we need to know what forms of technology have been found to be most useful in mathematics classroom and how they help students learn mathematical concepts.

Interactive white boards (IWB) are a more recent type of technology making its way into schools. There are many benefits that IWBs have over standard white boards in mathematics classrooms. IWBs are connected to a computer and have access to the internet. A teacher can easily show students a mathematical concept through multiple forms of representation using software programs or websites. Students can easily interact with an IWB and make manipulations using various IWB tools. IWBs can be used to engage students in learning and help students better understand mathematical concepts. McQuillian, Northcote, and Beamish (2012) found students enjoyed using this technology and were more engaged when IWBs were used in the classroom. IWBs could be integrated into lessons as either a partner or extension of self, depending on the strategy the teacher chooses to use. Either way, if the teacher integrates IWBs into their classroom the students will be more engaged in the content and student achievement will increase (McQuillian, Northcote, and Beamish, 2012).

Not all mathematics teachers have IWB's in their classrooms or schools. With that in mind, a common form of technology that most students in the US have access to is the internet. The internet is a great tool students can use in the role of a partner and an extension of self. YouTube has become a very popular website that has a lot to offer educators. YouTube videos have great potential for enriching the teaching and learning of mathematics (Stohlmann, 2012). *Khan Academy* videos are on YouTube and the videos offer teachers an alternative way to present the content to their students. The use of *Khan Academy* videos, either in the classroom or assigning students to watch them outside of the classroom, is using technology as an extension of self. The videos on *Khan Academy* cover all the standards set forth by the National Council of Teachers of Mathematics. If students are watching the videos at home or on their free time, this will allow for more student centered instruction during class. A teacher can use that time to help students who are struggling with the concept. Students can come into class already having some knowledge of the topic, which provides an alternative to the classical classroom approach by allowing the teacher time to do problem-based or inquiry-based learning where students can gain a deeper understanding of the concept. This is using YouTube as an extension of self, which leads to students gaining a conceptual understanding of the topic.

YouTube could also be used as a partner in the classroom to further enhance student learning. This could be achieved by using a video to pose a real world problem to the students. For example, in one video, a man is planning to paint his apartment. He wants to buy enough paint so he will not run out until after he has finished the entire apartment. The video shows students the layout of the apartment and the ratio of how many square feet per gallon of paint (Silva, 2012). Then students are asked to use the knowledge they have to develop a solution to the problem. The video is providing students with a visual representation of the problem that they would not have if they were just given a hand out. The video helps them think about the problem, draw out concepts that they should have some understanding of, and apply the concept. This also helps students become more engaged, as they see how the content they are learning can be applied to a real world setting.

Conclusion

Technology can play several different roles in a mathematics classroom. There are a few different factors that determine the role technology is playing in the classroom setting. These include the knowledge the teacher has about the technology, the students' familiarity with the type of technology being used, and how the teacher integrates it into their lesson. In order to effectively integrate technology into the classroom setting, education must be provided to teachers on the different forms of technology, so they are more comfortable incorporating them into their lesson plans. The most beneficial way to integrate technology into a mathematics classroom is either as a partner or an extension of self (Goos, et al., 2003). When technology is being used in these two roles it is being utilized to help students develop a better conceptual understanding of the topic and motivates students to become more active in the learning process.

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Gaining a Conceptual Understanding of Mathematics Through Communication

Shelby E. McElroy

Abstract: Teachers' instructional methods do not continuously provide students with the opportunity to benefit from the depth of conceptual understanding that could be accessed through greater communication. This article will explore what conceptual understanding is, why conceptual understanding is important, how we can achieve conceptual understanding through communication, and alternative forms of communication that can be used in the classroom, such as physical communication. Communication needs to be encouraged and promoted regularly in the classroom as it supports students' conceptual understanding of mathematical content by enabling students to create a framework for advanced concepts and clarify ideas. Strengthening communication directly leads to better conceptual understanding in mathematics creating broader applications for a lifetime.

Introduction

The reason we teach mathematics is not so in ten years students still know the quadratic equation, how to divide fractions, and the formula to find the volume of a cone. We teach mathematics so students experience a new way of thinking, a new way to solve problems, and a new understanding of how or why things work. I don't want a baseball player to calculate the exact angle a ball was hit off a bat; I want him/her to understand the angle is related to how high a ball will go, how far the ball will travel, and where that ball will approximately land. We need to teach applicable mathematics students can use outside the classroom. How do we ensure our students are able to use this mathematics? If we, as educators, can help our students gain a conceptual understanding of mathematics, our students will have a deeper knowledge of the content that they can transfer to real life applications. Unfortunately, conceptual understanding is not always achieved through the traditional practices of teaching mathematics. In order for students to gain a conceptual understanding of mathematics topics, communication must be encouraged and utilized on a regular basis within the classroom by everyone.

Conceptual Understanding and its Importance

Do you know how to add fractions? Do you understand the addition of fractions? Are those two questions asking the same thing, or are they two different questions? Before reading "Relational Understanding and Instrumental Understanding" by Skemp, I had never placed different definitions to the words know and understand. I used the terms interchangeably and probably incorrectly, as I am sure is the case for most people. I now recognize the meaning of know and understand relate to the difference between relational versus instrumental understanding, or terms most educators refer to as conceptual versus procedural understanding. Relational or conceptual, understanding is defined by Skemp (2006) as "knowing both what to do and why" (p. 89). There is a process and there is reasoning behind that process. Knowing the process and understanding why the process occurs shows someone has a conceptual understanding.

In contrast, if someone solely knows the process, he or she is demonstrating a procedural understanding. As an example, suppose a student is asked to add two fractions; the student thinks she can demonstrate her understanding by using the procedure of finding a common denominator and then adding the numerators. However, although this student has demonstrated she knows the procedure, she has not demonstrated her understanding of why the procedure is used. Instrumental or procedural, understanding is referred to as "rules without reasons" (Skemp, 2006, p. 89). Unfortunately, this is often the level of understanding students demonstrate while solving mathematics problems. To avoid this problem, I believe teachers should encourage students to go further in their learning, and help students in gaining a conceptual understanding of the mathematics.

The National Research Council (NRC) (2001) writes about conceptual understanding and its importance in education when they state the following:

> Conceptual understanding refers to an integrated and functional grasp of mathematical ideas. Students with conceptual understanding know more than isolated facts and methods. They understand why a mathematical idea is important and the kinds of contexts in which is it useful. They have organized their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to what they already know. (p. 118)

As the NRC explains, with a conceptual understanding, students are able to see mathematics as a useful tool. They can use it to solve problems inside and outside of the classroom, as well as use it to gain more knowledge in different areas. This method of knowing mathematics is much more practical and applicable than the traditional method of memorizing equations and practicing those equations on a limited number of applications. The question then remains, how can we help students achieve such knowledge in the classroom?

How Can we Achieve Conceptual Understanding?

In order to help students reach a conceptual understanding in mathematics, we need to promote and utilize mathematical communication. Students should be able to explain what they are doing, how they are doing it, and why they are doing it to others, which will lead to a deeper comprehension of the content. According to the NRC,

> Conceptual understanding also supports retention. Because facts and methods learned with understanding are connected, they are easier to remember and use, and they can be reconstructed when forgotten. If students understand a method, they are unlikely to remember it incorrectly. They monitor what they remember and try to figure out whether it makes sense. They may attempt to explain the method to themselves and correct it if necessary. (p. 118)

In order to facilitate retention of mathematical concepts, educators should encourage communication in the classroom. Communicating mathematical principles helps students organize their thoughts and present their ideas in a logical structure;

communication also helps students examine each construct in detail. The best case scenario, students learn to ask themselves the same questions they hear and see in class when they are asked to form mathematical justifications and explanations.

Promoting communication in a classroom strongly relies on the form and function of teacher questions. Teacher questions can be simple such as: "Why?", "How do you know that?", or "Can you show/tell me that again?" Teacher questioning should often be more complicated and stimulating such as "Is this like anything we have done before?", "Have you seen this outside of the classroom?", and "Is there another way to do this?" Questions could and should be asked by both the teacher and students in order to facilitate students thinking about their thinking concerning the mathematics being studied. There are many forms of communication that can and should take place within a mathematics classroom; you, as an educator, must decide which forms of communication will be most effective in supporting a conceptual understanding of mathematics for your students.

Alternative Methods of Communication

When learning about mathematics, the most assumed form of communication utilized in a classroom is verbal. Often times, students listen to the teacher's oral description of mathematics. Afterwards, students follow the procedures provided, practice using the procedure, and potentially share their numerical steps and answers with the class or teacher. This is an effective method if the goal is for students to have a procedural understanding of the mathematical content. However, since the optimal goal is for students to have a conceptual understanding of the content, a teacher needs additional methods of communication to allow students to deeply understand and express their knowledge of the material.

Written Communication

Writing is a productive form of communication to facilitate students' conceptual mathematical learning. "Writing in mathematics can also help students consolidate their thinking because it requires them to reflect on their work and clarify their thoughts about the ideas developed in the lesson" (National Council of Teachers of Mathematics, 2000, p. 60). Practice of written communication as a class will lead to communication among peers. Too often, students will only write down answers to problems as steps to a solution. Rarely do their answers or steps involve explanations, justifications, or complete sentences. Baxter, Woodward, and Olson (2005) use Ms. Carter, a mathematics teacher, and her students' writing to understand how teachers can promote conceptual understanding. Ms. Carter chose to utilize individual written journals as a regular activity to foster classroom communication. The journal activity involved teacher-developed writing prompts relating to mathematical topics being studied in class with the goal of improving students' awareness of their own thought, and facilitating students' personal ownership of knowledge (Baxter et al., 2005, p. 121).

Baxter et al. noticed "writing develops thought processes useful in doing mathematics: abilities to define, classify, or summarize; methods of close, reactive reading; metacognition, an awareness of one's own thinking and learning; and an awareness of attitudes toward mistakes and errors" (p. 120). Baxter saw with the journal-writing activity, Ms. Carter was able to note more than a simple wrong answer from student solutions; instead, she gained insight into the student's mathematical proficiency. For example,

> From reading the students' answers to the prompt requiring them to explain division to a fifth grader, she was able to see how her students made sense of division. For some of the more capable students, division was a systematic partitioning of sets of objects, while for others it was either rote memorization of steps or limited strategies, like repeated addition. (Baxter et al., p. 132)

The journal writing activity facilitated Ms. Carter's understanding of the students' level of conceptual understanding based on the explanations, justifications, and pictures. The writing activity helped students gather, organize, and represent their thoughts and ideas in a concise, organized fashion. "The advocates of writing in mathematics claim that students develop a more coherent and robust understanding of mathematical ideas by expressing their thinking in writing, even if that writing is less precise than formal mathematical expressions" (Baxter et al., 2005, p. 132).

Physical Communication

Communication comes in many forms. However, one form of communication—physical communication—is often overlooked. Physical gestures are movements many people use every day, sometimes unknowingly. It is thought that physical gestures enhance oral communication (Wilson, 2012). Specifically, Cook, Yip, and Goldin-Meadow (2012) considered whether hand gestures enhance speakers' comprehension and retention of information. Their findings show,

> Speakers benefit from their own gestures. Speakers in our study remembered more letters when they produced meaningful movements, that is, gestures, while explaining their solutions to a math problem than when they produced meaningless movements or no movements at all. Gesturing seems to lighten the speaker's working memory load and therefore serves a function for speakers as well as listeners. (p. 603)

The conclusion is if teachers can lighten the working memory load, then there is room for other information to be in students' working memory. With more working memory available, it is hypothesized students can focus on the information and store the information in their long-term memory. Thus, meaningful gestures are beneficial in that they help both the speaker and the listener communicate more effectively. With increased gesture use, students are able to experience a visual explanation as well as an oral explanation of the material. This then leads to an increased conceptual understanding of the material.

Mathematics is often conveyed through pictures and words. Teachers use representations such as numbers, shapes, operators, and mathematical vocabulary to help students learn and communicate mathematical ideas. "These representations hold the abstract ideas that make math a particular way of thinking…these ideas become understandable in the ongoing exchange of sign and symbol that happen when teachers and learners do mathematics" (Wilson, 2012, p. 83). As a specific example, Martin, a mathematics teacher, intentionally uses American Sign Language (ASL) mathematics instruction. "Martin describes gesture in his classroom as another tool for understanding something he and his students use intentionally alongside words and images to enhance learning" (Wilson, 2012, p. 84). American Sign Language is not something that all, or even most people know. However, even without exact use of ASL, gestures are likely to increase student learning.

Gestures can play the role of an assistant when paired with verbal communication. An example, provided by Wilson, is the Mystery Shapes game Martin and his students play in the class. Martin starts class by holding a solid bag containing an unknown shape and students have to guess the shape by asking questions about the shape's properties. A student asked for the number of faces on the shape, so Martin pointed to his face making a circling gesture while responding that the shape had six faces. Students begin copying his gestures. Someone else then asks if the shape contained any square faces. Martin informed the students all the faces were squares and traced the shape of a square in the air with his fingers, while his students again copied this gesture. Soon a student identified the figure as a cube while holding his hands out to show the near and the far sides of the cube, then held his hands high and low to show the top and bottom, and finally held his hands apart to show the left and right sides of the cube. Students nearby then copied this movement with their own hands. "Martin uses gesture in this activity as both a starting point for defining geometric properties and as a tool to make those definitions mathematically precise" (Wilson, 2012, p. 84). The gestures helped the students see the mathematical concepts and show mathematics in a different way. The gestures act as an aid to understanding vocabulary and meaning of terms within the geometry domain, thus offering students a conceptual understanding of mathematics.

"Gestures make tangible the ideas that are developing into whole concepts… gestures may be most important in the initial learning of new mathematical concepts, during which gestures can give students a way to hold onto ideas that are fundamental to further learning" (Wilson, 2012, p. 86). Martin's work with his students and prior research on gestures in the mathematical classrooms provide application and meaning of this concept. Gestures provide the opportunity for conceptual understanding. In these examples of gesture use, teachers must convey mathematical ideas in ways that are accessible to the students. "Gestures do not just reflect understanding, it builds understanding. Gestures are not static representations of ideas; they are mobile. Tracing cubes and rectangles in the air, students do not necessarily represent completed ideas, in the making of their gestures, thinking happens" (Wilson, 2012, p. 87).

Though physical communication is not commonly used explicitly, it can be and should be used to help students gain conceptual understanding of mathematics in the classroom. Creating physical language can help students learn, use, and understand mathematics. Physical gestures and writing are two alternative forms of communication that can be used in the classroom to support students' conceptual understanding.

Conclusion

Communication leads to students thinking about their thinking, and once this occurs, students will receive a better conceptual understanding of the mathematical content. NCTM (2000) explains,

> Through communication, ideas become objects of reflection, refinement, discussion, and amendment… When students are challenged to think and reason about mathematics and to communicate the results of their thinking to others orally or in writing, they learn to be clear and convincing. Listening to others' explanations gives students opportunities to develop their own understandings. (pg. 59)

Communication in the classroom helps not only the students who are presenting their thoughts and ideas but also helps the students who are the listeners/receivers of the information. Teachers need to teach and encourage our students to utilize communication in the classroom so students can recognize and organize their thoughts into complete coherent explanations. Students' explanations can occur via typical verbal communication or through alternative means such as writing or gestures. Growing a community of communicators will create enriching and fruitful classroom discourse, leading to better conceptual understanding in mathematics creating broader applications for a lifetime.

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Science

Embracing Students' Preconceptions: Deconstructing Best Practices for Addressing Alternative Conceptions in the Secondary Science Classroom

Robert Abramoff

Abstract: All students bring preinstructional knowledge to the secondary science classroom. When this preinstructional knowledge is inconsistent with intended learning outcomes, learning activities need to be modified by the teacher in response to students' demonstrated learning needs. These types of preconceptions, called alternative conceptions, need to be addressed proactively by the science teacher. Gone unaddressed, these alternative conceptions can lead to only superficial understanding of concepts by the students, or worse, complete detachment from the curriculum. Different methods have been proven most productive in enabling students' to build constructive knowledge from alternative conceptions. In general, the more hands-on and involved students are with their own learning, the less they will be restricted by their alternative conceptions.

Introduction

"Eh," I wasn't ten minutes into my first student teaching unit and I was already being confronted with a student's negative attitude about what we were learning, "why do we need to learn this? I'm never going to need to know how to do this in the future?" Rachel laid her head onto her desk, now fully demonstrating a complete withdrawal from what I was trying to teach.

It did not take long for one of my seventh graders to ask me a question that I was unsure of how to answer. It was a question that I had heard in science classes throughout my own educational career. It was a question that I too have thought about in the past. Yet, at this point, the task of responding to the question seemed overly daunting. The easy answer would have incorporated ideas such as educational standards or upcoming summative assessments, but for this student who was already becoming detached from the content, I knew that type of answer would not suffice.

In another class, Jonathon stated in a written preassessment that light emitted from the moon was less bright than the light emitted from the sun. In the assessment, he went on to claim how the fact that the moon was out at night and the sun was out during the day was the reason there were light and dark cycles on earth. Seventh graders are expected to learn that the moon reflects light from the sun and light and dark cycles are caused by the rotation of the earth on its axis.

Unfortunately, neither Rachel nor Jonathon were entirely prepared to be active learners in the secondary science classroom. Their preinstructional knowledge (preconceptions of the topics of the unit we were studying), potentially inhibited their ability to develop meaningful connections to the unit's learning goals. Rachel's preconceptions reflected a negative belief in the merits of learning the content while

Jonathon's preconceptions reflected a lack of accurate scientific understanding of the concepts. These seemingly detrimental forms of preconceptions, referred to in this essay as *alternative conceptions*, merit attention from the science teacher in order to efficiently build content understanding. This essay aims to deconstruct these two major forms of alternative conceptions, and make suggestions regarding the best practices young science teachers can use to promote the enhancement of student learning from these seemingly negative preconceptions. Alternative conceptions represent student thinking and must be addressed proactively by science teachers. Best practices for addressing and building content knowledge from alternative conceptions focus on hands-on, inquiry-based learning.

What are Alternative Conceptions?

Students bring many ideas into the classroom. This preinstructional knowledge is often referred to as students' preconceptions of a topic. There is a paradigm shift occurring in the accepted pedagogical approach to addressing student preconceptions, as teachers are realizing that this preinstructional knowledge shows us a great deal about students' cognitive processes and approaches to learning (Lucariello, 2014). In order to develop best practices for building curriculum to address these preconceptions, it is important to first understand exactly what constitutes preconceptions.

In general, preinstructional knowledge falls into two categories. First, there is preinstructional knowledge that is consistent with the content in the curriculum. These preconceptions are referred to as *anchoring conceptions* (Lucariello, 2014). Anchoring conceptions, when properly identified through an effective preassessment and continual student feedback during a lesson, can serve as effective and efficient points to build from during instruction. This ensures that valuable class time is not wasted re-teaching the content students have already mastered. However, when preinstructional knowledge is inconsistent with a lesson's content, the preconceptions are referred to as *alternative conceptions* (Lucariello, 2014). These alternative conceptions are the primary focus of this essay because they have the ability to inhibit student learning.

Alternative conceptions can take different forms in the secondary science classroom. The first form, exemplified by Rachel in the introduction, reflects a conceptual understanding of a scientific principle held by students who do not recognize the importance of learning the particular science content. These *negative preconceptions* represent ideas about the merits of curricula and are reflective of students' strong, negative emotions surrounding the importance of learning that subject (Lucas & Meyer, 2004). Students that fall into this category often possess an accumulating learning strategy when it comes to learning the course content. This type of learning strategy is characterized by a detachment from material and a focus on doing what is needed in order to receive a desired grade (Lucas & Meyer, 2004). An example of this type of negative preconception would be a student believing he does not need to learn the periodic table because he will not need to know the periodic table when he is a working adult. Instead, the student is just concerned with receiving a favorable mark.

Alternative conceptions are not limited to negative student attitudes about a subject however. Alternative conceptions may also reflect misunderstandings about concepts, as exemplified by Jonathon. Treagust and Duit (2008), define preconceptions as, "the learner's internal representations constructed from the external representations of entities constructed by other people such as teachers, textbook authors, or software designers" (as cited in Neumann and Hopf, 2012, p. 827). Here, alternative conceptions do not reflect a negative student attitude about the subject, but instead reflect misguidance on the nature of the scientific phenomena.

Both forms of alternative conceptions have the potential to inhibit meaningful student learning. Alternative conceptions that are reflective of a negative scientific attitude will discourage student engagement when left unaddressed. Alternative conceptions related to a misunderstanding of scientific principles will inhibit a student's ability to learn new content. This is because learning science often requires students to build new knowledge from foundational concepts. Fortunately, different teaching strategies have been identified as effective methods for addressing and building productive learning from students' alternative conceptions.

Best Practices for Addressing Alternative Conceptions

The importance of understanding and addressing student preconceptions in the secondary science classroom is grounded in the connection between preconceptions and student inquiry. The National Science Education Standards state that "students' understanding and abilities are grounded in the experience of inquiry, and inquiry is the foundation for the development of understandings and abilities of other content standards" (as cited in Yurumezoglu & Oguz, 2010, p. 15).

Independent Scientific Investigations

Different teaching techniques are considered more effective for building content knowledge from students' alternative conceptions. Researchers believe that one of the most productive ways to embrace student preconceptions is through properly developed and implemented scientific investigations (Yurumezoglu & Oguz, 2010). When students embrace an investigation or experiment, they are more inclined to use scientific facts and data to justify their thinking. They are also more likely to modify their thinking processes in order to align with the results of an investigation. Through using new information discovered during investigations, student inquiry has been shown to broaden students' sense of excitement, surprise and curiosity regarding a scientific concept (Yurumezoglu & Oguz, 2010).

Yip (2006) also supports the idea of independent investigations as a productive method for addressing alternative conceptions, suggesting that effective teachers discourage students from holding onto alternative conceptions when given creative control over their own learning. When students maintain preconceptions that are disproved through their own empirical research, they experience an excitement in their creation of scientific knowledge (Yip, 2006). This may seem contradictory to the philosophy that preconceptions are potentially not beneficial. However, student excitement can only be generated if the content discovered either aligns with or contradicts previous knowledge. When students are excited, they develop a connection to the content and are less inclined to work using an accumulating learning strategy.

There are long-term benefits for students who get the opportunity to do exploratory learning in the secondary science classroom. Doing scientific investigations at the secondary science level will benefit students, regarding detrimental alternative conceptions, when they take higher level science courses. Cartrette and Melroe-Lehrman (2012) analyzed a group of undergraduate science majors to try and determine how the students' research histories influenced their development of preconceptions and how these preconceptions inhibited their ability to undertake quality scientific investigations at the collegiate level. Ultimately, the researchers discovered it is the students who are least prepared to undertake quality scientific investigations that are most prone to holding on to potentially misleading alternative conceptions.

Teaching Science as a Process

Another effective method teachers can use to address alternative conceptions in the secondary science classroom is by changing the students' understanding of how science should be understood. In particular, teachers should focus on how science is a process of learning, instead of just a collection of independent facts.

Cartrette and Melroe-Lehrman (2012) suggest when a teacher focuses student attention on different scientific processes and what it means to undertake a scientific investigation, the students are less likely to fall back on their alternative conceptions. By studying seventeen undergraduate science students, whose general cognitive processes cannot be concluded as being too different than that of high school students, the authors concluded that students with more research experience and participation in hands on investigations are less likely to hold on to alternative conceptions throughout a learning segment (Cartrette & Melroe-Lehrman, 2012). To these students, science is something that focuses on deconstructing information and generating conclusions. Science is a gradual process instead of an independent collection of facts about the world.

The authors further promoted the idea that it was the lack of support students receive during their investigations that encouraged them to think critically. For example, lab instructions or a professor's presence gave students more cognitive freedom to hold onto their alternative conceptions (Cartrette & Melroe-Lehrman, 2012). While teachers must always pay attention to students as they work, especially during laboratory experiments, giving students the impression of freedom will help them to disregard their alternative conceptions if they exist.

Real-World Integration

Finally, real-world integration is another effective method science teachers can use to build content understanding from students' alternative conceptions. Without any type of real-world application regarding the purpose of learning specific content, alternative conceptions, even if addressed, may potentially become meaningless. Scherz and Oren (2006) analyzed a group of middle school science students to see how the students' preconceptions were altered after being exposed to the correct content as well as the practical, professional application of what they were learning about. In the end, the authors concluded that real-world based curriculum had the ability to alter students' alternative conceptions in several dimensions, all of which had a positive impact on student learning.

The authors found a strong correlation between the science students' positive image of what learning science is about and the practical application of science in the professional workplace (Scherz & Oren, 2006). Students, especially at the middle school level, often have preconceptions of science and scientists as being, "superficial, unreal, and even incorrect" (Scherz & Oren, 2006, p. 965). These students will be less inclined to continue learning science as they enter the high school and collegiate classrooms, unless their conception of science is developed. These preconceptions are not drawn from practical experience, but instead from images and intuition derived from the media (Scherz & Oren, 2006).

Students will try and find meaning in everything they learn. When content is relatable to the students on a personal level, the students have the opportunity to develop a connection to the content. By integrating real-world applications of scientific concepts in the classroom, there is a higher probability that students will be able to relate to what they are learning. When this occurs, alternative conceptions related to the merits of learning particular content will become less prominent.

Conclusion

Students bring a variety of preinstructional knowledge to the secondary science classroom. These preconceptions can be positive, helping students understand new content in a way that builds off prior knowledge. However, preconceptions can also be inconsistent with planned curricula. These latter preconceptions, labeled *alternative conceptions* by the American Psychological Association, can take several forms. The preinstructional knowledge can be related to an inaccurate scientific understanding of the natural phenomena or more general, related to the students' lack of motivation or negative perception of the meaningfulness of learning particular content.

Because preconceptions reflect student thinking, they should not be ignored in the classroom. Instead, teachers should plan and develop units that involve students engaging in hands-on experiences related to real-world scenarios in order to raise the probability that meaningful learning occurs from students' alternative conceptions. These types of experiments and student work have shown to be particularly effective in helping students overcome and build knowledge from their alternative conceptions.

While deconstructing and understanding alternative conceptions helps secondary science teachers understand the thinking process of their students, students also benefit from being able to learn about their own thinking. Students who are constantly challenged to analyze their own alternative conceptions grow as learners. They develop awareness of their own thinking processes and are able to recognize the methods that help them learn best. Science is a subject that is founded on the inevitability that individuals will make mistakes and learn from them. Appreciating the unique benefits of alternative conceptions recognizes that what some consider mistakes are just opportunities for cognitive growth and continual academic self-discovery.

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Inquiry-Based Learning
Fireworks and the Bohr Model

Corbin Brangham

Abstract: Many teachers continue to use direct instruction as the primary means of teaching students science content. Research and theory regarding science instruction overwhelmingly support the use of inquiry-based learning (IBL) to teach science concepts. IBL increases student understanding of science content and more authentically teaches students the nature of science. Abstract concepts, like the Bohr model, are difficult for students to understand. This paper reviews the curriculum principles of long-term IBL projects and provides an example of teaching the Bohr model of the atom using an IBL project centered on the study of fireworks. Abstract and difficult science concepts can be taught using IBL and it is to the benefit of our students to do so.

Introduction

> *In a ninth grade physical science classroom, Mr. Smith begins a lesson on the Bohr Model of the atom with a slideshow about energy levels. Some students diligently take notes on energy levels and electron transitions while others stare blankly, either not caring or completely lost. Mr. Smith explains that electrons absorb and emit light to move between energy levels. He goes on to explain that every element absorbs and emits different colors of light and gives real-world examples including fireworks.*

Mr. Smith does a lot of explaining and direct instruction in his class and the students spend the majority of the time listening; several students are clearly apathetic or confused. This type of instruction epitomizes the problem referred to by Yager, Ali, and Hacieminoglu (2010) when they state the following: "Typical school programs too often focus attention exclusively on the 'what scientists agree to be known and accurate' and to a lesser degree 'how they know'" (p. 57). Students are often subjected to lectures and slideshows on difficult, abstract topics like atomic structure. Yet, students learn science best by inquiry-based learning (IBL) (Tamir, Stavy, & Ratner, 1998). Therefore, if we want our students to understand the essential aspects of atomic structure, it should be taught using IBL. This emphasis on inquiry does not mean to abandon direct instruction entirely. Direct instruction of the inquiry process has been shown to have positive effects on student learning (Tamir et al., 1998). Furthermore, the combination of direct instruction techniques and authentic inquiry techniques has been found to be very effective (Crawford, 2000; Tamir et al., 1998). Thus, direct instruction is an essential part of IBL.

Many teachers say they struggle with designing inquiry-based lessons for abstract and difficult topics and resort to direct instruction like Mr. Smith. This can be especially true for student teachers and new teachers. This paper is an illustration of developing an IBL curriculum plan for the Bohr model of the atom. The Bohr model is an abstract concept that requires an understanding of the basic principles of quantum mechanics, one of the most abstract and complicated concepts in science. For this reason, the Bohr model is commonly cited as an example of a science topic better taught by direct instruction. This paper is intended as an example of the thought processes behind the development of IBL lessons for an abstract topic, like the Bohr model. Abstract and difficult science concepts can be taught using IBL and it is to the benefit of our students to do so.

The Nature of Inquiry for Learning

The National Research Council (1996) defines student inquiry as "the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (p. 23). The purpose of authentic scientific inquiry is to develop theories justified by evidence that explain the underlying mechanisms of a phenomenon (Chinn & Malhotra, 2002). Authentic inquiry also makes extensive connections between theory, methods, and data (Chinn & Malhotra, 2002). Genuine science evaluates methods in order to validate them and typically has messy data that requires complicated explanations (Chinn & Malhotra, 2002). In authentic inquiry tasks, the reasoning is complex and the thought processes are elaborate and nuanced.

Our challenge as teachers is to provide students with experiences that emulate the thought processes involved in authentic inquiry (Chinn & Malhotra, 2002), while maintaining an appropriate cognitive load (Singer, Marx, & Krajcik, 2000). Bell, Smetana, and Binns (2005) describe four levels of inquiry based upon the cognitive load. The lowest level, confirmation experiments, is not actually inquiry since the students complete the task in order to confirm a result they already know. In directed inquiry, students are asked to follow a prescribed procedure to determine the answer on their own. In guided inquiry, students are asked to develop their own procedures in order to find an answer. Open inquiry involves a student with minimal guidance who must develop the question and methods in order to find an answer. The table below summarizes the sources of information for each level of inquiry.

Table 1
Sources of information in the Four-Level Model of Student Inquiry.

Level of Inquiry	Question	Methods	Solution
Confirmation	Teacher	Teacher	Teacher
Directed Inquiry	Teacher	Teacher	Student
Guided Inquiry	Teacher	Student	Student
Open Inquiry	Student	Student	Student

Note: Adapted from Bell et al. (2005).

Curriculum Design

Singer et al. (2000) describe seven essential curriculum design principles for extended inquiry projects: contextualization, standards, inquiry, collaboration, learning tools, artifacts, and scaffolding. The following curriculum plan is designed to allow students to discover the underlying concepts of the Bohr model of the atom. It is an illustration of the ideas in the Next Generation Science Standards (NGSS) (National Research Council, 2012), the nature of authentic inquiry (Chinn & Malhotra, 2002), and the set of principles designed by Singer et al. (2000). Curriculum design is also heavily influenced by the roles that both teacher and student assume. These roles are much different for IBL than traditional education.

Roles of the Teacher and Student

Crawford (2000) describes ten roles a teacher must take on when conducting IBL in the classroom. The roles of innovator, experimenter, and researcher are assumed when developing curriculum. In order for inquiry to occur, the teacher needs to design innovative investigations, experiment with new teaching and assessment methods, and collect and use feedback on his teaching. When directly interacting with students, the teacher takes on the roles of motivator, diagnostician, guide, modeler, mentor, collaborator, and learner. In this project, students may feel overwhelmed by the difficulty of the concepts and it is important for the teacher to be a powerful motivator during these times. In order to do so, the teacher must be able to diagnose whether students are struggling and what specific ideas with which they are struggling. This diagnosis is also important for helping the teacher to guide students and help them make sound decisions about the investigation without revealing too much information. Students are not likely to know how to use a handheld spectrometer, analyze data, or set up a photoelectric experiment, so the teacher will need to model these behaviors along with other behaviors consistent with authentic inquiry, such as asking more questions during an investigation.

Being a mentor, collaborator, and learner involves performing all the previous roles. These three roles emphasize the relationship between the teacher and the students. The students need to see the teacher as an expert in investigations who is working with them to learn something new. The teacher needs to use all three roles to develop a community of scientists within the classroom. These last three roles of the teacher are also important in allowing students to take on non-traditional roles. If the teacher is a mentor, collaborator, and learner, then the students must become active collaborators such as leaders, apprentices, teachers, and planners (Crawford, 2000).

Context

It is important to situate the problem that is the focus of an IBL project in the real-world of the students (Crawford, 2000). This context needs to contain a broad and open-ended driving question, sub-questions to help students see the science concepts related to the driving question, and anchoring events designed to help make abstract concepts more concrete (Singer et al., 2000). In the study of the Bohr model, a phenomenon that is the direct result of quantized energy should be chosen for the students to study. There are several natural phenomena that may be used to engage student interest including colors of fireworks. A possible driving question would be "Why are fireworks different colors?" There are several options for sub-questions: What are colors? What is light? What is energy? How are fireworks made? Students may be able to answer some sub-questions based on prior knowledge. At this point, other phenomena such as the color of neon signs, halogen bulbs, and the sun can be used as additional examples. The distinct lines in these spectra should prompt more questions. It is important that students ask their own questions, but the teacher should ask important sub-questions if the students are not doing so (Singer et al., 2000). Anchoring events could include viewing the spectra of small fireworks, elemental bulbs, and fluorescent lights. Further contextualizing depends on the direction the inquiry takes. It is the nature of such projects to branch out in unexpected directions as students ask their own questions (Singer et al., 2000).

Standards

In accordance with the NGSS, the goal of the atomic structure unit in high school physical science is for students to arrive at a model of the atom consistent with the Bohr Model including some aspects of quantized energy (National Research Council, 2012). At the beginning of this investigation, students should already have a model of the atom consistent with that of Rutherford. The students will need to move from an unordered electron cloud concept to one with fixed electron orbits. It is important that students do not adopt a planetary model because this model does not include quantized energy and cannot explain phenomena such as fireworks or line spectra. Quantized energy and photons are the essential concepts required to formulate the Bohr model of the atom from the Rutherford model.

Inquiry

Students and teacher should work together to design an investigation that will lead students to collecting relevant data (Crawford, 2000). The teacher should take care to guide students and not to give them direct answers. Experimental designs should be based off the sub-questions asked by students and their current theoretical knowledge (Chinn & Malhotra, 2002). During the investigation into the Bohr model, it may be helpful for the teacher to inform the class of the photoelectric effect and some of its properties. This could be presented in a number of ways, but if the teacher were to present it as work done by other scientists, it would allow the opportunity to replicate another scientist's work. This is an important component of authentic inquiry often missed in science classrooms (Chinn & Malhotra, 2002). If the equipment for a photoelectric effect experiment is not available, simulated experiments are available online (LeMaster, McKagan, Perkins, & Wieman, 2013). In order for students to connect the idea of quantized light energy to the energies of electrons in orbits around a nucleus, they must also be reintroduced to the concept of electrical potential energy. Coulomb's Law should have been previously studied and may be reintroduced to discuss the potential energy of the electron.

Collaboration

According to Singer et al. (2000), collaboration in IBL projects may include small group work, class discussions, or collaboration with community members. There are several methods to ensure collaboration between students. Small groups could work on individual sub-questions and report back to the class. Think-pair-share sessions could be used to help students with experimental design or data analysis. Specifically in the Bohr model investigation, collaboration with the community could be accomplished by having a local expert on fireworks explain the process of making fireworks. In all projects, collaboration with the teacher should be ongoing throughout the entire process (Crawford, 2000; Singer et al., 2000). The teacher should be taking on all of the roles described by Crawford in order to help students accomplish their learning goals.

Learning Tools

Learning tools should mirror those used by scientists, but with learner-centered design which addresses technology issues and provides scaffolds as the student needs these supports (Singer et al., 2000). Quantitative studies of energy levels in the Bohr model or photoelectric effect are beyond the scope of this course (National Research Council, 2012); however, automated graphing software could be used to help understand the information gathered during a photoelectric effect experiment. Physics Education Technology (PhET) designed a photoelectric effect simulator with built-in graphing features that allow students to see specific trends (LeMaster et al., 2013). Furthermore, this simulation allows students to see the number and speed of the electrons, which makes the abstract idea much more concrete.

Artifacts

Artifacts created by students are to be shared, critiqued, and revised (Singer et al., 2000). These artifacts would both enhance student learning and serve as assessments of student learning. Students could produce a variety of artifacts during this investigation. Authentic artifacts would include student models of phenomena, group presentations, and students' logbooks of their thoughts, actions, and observations throughout the investigation (Singer et al., 2000). Other important artifacts include lab reports and concept maps. These artifacts should be assessed throughout the investigation and used to promote discourse. The public discussion of artifacts leads to revisions and construction of student understanding (Singer et al., 2000). The culminating artifact should be a detailed and thorough response to the driving question and important sub-questions.

Scaffolding

Scaffolds should be chosen to model strategies, sequence inquiry processes, assist with technology use, reduce complexity, and highlight concepts (Singer et al., 2000). Scaffolding should be done at the teacher's discretion and should be designed to guide learning. Scaffolding can be provided directly by the teacher or can be built into the learning materials and technology used (Singer et al., 2000). Individual aspects of the inquiry process can also be scaffolded by changing the level of inquiry according to the scale presented by Bell et al. (2005). Differentiation can be achieved by having different students or groups of students at different levels of inquiry. The level of inquiry should also be changed depending on the goals and cognitive demands associated with the task. In the Bohr model investigation, most students should be capable of guided inquiry for the project as a whole. As mentioned before, the teacher will need to provide assistance with concepts and questions beyond the students' prior knowledge. Certain tasks, like the photoelectric experiment, should be confirmation so that students gain the experience of confirming another scientist's work. The first analysis of a spectrum should be directed inquiry. Students are not likely to already know how to analyze a spectrum in terms of energies before this investigation.

Conclusion

Authentic inquiry requires complex cognitive processes and is heavily theory-laden (Chinn & Malhotra, 2002). In order for the classroom to function as an IBL environment, the teacher must take on new roles in the classroom including guide, modeler, mentor, collaborator, and learner (Crawford, 2000). The curriculum principles described by Singer et al. (2000) provide a framework that encourages authentic inquiry experiences in the classroom. These principles account for context, standards, inquiry, collaboration, learning tools, artifacts, and scaffolding. Further support can be supplied to students through the use of the four level inquiry system of Bell et al. (2005). Mr. Smith's classroom looks much different after he applied IBL principles. Students are actively learning and show interest in the content.

> *Mr. Smith has his students investigating the source of colors in fireworks. The students are asking questions, making observations, and proposing models. Students discuss ideas in groups and present them to the class for productive discussions. A student question about the aurora borealis leads the class to an unplanned discussion on the connections between astronomy, geomagnetic fields, and atomic structure. Mr. Smith now spends his time working with his students and helping them investigate instead of lecturing.*

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No "One Right Way": The Importance of Differentiating Engagement Strategies in Science Content

Alicia R. Schifferly

Abstract: Engagement in content areas of secondary education has drawn great attention due to its link to student learning, motivation and achievement. This recent appeal has led to a vast array of suggested strategies for getting students engaged in science content, which has been a catalyst for teachers feeling overwhelmed attempting to decide the most successful strategy to engage students. The countless recommended strategies serve as evidence that no one right method exists. Therefore teachers are required to differentiate engagement based on students' unique academic needs, personal interests, life experiences, and culture. Effective student engagement in science content creates the path to participation in scientific inquiry and ultimately authentic learning and achievement.

Introduction

Staging a crime scene in the classroom to determine which teacher in the building ate my doughnuts and drank my coffee as part of a "Whodunit" investigation to use modern genetic technology and the properties of DNA; building jellybean, licorice, and marshmallow models of DNA molecules; composing and performing rap songs to summarize the process of photosynthesis; and writing acrostic poems to understand the details of cellular respiration. All of the above mentioned were actual events that took place in my classroom. All occurred in an attempt to get students engaged in science content. Sound familiar? It's very possible that like me, you have tried countless strategies to get your students engaged and interested in the content you are teaching. Despite several successful attempts at engaging students as well as the occasional setback, you still feel defeated when not every student in your classroom is engaged in the content.

After reading the research findings of the current articles and texts and spending a considerable amount of time in today's secondary science classrooms, one would unarguably agree the most successful way for students to learn science content in secondary science classes is by means of inquiry (Donovan & Bransford, 2005). Inquiry is the foundation for science as well as the basis for science education. One part of inquiry is questioning. There are several different types of questions that can and should be asked in science classrooms, one of them being what the scientific community knows about scientific phenomena that occur in the natural world. Inquiry takes this question one step further by also emphasizing how scientists know what they know and why it is relevant to students. Questioning leads to other essential components of scientific inquiry. These components include conducting investigations, collecting evidence, developing an explanation, and communicating and defending conclusions to peers and the scientific community. The components of scientific inquiry form a continuous process that never ceases.

However, it is essential that students be engaged in science content in order for scientific inquiry to prove effective. Many science classes lack scientific inquiry due to the deficiency of student engagement. Engaging students in science content is important, although, the act of successfully engaging students oftentimes proves difficult, as different students demand different modes of engagement. The individuality of students' academic needs, personal interests, life experiences, and culture requires teachers to differentiate engagement.

What is Engagement?

The term "engagement" encompasses a variety of definitions and meanings in the field of education. Due to the growing interest in the topic of student engagement, a large number of researchers have incorporated their own ideas on the meaning; therefore, giving the word multiple definitions. Some research articles and theoretical works take a more general approach to define engagement and use a more inclusive, overarching definition. For example, Uekawa, Borman, and Lee (2007) define student engagement as paying close attention to classroom activities, interest in the content of lessons, and even heightened states of awareness, confidence, and performance. Other authors view student engagement as more complex; therefore, it becomes multifaceted definition that includes different subcomponents. For example, Fredricks, Blumenfeld, and Paris (2004) break down engagement into three aspects, behavioral, emotional, and cognitive, each with their own meaning, which they explain when they state the following:

> Behavioral engagement draws on the idea of participation; it includes involvement in academic and social or extracurricular activities and is considered crucial for achieving positive academic outcomes and preventing dropping out. Emotional engagement encompasses positive and negative reactions to teachers, classmates, academics, and school and is presumed to create ties to an institution and influence willingness to do the work. Finally, cognitive engagement draws on the idea of investment; it incorporates thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills. (p. 60)

These authors also suggest that the three components of engagement are not isolated, but rather that they are dynamic and interrelated. For the purpose of this article, emphasis will be placed on cognitive engagement due to its link to comprehending ideas and mastering skills, which are critical aspects of scientific inquiry.

Why Engagement is Important

Student engagement in content is a topic of interest that has appealed to many professionals in the field of education due its impact on learning, academic performance, motivation, achievement, and dropout rates (Fredricks, Blumenfeld, & Paris, 2004). Current research has found student engagement to be "a robust predictor of student achievement and behavior in school regardless of socioeconomic status" (Klem and Connel, 2004, p. 262). Interest in the topic of engagement has also stemmed from increased competitiveness of the global economy and enterprises, as well as the decline of science literacy of American students in comparison to other countries (Appleton & Lawrenz, 2011). Effective student engagement works to narrow achievement gaps, and leads to further learning and understanding of science content.

Successful student engagement in science content also promotes student participation in scientific inquiry (Hug, Krajcik, and Marx, 2005). Engaging students in science content creates a path for exploring natural phenomenon, communication, conducting investigations, and developing products (Hug et al., 2005). These activities are consistent with those of scientific inquiry. Inquiry-based learning diminishes the likeliness of rote learning and memorization of facts and instead encourages authentic learning and understanding of science as an ongoing process.

Ways to Engage

Multiple strategies exist for engaging students in science content. Strategies suggested by researchers and professionals in the field range from incorporating innovative technology in the lesson to teacher support of students including involvement and structure. Hug et al. (2005) recommend using technology such as a web-based tool or Thinking Tags, wearable badges that are programmable to simulate the transmission of diseases, as a means of engaging students. Learning technologies allow for exploration of natural phenomena, therefore creating a pathway to scientific inquiry while promoting authentic learning and understanding of science concepts. In addition, Edmin (2009) presents a cultural framework to promote engagement, "My use of hip-hop and the rap cypher are merely an anchor to drive home the point that students' participation in cultural phenomena where they are truly engaged should mirror how teachers engage them in the classroom" (Edmin, 2009, p. 17). Incorporating important aspects of students' culture within lesson delivery, assignments, assessments, class discussions, and the overall atmosphere of the classroom stimulates student engagement in science content.

Furthermore, Smart and Marshall (2013) advocate using classroom discourse, particularly higher-order levels of questioning, to increase student engagement. "In classrooms where higher-order questioning was observed, students also engaged at deeper levels with science concepts, formulating hypotheses and using evidence to draw conclusions about phenomenon" (Smart & Marshall, 2013, p. 265). Additionally, Tan and Barton (2010) suggest using students' individual lives, experiences, and proficiencies as a connection to science content. The research and literature in the field of education offers a plethora of methods to engage students, which are not limited to the mentioned strategies. The vast array of techniques presented by the community is evidence that no "one right way" exists to engage students in science content.

Which Strategy Should I Use?

Deciding which strategies to use in the classroom in order to successfully engage students can be challenging and even overwhelming. The current theory and research in education suggests a variety of different methods to engage students in science content. A method of engagement may be effective for some students but not for others because of individual need and identity. Because of diversity, it is crucial for teachers to know the students in their classrooms in order to differentiate engagement. This includes, but is not limited to the specific academic needs of the student, personal interests, culture, and life experiences. Specific academic needs might include a greater challenge for a gifted student or literacy support for an English Language Learner. Personal interests can range anywhere from long distance running to playing the guitar. Student culture might include fashion trends or language dialects. Life experiences might involve the student's home life with family or a student adjusting to living with a chronic illness. When teachers know and understand the individual needs and identities of students they can accurately decide which strategies and methods of engagement will be successful for them.

Take a moment to imagine the following situations occurring in your classroom. As the biology teacher, you know one proposed strategy for engaging students in science content is the incorporation of innovative technologies into the lesson (Hug et al., 2005). You decide to attempt this strategy and elect to use a short WebQuest activity to engage students in the events involved in protein synthesis. However, this strategy demonstrates to be unsuccessful at engaging the student who struggles to use technology. This student is unfamiliar with technology such as web-based software as he or she does not have access to a computer or Internet at home because the family is unable to afford it. The lack of engagement exhibited by this student will hinder participation in scientific inquiry therefore inhibiting learning and achievement.

You also know that another strategy suggests using student culture as a pathway to engagement (Edmin, 2009). Keeping this suggestion in mind, you decide to have students participate in a rap cypher to engage them in the structure, function, and interrelatedness of eukaryotic organelles. This strategy is successful at engaging the student who walks into class everyday with headphones in his or her ears while head bobbing to the beat of the rap song. You recall hearing a conversation this student had with another student in class about how he or she has grown up listening to music and music is not only an interest to him or her but also a part of life. As a result, this student is engaged in the content of eukaryotic organelles and therefore likely to be participating in scientific inquiry and authentic learning.

Both examples highlight the importance of the teacher knowing and understanding the students' specific academic needs, personal interests, life experiences, and culture. The first situation demonstrates the outcome of the teacher lacking knowledge regarding the student's needs and life experience. The method of engagement proved to be ineffective. On the contrary, the second situation illustrates how the teacher knew an aspect of the student's culture and used that knowledge to engage the student in the science content.

Conclusion

Engaging students in science content is the essential gateway to students' participation in scientific inquiry and therefore authentic learning. Effective student engagement is linked to numerous benefits, such as greater achievement and learning of science content and practices (Klem and Connell, 2004). Researchers in the field of education provide an assortment of suggested strategies to engage students in content that extensive research has proved successful. These strategies range from incorporating student culture into lessons and assignments to emphasizing discourse and high-order levels of questioning. The vast array of techniques suggested by the professionals in the community indicates that no "right" way of getting students engaged exists. As a result, it is essential for teachers to differentiate engagement based on student need and identity. To do this, teachers must take an active approach to getting to know their students. This includes students' academic needs, personal interests, life experiences, and culture. Teachers can get to know their students by partaking in genuine conversation with them as well as conducting student interest inventories and academic need questionnaires. Differentiating engagement will promote participation in scientific inquiry and therefore successful learning and achievement of all students.

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Not a Suburban Experience
Shaping Engaging and Meaningful Experiences for Urban Science Students

Adam Z. Thieroff

Abstract: Urban science education has failed to incorporate students' identities and cultures in science learning and the resulting disconnect has led to student disengagement from the science classroom. By valuing our students' experience, understanding how to incorporate their identity and culture in the science classroom, creating a collective third space, and providing community-based learning opportunities we can allow our students to access funds of knowledge that enable them to reengage in science learning. It is not our job as urban science educators to provide suburban experiences for our students, but rather, an experience that is shaped with knowledge of their identities and culture, relevant to their lives, and an extension of their life experience.

Introduction

When I began the process of writing this paper, I did not expect to discover how ignorant and misguided my ideas were about urban science education. While working in an urban school I became interested in exploring what types of experiences engage urban students in science learning. As I began my research, I soon realized that my question was not free from bias. As a thirty-year-old white male, who was raised in the suburbs, I was really asking, "Which of my experiences can I provide urban students to engage them in science?" The nature of my question suggested that I found urban students' life experiences to be an inadequate foundation to build scientific knowledge. From the beginning, I was invalidating their experience. I was trying to understand how to teach science with a complete disregard for my students' culture and identity. As a new teacher who has had little exposure to urban school settings, unpacking this has been eye opening. The manuscript that follows is an attempt to share what I have learned as a result of my research on the topics of urban student culture, identity, and what teachers can do to help shape experiences that engage urban students in science learning.

Research has shown that many students find traditional science impersonal, dismissive of their life worlds and career goals, frustrating, and intellectually boring. Many argue the disconnect between students' lives and school science is the main cause for their disengagement in science (Mallya, Menasah, Contento, Koch, & Calabrese Barton, 2012). Engagement has received attention as a means to increase science achievement scores and open gateways into the science classroom (Emdin, 2010a; Fredricks, Blumenfeld & Paris, 2004; Lee, Robinson & Sebastian, 2012). While engagement in the field of educational philosophy has been described extensively, I use the term more loosely to describe behavioral, emotional, or cognitive involvement in school science. By evaluating our bias as teachers and working to understand our students' identity and culture we can begin to understand how to create collective third spaces in our classrooms and provide community-based learning experiences for our students. This will provide experiences that allow them to access funds of knowledge that enable them to engage in science learning in new and meaningful ways. It is not our job as urban science educators to provide suburban experiences for our students, but rather, an experience that is shaped with knowledge of their identities and culture, relevant to their lives, and an extension of their life experience.

Maintain an Anti-Deficit Perspective of Urban Science Students

The term *urban student* has been used by many educators to position students as "other" than the "normal" student. Suggesting that urban describes a student who is disinterested in learning, disruptive, unable to do well, and deficient in life experience (Emdin, 2010a). This deficit perspective, which has been used throughout history to marginalize students, is not only unjust, it is inaccurate and misleading (Larkin, 2011).

As science educators, it is important to rid ourselves of any bias we may hold toward urban students so we can maintain an anti-deficit perspective. *Urban* should only imply a context where a student lives and learns. Urban students have valuable life experiences. These experiences may differ from ours as educators, but that should not serve to invalidate those experiences. We should work to embrace student knowledge and experience and the opportunities they present, focusing our attention on how we can connect those experiences to science content (Larkin, 2011). To do this, however, we must truly understand student culture and identity so we can effectively structure activities to engage students.

Understanding Urban Student Culture and Identity in the Science Classroom

There has been an increasing focus on the importance of understanding and incorporating students' culture and identity in school science. Too often, urban students are expected to change upon entering the science classroom; the way they interact and express themselves outside of class are not considered acceptable inside class. The majority of science classrooms are structured in ways that force students to give up their identities to achieve success, which limits their ability to find a sense of belonging (Elmesky, 2011). When urban students experience this alienation, many find the belonging they seek in out-of-school youth culture. This culture, referred to by Emdin as "hip-hop culture", has its own customs, beliefs, practices, and understandings that are exclusive to those who have been economically victimized by their physical location within inner cities (Emdin, 2010a, p. 5). When students who are deeply engaged in this culture enter a science classroom that does not acknowledge or value their identity, they are isolated from their learning. They are detached from themselves and then attached to something else (school science) that has nothing to do with them. This is why Emdin (2010a) says, "A focus on curriculum (however detailed) without either infusing it in the students' culture or including aspects of student culture in its implementation, divides students from the school" (p. 8). The first step to connect students to science through hip-hop is by demonstrating the similarities between the two. Emdin (2010a) points out that, "Both science and hip-hop attempt to generate a consensus in a community of practitioners, develop theories for making sense of the world based on observations, and validate or dispute these theories based on evidence that either supports or counters them" (p. 9).

One aspect of urban student culture that is not supported in the science classroom is the way students communicate. Emdin (2010b), points out students who are part of hip-hop culture often communicate with heightened gestures and loud speech, behavior that is generally stifled in the classroom. However, classrooms that support forms of communication that emulate how students communicate in out-of-school contexts were described by students as, "spaces where teachers value students' thoughts and opinions" (Emdin, 2010b, p. 13). Classrooms that supported these forms of communication also resulted in higher achievement scores on science tests (Emdin, 2010b). When we take the time to demonstrate to students that their culture and identity are important and have a place in our classroom, they will begin to engage with school science in new and meaningful ways. This creates a space for students where they can realize new possibilities for who they are capable of becoming in the science classroom.

Creating a Third Space; Identity Transformation in the Urban Science Classroom

When we fail to connect student culture and identity to school science, we construct boundaries that can prevent access to science learning. As science educators, understanding the presence of these boundaries and students' ability to navigate them is important for understanding how students will interact with academic activities (Bang & Medin, 2010; Tzou & Bell, 2012). Many researchers have discovered that by constructing a collective third space we can eliminate boundaries and provide multiple means by which students can access scientific content by drawing on their own funds of knowledge (Tan & Calabrese Barton, 2010). Funds of knowledge refer to historically accumulated and culturally developed bodies of knowledge and skills (Moll, Amanti, Neff & Gonzalez, 1992). Collective third space is described by Gutierrez as a, "particular social environment of development [in which] students begin to reconceive who they are and what they might be able to accomplish academically and beyond" (as cited in Tan & Calabrese Barton, 2010, p. 40). Other research describes this type of space as a place where both teacher and student meet in a figurative space between each other's worlds to work toward the common goal of learning and are relationally defined by give and take from both parties (Emdin, 2010a; Elmesky, 2011).

Incorporating this type of space in the science classroom requires a shift in thinking by the teacher. We must be willing to share classroom control with students and allow them to produce artifacts that may not be traditionally accepted or familiar to the science classroom (Elmesky, 2011; O'Neil, 2010; Tan & Calabrese Barton, 2010). In this third space, students are able to draw from funds of knowledge, which allow them to gain authority in their science education and engage in science learning in new and meaningful ways (Tan & Calabrese Barton, 2010). While collective third spaces described in research are similar in form and function, they are constructed using different methods.

One way to create a third space in the science classroom is through the construction of figured worlds. A figured world is a social construct whose members take on positional identities, which have power and rank, and work to coproduce discourses and artifacts (Tan & Calabrese Barton, 2010). For example, during a lesson on freshwater ecosystems, a teacher could create the figured world of storytelling by allowing a student to share a story with the class about a time when she caught a fish using a lure that mimicked a baitfish. As students participate in these worlds their idea of who they can be in science is transformed. Urrieta states,

> Through participation in figured worlds people can reconceptualize who they are, or shift who they understand themselves to be, as individuals or members of collectives. Through this figuring, individuals also come to understand their ability to craft their future participation, or agency, in and across figured worlds. (as cited in Tan & Calabrese Barton, 2010, p. 41)

Urrieta's sentiment can be expressed through the previous example. Prior to this experience, the student who told the story may have felt no particular connection to biology. When the teacher allowed her to share her story in class, she became an authority on the topic of discussion. The results might be that she found herself relating more positively to biology and the class viewied her as an authority on freshwater ecosystems. There are other ways to create collective third spaces aside from constructing figured worlds. Elmesky and Emdin speak extensively on the idea without ever using the term "third space."

Elmesky calls for science classrooms to "transform and shift… to embrace and afford students' hybridization of their identities as they create creolized forms of science" (Elmesky, 2011, p. 74). He draws on knowledge of creolized language, which is a simplified language that has developed from the native tongue, to coin his term. Elmesky's creolized science describes scientific artifacts and discourse that are not traditionally accepted in the science classroom, but are centered on scientific concepts. An example would be a student creating a rap about Newton's Laws of Motion.

Emdin discusses the success of cogenerative dialogues in urban science classrooms. Cogenerative dialogues are, "collective goal-oriented conversations about experiences that individuals share in particular social fields" (Emdin, 2010a, p. 11). Fields refer to shared space where individuals work and communicate. The goal of these discussions is to improve the social field. They are grounded upon rules of shared floor time and mutual respect and require continual exchanges amongst all concerned parties until the goal is reached. Through cogenerative dialogues, conducted with urban science teachers and students, teachers were able to draw on students' funds of knowledge to cogenerate plans for learning that resulted in student affiliation and engagement in science learning. Teachers also learned about their students' lives and were able to shed misconceptions they held about their urban students' desire to participate in science learning (Emdin, 2010a).

If urban science teachers can effectively create collective third spaces in their classrooms, we can expect to find more students accessing funds of knowledge that allow them to make personal connections with science. These connections will lead to increased science engagement and a transformation of how students view themselves in relation to school science. Another important aspect of providing relevant science experiences to students is involving the communities they are part of in the learning process.

A Community-Based Approach to Urban Science Education

One of the challenges in urban science education is a failure to connect scientific concepts to students' life worlds. Students, who are surrounded by scientific innovations every day, struggle to understand how science is relevant to their lives. One method that has been successful in bridging this gap is the use of community-based learning. This can involve working on problems found in students' communities or simply drawing on community funds of knowledge and incorporating these ideas into science learning.

In a study conducted by Bang and Medin (2010), a framework for employing community-based science was applied in Native American communities that worked to use community-derived knowledge in science education. While Native American is not necessarily the same demographic as urban, both communities face very similar problems in relation to science education. Bang and Medin reframed the design of the learning environment to incorporate authentic problems, place-based issues, and parents, elders, and other community members. They correctly hypothesized that students would take ownership and engage in science learning if they understood science as a practice used by their tribe throughout history.

The idea of drawing on community-based knowledge was also found to increase student engagement in Emdin's (2010a) study. He described that students recommended bringing in people from the community to serve as teaching assistants using local funds of knowledge to help connect students to science while merging their school and home life worlds. As a science teacher, Emdin brought in participants of hip-hop culture who had jobs or interests related to science curriculum. Examples included rappers who discussed the physics of sound proof recording studios and a graffiti artist who taught students the chemistry of tin-platted steel containers for holding paint and different pigments used in those paints. Emdin reported that student engagement greatly increased in every situation where community funds of knowledge were used in science class. Bang, Medin, and Emdin demonstrated by accessing funds of knowledge found in students' communities that they were able to provide experiences that greatly increased student engagement in school science.

Conclusion

When I began this process I thought it was my experiences that would somehow engage students in science. I know now that would have only served to further alienate my students. If we want to be truly successful in shaping engaging experiences for urban students, then we need to start by knowing our students and working to find novel ways to connect their life and culture to the science classroom. Creating a space where students are able to make these connections while accessing community-based funds of knowledge is vital to ensuring that we are providing experiences that are relevant to their life experience and meaningful to their science education. Doing so, can often result in "non-traditional" classroom experiences and artifacts, but does that really matter? The need is to ensure that our students, no matter their background, are engaged in science learning and leave our classrooms with new understandings of science and the world around them. A student-centered approach to science education does not only apply to urban classrooms. I would encourage you, no matter what setting you find yourself teaching science, to find new ways to know your students, to connect science to who they are as individuals, and to work to make science real and relevant to their lives and experiences.

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Fostering Urban Student Engagement in Science with Engineering Design

Mary E. Kreuz

Abstract: Failure to educate students in science is most severe in urban schools; lower achievement compared to non-urban schools is documented. The key to alleviating the achievement gap is rooted in focusing on the deeper problem of student engagement; we cannot expect the achievement gap to dissipate if we are not engaging our students in science. This article discusses how engineering design can improve urban students' engagement in science by empowering them to create solutions to human needs that are meaningful in their own lives, bringing real life relevance to the science classroom. Engineering design fosters key elements of student engagement, including students' sense of belonging in the science classroom, commitment to and investment in learning science, and participation in science.

Introduction

The science achievement gap between urban and non-urban students is daunting. Statistics show that students most largely represented in urban schools—students identified as low-income, minority, or limited English proficiency (LEP)—are less likely to succeed in school compared to students identified as higher-income, non-minority, or native English speaking (Ladson-Billings, 2006; Sandy & Duncan, 2010; National Center for Education Statistics, 2012; Carter & Welner, 2013; Milner IV, 2013). Furthermore, high school graduation rates are lowest for urban students compared to all other groups (Swanson, 2009; Carter & Welner, 2013). While educators purpose to close the achievement gap, discussions about the issue often lead to an atmosphere of defeatism and hopelessness; one study suggested that the achievement gap would continue forever (English, 2002). Are we condemning low-income, minority, and LEP students to failure before we give them a chance to succeed? Are the statistics that predict urban student failure discouraging educators from striving to engage urban students in learning? We cannot afford to exacerbate the achievement gap by reducing urban students to bleak statistics and then failing to engage them in learning. As science educators, our primary focus must be on how to *engage* our students in science, for we cannot begin to fix the achievement gap before we successfully engage our students in learning. An effective strategy for engaging urban students in science is integrating engineering design into the regular science curriculum.

Student Engagement

Many educators recognize that too many students show disengagement, characterized as "bored, unmotivated, and uninvolved" (Christenson et al., 2008, p. 1099). However, defining and recognizing student engagement is often ambiguous for science educators. Uekawa, Borman, and Lee (2007) gave one possible illustration of student engagement: "Engaged students pay close attention to ongoing classroom activities, are interested in the content of classroom lessons, and may also experience heightened states of awareness, confidence, and performance" (p. 2). Christenson et al. (2008) provided another definition of student engagement, which involves three key elements: (a) "commitment to and investment in learning," (b) sense of "belonging at school," and (c) "participation in the school environment and initiation of an activity to accomplish an outcome" (p. 1099). Even once engagement has been defined more clearly, educators still struggle to understand what constitutes an engaging opportunity.

While teaching in a high-need urban public high school in Northwest Ohio, I have observed that science teachers often facilitate activities they believe are engaging only to find that students still exhibit boredom and a lack of motivation and involvement. In this urban high school, students particularly struggled to reach science proficiency compared to any other subject; furthermore, the 4-year graduation rate for students was just over 70%, a failing grade for the 2012-2013 school report card (Ohio Department of Education, 2013). This particular school's low graduation rate and lack of science proficiency parallels the national trend in urban schools (Ladson-Billings, 2006; Swanson, 2009; Sandy & Duncan, 2010; National Center for Education Statistics, 2012; Carter & Welner, 2013; Milner IV, 2013). In spite of "engaging opportunities" provided by teachers, many urban students lack a sense of belonging in the science classroom, show little commitment to and investment in learning science, and fail to participate in science. How can we give urban science students true engaging opportunities?

True engagement in science should be reflected in student achievement of science proficiency. Research shows that engineering design improves student achievement in science (Apedoe, Reynolds, Ellefson, & Schunn, 2008; Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008; Silk, Schunn, & Cary, 2009; Schnittka & Bell, 2010). Thus, exploring engineering design as a means of engaging students in science is appropriate.

Engineering Design: A Good Fit for Urban Students

Engineering Meets Human Needs and Wants

The National Research Council (NRC) (2012) has established a comprehensive explanation of engineering design in K-12 classrooms. The term *engineering* can be used to describe "a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants" (NRC, 2012, p. 202). Bouillion and Gomez (2001) found urban students who perceive lessons as empowering them to shape their life, community, and world are more likely to accept lesson content and pursue related content and skills. Thus, urban students may engage in science learning through engineering design, for success in engineering is based upon the degree to which a human need or want has been attended (NRC, 2012). Real-world problems that build connections for urban students are characterized by having no well-defined answer, being interdisciplinary in nature, and holding relevance to the curriculum *and* students' lives (Bouillion & Gomez, 2001). Engineering design can provide such real-world problems for urban students; as defined by the NRC (2012), engineering "begins with a problem, need, or desire that suggests an engineering problem that needs to be solved" and engineers "ask questions to define the engineering problem, determine criteria for a successful solution, and identify constraints" (p. 50).

Engineering Includes Traditionally Marginalized Students

Many urban students have described science in association with "boredom, anxiety, confusion, and frustration" (Basu & Barton, 2007, p. 466). Furthermore, urban students have expressed that most school projects feel unrelated to their lives and fake (Fusco, 2001). Often, science reflects middle-class experiences and may exclude urban students, many of whom are marginalized in the science classroom (Atwater, 1996; Lee & Fradd, 1998). The Next Generation Science Standards (NGSS) include engineering with science, which may have major implications for urban students in particular, as engineering design is "inclusive of students who may have traditionally been marginalized in the science classroom or experienced science as not being relevant to their lives or future" (Next Generation Science Standards, 2013, p. 2). Fusco (2001) found that science was relevant for urban students when it was (a) born from students' "concerns, interests, and experiences inside and outside science," (b) an "ongoing process of researching and then enacting ideas," and (c) "situated within the broader community" (p. 860). Engineering design can satisfy urban students' concerns, interests, and experiences through its goal of meeting human wants and needs. Furthermore, engineering design is an ongoing process of researching and enacting ideas by its iterative and systematic nature: "iterative in that each new version of the design is tested and then modified, based on what has been learned up to that point" and "systematic in that a number of characteristic steps must be undertaken" (NRC, 2012, p. 46).

Engineering design also addresses the broader community. The National Science Board (2010) asserts that engineering in particular is critical to undertaking the world's challenges. Students' exposure to engineering design activities can spark engagement in the study of science, technology, engineering, and mathematics (STEM) and/or future careers (NSB, 2010). The National Research Council (NRC) (2012) makes a powerful statement about the potential effects of student engagement in science and engineering when they state the following:

> We anticipate that the insights gained and interests provoked from studying and engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change. (p. 9)

Thus, engineering design can give traditionally marginalized students the opportunities they desire in the science classroom through provision of real life relevance.

Engineering Provides Student-Directed Learning Opportunities

Bryan and Atwater (2002) discussed the common misconception among teachers that students from culturally diverse backgrounds, such as students in urban schools, are not as capable as other students. Perhaps urban students do not successfully engage in learning within a teacher-centered environment. Studies have shown that Hispanic and African American students (compared to white and Asian students) do not respond as well to teacher-centered instruction and perceive such education as non-relevant (Yair, 2000; Uekawa, Borman, & Lee, 2007; Parsons, 2008). Engineering design within science courses should give middle and high school urban students ample opportunities for student-directed learning. Engineering design gives middle school students opportunities "to plan and carry out full engineering design projects in which they define problems in terms of criteria and constraints, research the problem to deepen their relevant knowledge, generate and test possible solutions, and refine their solutions through redesign" (NRC, 2012, p. 71). When students reach the high school level, they should be able to navigate engineering design projects that are more complex and related to major issues on the local, national, and global scales (NRC, 2012). While skills expected in middle school should continue to be utilized in high school, there should be a greater emphasis on "researching the nature of the given problems, on reviewing others' proposed solutions, on weighing the strengths and weaknesses of various alternatives, and on discerning possibly unanticipated effects" (NRC, 2012, p. 71). By its very nature, engineering design gives urban students opportunities for relevant student-directed learning in science.

Engineering Design and Urban Student Engagement Success in the Classroom

Student Sense of Belonging in the Science Classroom

Providing an authentic learning activity, such as an engineering design project, may foster students' sense of belonging in the science classroom as they see science as relevant to their own lives and future through the social relevance and transformation fostered through engineering. When students feel a sense of belonging, they are more likely to be motivated to learn and achieve (Faircloth & Hamm, 2005). One study found that application of science pedagogy involving robotics in engineering design engaged a particularly high-need group that is greatly represented in urban schools, English as a second language and limited English proficiency students (Robinson, 2005). Results of this study showed engineering design fostered students' sense of belonging in science, a content area in which they previously felt inadequate. Another study found that students from socioeconomically disadvantaged backgrounds, also greatly represented in urban schools, feel a sense of belonging in the science and engineering fields when they are motivated by investigative interests (Conrad, Canetto, MacPhee, & Farro, 2009). This suggests that the rich investigative opportunities provided in engineering design activities might attract socioeconomically disadvantaged urban students to science and engineering fields, helping them engage in science through their sense of belonging in the science classroom.

Student Commitment to and Investment in Learning Science

A student's commitment to and investment in learning science is displayed in a variety of ways. In one study, low-achieving students showed commitment and investment through engaging in engineering design (Doppelt et al., 2008). Students displayed engagement through their intense focus and diligence to improve their unique engineering designs: "during the presentation session they often needed to be told to pay attention to other students who were presenting because they kept working right up to the time their group member was to present" (Doppelt et al., 2008, p. 32-33). Furthermore, implementing engineering design increased students' desires to learn and their interests in science topics, conveying commitment to and investment in learning science (Doppelt et al., 2008).

Student Participation in Science

A student's ultimate engagement in science should be reflected in his or her doing science (Cartier, Passmore, & Stewart, 2005). One study reported that students generally identified as low achievers showed initiation of activities to accomplish tasks when engaging in engineering design in the science classroom (Doppelt et al., 2008). The study suggested that the "freedom to learn" through engineering design gives traditionally low achievers opportunities that help them engage in doing science and reach higher levels of achievement (Doppelt et al., 2008, p. 34). In fact, authors reported that students in this study who "previously had problems paying attention in class and remaining engaged" became "attentive and fully engaged during the implementation" of the engineering design module (Doppelt et al., 2008, p. 33). This observation suggests that students who previously did not participate in science were participating after implementation of engineering design. Another study indicated similar outcomes of implementing engineering design in the urban science classroom; students who had poor attendance before an engineering design unit were attending every class period during the unit in order to participate in science (Apedoe, Reynolds, Ellefson, & Schunn, 2008).

Conclusion

There are many advocates for engineering design in the classroom. Much of the literature focuses exclusively on how engineering design can increase science achievement and may help close the achievement gap between urban and non-urban students. While acknowledging the importance of closing the achievement gap, it is important to focus on student engagement in science as a prerequisite for student achievement. Engineering design brings real life relevance to traditionally marginalized urban students in the science classroom by empowering them to create solutions to human needs that are meaningful in their own lives. Engineering design can foster urban student engagement in science by cultivating students' sense of belonging in the science classroom, commitment to and investment in learning science, and participation in science.

Urban students deserve the best education we can offer. For the advancement of our students, we must strive to overcome every challenge with an attitude of hope and victory. Let us rise to confront the achievement gap by offering exceptional means of engaging students in learning. It is time to revolutionize the way we think about engaging students in science; perhaps then we will see the achievement gap close. I challenge you to implement engineering design in the science classroom in order to engage urban students in science.

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Be the Change You Wish to See in Your Field How Teaching Evolution at a High School Level Impacts Biology Education

Christopher M. Wojciechowski

Abstract: As a result of outside societal pressures many science educators do not give the theory of evolution a full treatment in the classroom. This lack of coverage of the theory seems to stem from science educator levels of acceptance and comfort. This paper brings together research that indicates the following: the most significant impact on the acceptance of the theory of evolution occurs at the level of secondary education; comfort level with the theory of evolution correlates with exposure to the theory in school; and comfort with the theory of education leads to stronger coverage by educators in the classroom. This paper shows how science educator coverage of evolution can have a positive effect on the field as a whole.

Introduction

Imagine for a moment that you have spent weeks laying out a concept for your students. The development of this theory in its present form took hundreds of years to mature, through the efforts of multiple generations of great minds. Over the course of a century and a half research demonstrated the predictive value of this theory time and time again. At the heart of this theory is our entire understanding of the way that - within the bounds of our reality - every organism on our planet came to be what it is today, including ourselves. Great minds in the field of biology have come forward with statements such as "nothing in biology makes sense except in the light of [this theory]" (Dobzhansky, 1973). In order to fulfill your obligations to your students you are tasked with distilling hundreds of years of theory and research into a single year of instruction. This is so your students will be prepared for the next level of courses attempting to do much of the same thing as they move toward becoming scientists themselves or well-informed and logically thinking citizens. Despite the fact that you have been tasked with this obligation by your nation and state you are rebuffed in your efforts to teach the core unifying theory within your field by students, parents, and at times the faculty and administration at your school. How can this be?

A theory can be defined as a well substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses (National Academy of Sciences, 1998). A theory is going to be backed by evidence and hold predictive power. Our society has come to accept a variety of theories that are backed by evidence, which we can not observe in action. We accept that we are made up of atoms because of the predictive value of this knowledge. This is despite the fact we can not observe individual atoms. Humanity came to accept Copernicus' heliocentric theory before satellites were sent into space, because of its predictive value. Despite all of this a major subset of our population does not accept, or is unwilling to accept in its present form, the theory of evolution. In many cases the very professionals tasked with passing the knowledge of this theory on to students are uncomfortable with teaching it. This stems within the United States (as well as many other nations) from a bias toward "fairness" to a concept that is not backed by evidence. This concept is called *creation science* (Shankar, 1989). In spite of not being based on sound research the outcry for fairness toward this field has led educators to feel pressure to present it, or at least engage a conversation about it in the classroom. This takes away instructional time and more importantly develops another generation of our population that feels uncomfortable accepting evolution. The same theory that unifies the field which studies life: biology.

The question that comes to mind is: What is it that keeps us from developing a generation of life science educators that are completely accepting of evolution? What this paper intends to show through the collected research is that comprehensive education of secondary students can now have a positive impact on life science education in the future.

Which Educators are Comfortable?

According to the research, the educators that avoid teaching evolution are those who are uncomfortable with the topic. Educator comfort level is the most important factor in determining whether or not an educator will teach a full and comprehensive unit on evolution (Fowler & Meisels, 2010). The question from here is: what is the most important factor in developing educator comfort level with the theory? According to Fowler and Meisels (2010) the most important factor is the amount of time spent in class as a student with the theory. In their study, a survey taken by 353 Florida public school biology educators on the topic showed that acceptance correlated with multiple factors overall. The strongest indicator was the number of credit hours taken in biology courses. The educators with more credit hours overwhelmingly accepted evolution, where as those with minimal credit hours were overwhelmingly against it. Further this research also stated there was a similar result among those that had taken a course in either evolution itself as well as those that had taken a course on the nature of science. The idea that educator comfort level leads to stronger coverage in the classroom is backed up by the research of Rutledge and Mitchell (2002). Results of their survey of 552 Indiana public school biology educators showed higher comfort level correlated directly with more instruction time on the subject of evolution.

Why Do We Teach Evolution and not Creation "Science"?

The primary cry of those who oppose the singular teaching of evolution in the science classroom is that it is not *fair* to creation science (Shankar, 1989). Why is it that educators must teach evolution above other *theories* of human origins?

One possible goal for a science educator is the development of a student capable of using deductive reasoning. Deductive reasoning uses evidence to build a conclusion. In the course of using deductive reasoning one can develop theories that have predictive power. This is a way of making logical sense of the world around us: making our decisions and building our view of the world based on what the evidence tells us. This is how the scientific method works; it draws on an observation to make a hypothesis. The hypothesis is tested to develop evidence. The evidence is used to reach a conclusion. Finally the conclusion is tested for veracity. The opposite of this would be inductive reasoning, where one begins with a conclusion and then seeks out data to support the conclusion. This is not to say that inductive reasoning is not scientific; however, in the case of creationism the conclusion is dogmatically supported by the population despite a consistent lack of data to support it. This is the way in which religion departs from inductive reasoning. Inductive reasoning inherently allows for the possibility of the conclusion being false. The National Academy of Sciences (NAS) (2008) observes as follows:

> The arguments of creationists reverse the scientific process. They begin with an explanation that they are unwilling to alter – that supernatural forces have shaped biological or Earth systems – rejecting the basic requirements of science that hypotheses must be restricted to testable natural explanations. Their beliefs cannot be tested, modified, or rejected by scientific means, and thus cannot be a part of the processes of science. (p. 43)

This opposes the type of thought that is taught in a science classroom. What this means is that the push to give equal treatment to creationism in the classroom moves against what is meant to be a part of science curriculum. This is why it is important to engage the question of: What is it that keeps us from developing a generation of life science educators that are completely accepting of evolution? It seems to go against what it is to be a life science educator to teach creationism. Despite this hundreds of thousands of students in states like Florida (Fowler & Meisels, 2010) and Ohio (Borgerding, 2012) receive an education on the theory from educators that are not comfortable teaching it.

What Limitations Exist in Teaching Evolution at a Post-Secondary Level?

Unfortunately there seem to be limitations to the amount of growth in acceptance that can be seen at a post-secondary level. In the United States initial acceptance rates tend to sit above 50% across a variety of studies conducted throughout the past 15 years. Looking at McKeachie, Lin, and Strayer's (2002) research, acceptance rates were just over 50% in a study of first year biology students. Moore, Cotner, and Bates (2009) looked at a similar student population and found similar numbers. In each of these cases acceptance rates rose by about 10 percentage points over the course of the study. Ingram and Nelson (2006) saw acceptance rates starting in the 60% range when looking at senior level students from either biology or biology related fields. In their study of students with a deeper biology coursework background the rise in acceptance rate was less than 10% on average. This is interesting because the numbers correlate with those found in a nation with drastically different initial acceptance rates from the United States. Peker, Comert, and Kence (2010) conducted a study with Turkish students of various levels of accomplishment at a post-secondary level and results showed similar growth. The major difference is the students in Turkey have grown up under a regime that has mounted an anti-evolution campaign. This campaign has dominated the discussion of the theory for over thirty years in Turkey. As a result of this, these students are leaving their secondary education with an acceptance rate below 25% on average. Peker, et al. looked at four populations of students, all entering biology or a biology related field. Upon completion of their senior year the acceptance rate rose by 10 percentage points on average.

The significance of this lies in the fact that those Turkish students had a drastically different upbringing from that of American post-secondary students. In America, we have slowly managed to integrate evolution into the standards nationwide. In Turkey, evolution has been attacked by campaigns for over three decades. Although some American students enter their post-secondary coursework without an introduction to evolution, the studies indicate this is more exception than rule (Moore, et al., 2009). Students in Turkey on the other hand do not have an introduction to the theory. The students that Peker, et al. (2010) studied were all biology students or entering biology related fields. As a result of these factors one would expect, upon their introduction to the theory, a spike in acceptance rate growth relative to that in the United States. However, the growth rates are similar to those of American post-secondary students that have already been introduced to evolution as a core concept. What this seems to show is once students have arrived at a college level there is only so much that their professors can do to shift their belief structure to one that is completely accepting of evolution. The primary difference in the acceptance rates of evolution in students seems to occur prior to entering college level coursework.

This highlights the importance of what high school educators are doing in the classroom to cover the subject in a comprehensive manner. If we are going to develop a full generation of life science educators that are comfortable with the theory of evolution, developing comfort level prior to post-secondary coursework appears crucial. The studies referenced earlier showed the more coursework an educator had in biology, the more comfortable the educator would be with the subject. However further studies show that the college level course work can only do so much to increase acceptance levels and comfort with the topic, even among those going into biology or biology related fields. If our college level coursework can only do so much to increase acceptance rates it appears our best way of ensuring the growth and health of the field is to focus on education at a high school level.

How Does This All Tie Together?

We have developed a population that is conflicted on a core concept of biology, the study of life. Despite this fact educators are not making a full and comprehensive treatment of the subject a priority in all classrooms (Fowler & Meisels, 2010). When a strong portion of a nation's life science educators are not comfortable with a unifying concept within the field, it means that the field could be in a stronger place. Our post-secondary system is doing well to increase the acceptance of the theory of evolution in our life science educators, however we see that there is only so much that they can do (McKeachie, et al., 2002; Moore, et al., 2009; Ingram & Nelson, 2006; Peker, et al., 2010). Our strongest impact on acceptance and comfort with evolution seems to be on a secondary level. The studies seem to show, as well, that our educators' thoroughness in covering evolution seems to correlate directly with their comfort level. The entire system, seems in many ways, to be cyclical in nature. Our comfort and nuance in teaching the subject has everything to do with developing a population of possible educators that can teach evolution with comfort and nuance.

In terms of direct strategies for developing this comfort in our students, the options are varied and numerous. Many of the strategies do seem to conflict with each other. Regardless of the strategy used it is the ability of high school educators to teach evolution that may most strongly impact the health of the field. Developing a nuanced approach that maximizes student comfort, and spending more time on the theory of evolution appear to be among the strongest factors for developing a population of life science educators we can be proud to work alongside in the future. Today they're your students; tomorrow they may be your colleagues and administrators. Do yourself and your field the favor of gifting them with a high level of comfort with the theory of evolution.

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Social Studies

Making Social Studies Social
The Use of Debate in the Social Studies Classroom

Lauren Ruple

Abstract: Many social studies teachers fall into the habit of using the same traditional methods of teaching such as lecture, notes, and textbooks making social studies a monotonous, boring, and an unengaging routine of instruction for students. This article will focus on the use of debate as an instructional method in the social studies classroom. It will explore the enhancement of critical thinking, student relevance, collaboration, oral, written, and content skills, as well as student empathy as benefits of using debate as a differentiated method of instruction. Possible challenges such as student competition, class size, and time demands will also be weighed as the use of debate in the social studies classroom is discussed.

Introduction

Monday: Lecture, notes, textbook, repeat.

Tuesday: Lecture, notes, textbook, repeat.

Wednesday: Lecture, notes, textbook, repeat.

Is this getting old? I don't blame you! Unfortunately, this is the reality that many students face every day in their social studies classrooms, a monotonous and unengaging routine of instruction. Where is the discussion? Where is the collaboration? Where is the opportunity for students to formulate and support their viewpoints? Where is the human interaction and engagement that makes social studies, social? In beginning my journey of becoming a social studies teacher, I was asked, why is it so important for students to learn social studies? To be honest, I didn't know the answer to that question at first. All I knew was I liked it, it interested me, and I wanted to talk about it all day and every day as my career. But the reality is, it is important for students to learn social studies in order for them to be well informed, responsible members of society that value their civic duties and are motivated to make well-informed decisions within the society that they live. But how can we effectively engage students in realizing the importance of this because the method of lecture, notes, and review questions found in the traditional social studies classroom just doesn't cut it! Key, Bradley, & Bradley (2010) state,

> The underlying story, opinions, and perspectives that make history interesting to students can be brought into the classroom using a variety of materials. The challenge is using a variety of materials and instructional activities that stimulate interest and motivate them. Using varied approaches can result in increased student interest and valuing of social studies. Social studies and learning are powerful when they are meaningful, integrative, value-based, challenging, and active. (p. 118)

Of course, there are a plethora of resources, activities, and, materials to choose from when differentiating learning activities in the social studies classroom. Throughout this article, I will focus on only one of them and that is the use of debate as a teaching method in the social studies classroom.

Why Use Debate?

Encourages Critical Thinking

As members of society, it is our civic duty to pose questions, consider alternative viewpoints and build understanding in order to make decisions and solve problems in our everyday lives. This is exactly what debate achieves in the classroom. It encourages students to think critically. According to Scott (2008), "A well-cultivated critical thinker solves a complex problem by raising vital questions, gathering relevant information, determining findings, and communicating effectively" (p. 40). The process of debate in the classroom consists of just that. Students gather and read documents in order to be well informed on the topic at hand. They then decide on their own personal viewpoint compared to the viewpoints of others. Lastly, they voice the arguments they have built to others who may or may not feel the same way. This causes students to constantly apply, analyze, synthesize, and evaluate not only the social studies content, but also how their peers view that content. Wait, did I say apply, analyze, synthesize, and evaluate? Yes I did, and if you are a fellow educator, I'm sure you instantly noticed that those are the last four steps to higher level thinking in Bloom's Taxonomy (Seaman, 2011).

The classroom example of lecture, notes and review questions that I previously mentioned typically promotes the lowest levels of Bloom's Taxonomy which are knowledge and possibly comprehension, enabling students to only recall and grasp meaning. Debate not only uses lower level thinking such as knowledge and comprehension but it extends to the higher levels of Bloom's Taxonomy using the thinking skills of application, analysis, synthesis, and evaluation. These skills lead students to relate knowledge to new situations, show relationships, form new ideas, and make judgments. Using debate in the classroom enhances critical thinking as well as promotes higher level thinking and "incorporates other skills including listening, researching, problem-solving, reasoning, questioning, and communicating" where the typical methods of lecture, notes, and review questions do not. (Scott, 2008, p.41).

Creates Student Relevance

Social studies is a subject where the content often consists of issues from the past and from around the globe. This can make it difficult for students to show a high level of interest, forcing social studies teachers to hear those dreaded words…"Social studies is boring." And to be honest, I would probably be saying that very same thing if I were in a social studies class that consisted of the same activities day in and day out. Debate on the other hand, creates relevance for the students. Scott (2008) states, "Debates in the classroom have been effective by letting students connect as they explore topics that affect society and learn subject knowledge" (p.41). Therefore, debate doesn't begin and end with the facts. Don't get me wrong, the facts are very important but debate goes deeper. It causes students to take what they have learned from those facts and connect them with their own individual and unique thoughts and feelings.

Debate gives students a sense of responsibility for an issue. Musselman (2004) states, "By debating interpretations with other class members, students come to see themselves as co-producers of a historical knowledge that is never final—in other words, a process that always needs their input, whether or not they become professional historians themselves" (p. 336). This makes it personal for students. It is no longer a series of factual information in a textbook about an event that already happened in a place that they have never heard of, but it is now an event that needs their input and expression of viewpoints. Their feelings matter, their thoughts matter, their beliefs matter and most importantly they matter and feel as though they can make a difference whether it is class-wide or worldwide.

Promotes a Social Learning Environment

We all can agree that the world of social studies consists of a large amount of human interaction. Government, history, geography and economics, for example, have always been dependent on and affected by communication and the decisions that people make. So why not provide learning activities in the social studies classroom that are heavily based on student interaction? Effective communication among people is a main component of an efficient society. Debate simulates this effective communication and social interaction as well as promotes collaborative learning among students. It makes social studies, social.

"Debates emphasize the open-ended quality of historical scholarship and the importance of discussion with students in formulating more sophisticated understandings of history. Debates make clear that our history requires collaboration as much as isolated humanism" (Mussleman, 2004, p. 336). The collaboration found in debates can even be more effective and beneficial in learning the social studies content than independent learning. Scott (2008) states, "Collaborative teams achieve higher levels of thinking through the use of persuasive evidence. This collaboration allows individuals to retain information longer and the opportunity to engage in discussion and shared learning" (p. 41). Debate can achieve higher levels of learning through collaboration where independent learning activities such as the traditional lecture, note taking, and textbook review questions cannot.

Strengthens Oral, Written and Content Skills

Debate strengthens student oral and written skills and the ability to retain content knowledge. Students are diverse with varying strengths and weaknesses. Watts-Taffe et al.(2012) state, "An important way to honor the multiple ways in which students are diverse [gender, ethnicity, language, race, socioeconomic status, and exceptionalities (physical, mental, emotional, intellectual)] is to offer appropriately differentiated instruction" (p. 305). Debate does just that. It is an activity that offers alternative means of representation over the traditional textbook, note taking and review questions. Debate allows students to improve on their areas of weakness and enhance their areas of strength. Some students are exceptional writers but lack presentation skills, where other students are phenomenal speakers but have difficulties transferring their ideas into written explanations. For example, Musselman (2004) explains,

> These debates provide those students who have more developed oral than written skills with an activity through which they can achieve a confident grasp of the course material. I have had several students with poor writing skills improve their performance in my class because their facility with reading comes out more clearly when they are speaking. Conversely, students who write well but are less confident speakers discover and are able to work on a much-neglected skill. (p. 345)

Not only does it provide students with an activity to practice areas of weakness and heighten areas of strength, debate also increases the ability to retain content knowledge. After using debate as a learning tool in the classroom, Scott (2008) asserts that, "A majority of the students responded that the debate process aided them in gaining disciplinary knowledge and having a deeper understanding of the content, helped them with analyzing and presenting their arguments" (p.41). With debate, the process of learning the content is scaffolded. It is first learned through the act of reading resources. It is then developed by building and supporting individual arguments based on the facts learned. Lastly, it is discussed and analyzed from different viewpoints and various angles. As a result, content knowledge is highly built upon and supported throughout this process.

Creates Student Empathy

Debate also creates empathy among students. Empathy is important in the social studies content. It can be difficult for students to identify with a broad spectrum of issues and events dealing with opinions and actions that are different from their own. After asking students their feedback about debate as a learning activity Scott (2008) reports, "Students replied that classroom debates helped them to recognize and deal with various points of view" (p.41). Debate helps students to recognize that many times, social studies is subjective or in other words open to interpretation depending on the individual person. There isn't always a right or wrong answer. Often, the importance of the social studies content deals with considering and relating to the various viewpoints of others, making empathy essential.

"Students also reported that the debates helped them to understand that history is highly contested. One student said, Many times I thought the debates would be completely one-sided, but I was very impressed with the arguments that both sides were able to come up with" (Musselman, 2004, p.346). Since social studies content is often highly contested, voicing and listening to different opinions and arguments through debate causes students to recognize that people are diverse in their thoughts. Another student responded with, "I will forever approach history textbooks with scrutiny rather than blind faith that the texts are true" (Musselman, 2004, p.346). This student recognizes that even reliable resources such as textbooks, can reflect the opinions of authors causing bias in their writing. The student empathy that debate creates causes students to recognize the bias they see in textbooks and compare and contrast it to their own thoughts. People think and act differently and they aren't always aware that others might not agree. Debate unpacks those different opinions, creating student awareness and empathy.

Possible Challenges of Using Debate

There are three challenges with the debate teaching method in the classroom that Musselman (2004) poses. The first challenge is the competitive nature that some students hold. Musselman (2004) explains, "Above all, students need to understand that the ultimate point of the debate is understanding, not competition" (p. 346). Students can lose focus when they are distracted by who won or lost thus, the value and message of the debate can be lost. In reality, everyone wins in a debate as students learn content, think critically and practice skills that are not often utilized in a lecture based class.

Another potential challenge with debate is class size. A large class size can be distracting, less efficient, and intimidate some students from participation. Smaller class sizes can help a class debate be more structured and effective as a learning tool for students, as they are likely to be more involved, open, and on track. Musselman (2004) explains that the final challenge worth discussing is time, and states, "The development, maintenance, and grading of these debates requires a significant time investment by the instructor" (p. 348). I can see this being an issue. Students need a large amount of class time to familiarize themselves with the content and develop their arguments. It also takes time for the actual debate to take place ensuring that all students get a chance to express their views and all aspects of the issues are addressed. And yes, it will take time to grade the students in the debate.

With all of this in mind, I still argue that the benefits of debate outweigh the costs. It does take a large amount of class time. However, lecturing also takes a large amount of class time except it is in a way where there is no active student participation or stimulating discussion. In addition, all types of grading take time. Grading a debate would take no longer than grading a quiz or test.

Conclusion

So instead of lecture, notes, textbook, repeat, why not include the discussion, collaboration, argumentation and engagement that makes social studies social? Structured debate provides students with an activity that encourages them to think critically, amplifying their use of higher order thinking. It presents students with a learning activity that creates relevance for the students and instills a sense of pride and responsibility in the expression of their viewpoints. Debate is based strongly on student collaboration enhancing retention and strengthens a multitude of student skills such as writing, speaking, content knowledge, and empathy.

Competition, class size and time can pose potential drawbacks, but the benefits clearly outweigh the costs as students take ownership of their learning and become experts in all aspects of an issue. There are a plethora of resources, activities, and materials to choose from when differentiating learning activities in the social studies classroom and debate is only one of them. But debate is a tool that effectively engages students in realizing the importance of learning social studies in order to become well informed, responsible members of society. They will value their civic duties and will be motivated to make well-informed decisions within the society that they live. The traditional method of teaching social studies through lecture, notes, and textbook questions simply doesn't achieve the same result. Mastin (2002) states, "Our pleasure that we enjoy in our discipline is that of surprising our pupils with new and stimulating resources. We need sources that immediately arrest their attention and act as springboards into another world for the short time we have them" (p. 54). Isn't that what we all want as social studies teachers anyway? So pause the lecture, take a time-out from the note taking, briefly close the textbook and take advantage of debate as a learning tool in the classroom that makes social studies social again.

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Open for Discussion: Rethinking Teacher Neutrality in Classroom Discourse of Controversial Issues

Curt Zito

Abstract: Discussion of controversial public issues in the social studies classroom is widely regarded as an effective method to enhance critical thinking, public discourse and tolerance – civic traits synonymous with democratic society. However, many teachers accept the long-standing doctrine of neutrality as their only option in leading such discussion, failing to consider that making their own positions known, in a forum offering a balance of viewpoints, may actually enhance student learning by modeling and encouraging student development of these very same democratic traits.

Introduction

The current state of civic awareness in our country, by most accounts, leaves much to be desired. This was occasionally brought to light on *The Tonight Show* with Jay Leno, where he would stop random, typical American citizens on the street and ask seemingly simple questions about our government or current news events and usually receive responses that were fitting for a comedy show. I wonder how many of us sitting and watching at home could do much better. A recent report produced by the Campaign for the Civic Mission of Schools (2011) reaffirms what Mr. Leno lightheartedly conveyed to us. Americans, in general, lack basic knowledge of the workings of our government. Further, and more relevant to the direction of this paper, is that young people, this country's future, appear to be increasingly disconnected with politics and current events, or at least unskilled in the deliberative discourse of such issues. Byford, Lennon, and Russell (2009) note the following:

> Unfortunately, in today's society, students are often unable to justify their own opinions and debate various issues through rational reasoning. One cause of this perceived inability to justify their opinions may be the current internet society. Arguments made by students are often based on disagreement and not rational reasoning. Students seem to gravitate to information on websites that merely reflect their own beliefs. Thus, students fail to learn anything that helps them develop into effective decision-making citizens. (p.166)

Even when discourse does exist, it is often accompanied by a tone of incivility and lack of tolerance for opposing viewpoints. As alluded to above, this may have to do with the indulgence in social media, where anonymous blogs marked by dominant rhetoric and viciousness are common. This may have to do with the nature of our political and social culture where polarized ideology is evident through "talking heads" shouting one-sided views on a cable network channel that broadcasts only similar views, or in our own government, which has demonstrated that members of congress are not above similar partisan practices. Whatever the reasons, it appears to many that we have lost our way in promoting and modeling informed, responsible deliberative discourse, a significant trait of democratic citizenship.

In my ideal classroom, the teacher would facilitate and participate in lively, thoughtful discussion where students provide reasoned evidence to support their positions, while being open to counter viewpoints, leading students to re-examine, re-address and re-discuss ideas and views. The ultimate goal is to instill in students a sense of obligation – a civic duty – to become informed citizens who openly and civilly discuss important political and social issues. Supporting such an ideal, the Campaign for the Civic Mission of Schools (2011), cites research conducted by Mutz (2006) claiming that "'cross-cutting' political talk—in which citizens engage in discussions about important issues and events with people who disagree—develops tolerance for others and builds understanding of the range of views about how to best solve public problems" (p. 28). Unfortunately, as we already know, importance of issues is sometimes not enough to foster spirited, insightful discussion. Student engagement and participation is tied to student interest in the subject matter. Enter controversy.

The Case for Controversial Public Issues in the Classroom

Controversial public issues can be defined as questions of public policy, which are open to significant disagreement. Gun control, capital punishment, affirmative action and the minimum wage rate are just a few examples. Hess (2011), who has authored many articles and books on the topic of educating with such issues, notes, "A democracy without controversial issues is like an ocean without fish or a symphony without sound … It is not going too far to say that without controversy there is no democracy" (p 69). Many studies have linked an increase of student interest and engagement to the use of controversial issues in the classroom. This is not surprising as such issues are often relevant to the students and, by their nature, foster strong, polarizing opinion. Introducing such issues in the classroom can be an effective way to stir up thought and discussion, and possibly lead students to finding, and adding, their thoughts and voices on current events and issues. According to Hess, "Students need to recognize that their views matter – not because there is something special about young people, but precisely because there is not. Their views matter because all views matter in a democracy" (p 70). Schools are near perfect settings to enter into these discussions. Gutman (1999) points out that, "Schools have a much greater capacity than most parents and voluntary associations for teaching children to reason out loud about disagreements that arise in democratic politics" (p 58). Theiss-Morse (2002) stresses that we need to change our approach to civics education, de-emphasizing facts and volunteerism, and exposing students to the reality of political conflict. She explains,

> Students will not become good citizens by memorizing lists of what a good citizen does but, rather, by recognizing that ordinary people have refreshingly different interests, that these interests must be addressed even when they appear tangential, that each issue has an array of possible solutions, and that finding the most appropriate solution requires time, effort, and conflict. When schools avoid controversial political issues, which they tend to do, students are

> left with only a saccharin civil side of politics and are therefore more likely to react negatively when, in the real world, they are exposed to the gritty, barbaric side of politics. (p. 87-88)

Acknowledgment of the benefits of utilizing controversial public issues in the classroom is fairly universal, as evident from just a few of the published studies noted above. What is not so universal is reaching consensus on social studies teachers' approaches in working with such issues, which is often seen as adding controversy to controversy.

To Be ... Or Not To Be (Neutral)

Controversial public issues, by their nature, are likely to be a challenge for teachers to incorporate in the classroom. Several studies have concluded that many teachers, pre-service teachers in particular, lack the confidence in teaching such issues (Byford et al., 2009; Misco & Patterson, 2007). This can be related to a lack of knowledge on the issues themselves or due to the objectionable response the teacher anticipates when discussing such issues with students at the middle and high school levels. This leads to many teachers having reservations about incorporating such issues in the curriculum, which, in turn, can lead to inadequate depth of treatment of these important issues, or choosing not to address them at all.

One of the more common reasons for teachers' reservations in implementing the discussion of controversial issues in the classroom is fear of indoctrination, whether in actuality or through perception. This explains why most teachers are so insistent on assuming a position of neutrality when teaching controversial issues. From a teacher's perspective, by presenting his or her views, there exists the possibility that students are less likely to think on their own, adopting the views of the authoritative teacher. Even if a student does hold a contrary position, he or she may be less likely to voice this opinion. Claims of perceived indoctrination may lead to backlash from a school administrators or parents, particularly if those positions do not align with the teacher's. This is of even greater concern in this day and age, when students with phones or tablets can readily capture on video teachers passionately leading and promoting discussion of these hot topics. There are cases of teachers being disciplined and even fired for discussing issues surrounding the September 11 attacks. One teacher was told not to spend more than two class periods on discussing the controversial issue of how the U.S. should respond in Afghanistan (Hess, 2004). It is understandable why teachers would maintain a stance of neutrality and not disclose his or her position on political or social affiliations, issues or causes. However, is this truly the best stance to take?

The National Council for the Social Studies (1969), declares the following in its position statement titled *Academic Freedom and the Social Studies Teacher*:

> As a professional, the teacher strives to maintain a spirit of free inquiry, open mindedness, and impartiality in the classroom. As a member of an academic community, however, the teacher is free to present in the field of his or her professional competence his/her own opinions or convictions and with them the premises from which they are derived. (p. 4)

This speaks of the academic right the teacher has to choose not to take a position of neutrality. But there is no real justification for a teacher exercising this right unless there is a benefit to student learning and development. Teachers are often called upon to model desired student behavioral expectations. There would seem to be a disconnect if a teacher, prompting his or her students to openly support a position with reason, open to examination and discussion, does not serve as an example. In his book, *Pedagogy of Freedom: Ethics, Democracy and Civic Courage*, Freire (1998) states, "To teach is not to transfer knowledge, but to create the possibilities for the production or construction of knowledge" (p. 10). I doubt many would argue with this assertion. A teacher can create this possibility by providing an open classroom environment. I refer to an open classroom as one where teacher and students deliberate, question and enter into discourse, ideally with those who hold different opinions and beliefs than their own. "Certainly the student is in a better position to question a belief when he knows what it is" (Metcalf, 1952, p. 25).

This suggests the teacher may be doing the student a disservice by taking a neutral posture. To inspire inquiry and discussion, a teacher has an obligation to participate in this construct of knowledge. Freire (1998) adds,

> I cannot deny or hide my posture, but I also cannot deny others the right to reject it. In the name of the respect I should have toward my students, I do not see why I should omit or hide my political stance by proclaiming a neutral position that does not exist. On the contrary, my role as a teacher is to assent the students' right to compare, to choose, to upture, to decide. (p. 48)

Along with the noted academic considerations, there is also some research that supports student acceptance of teachers not adopting a position of neutrality in discussing controversial issues in the classroom. A recent noted study of high school students, the majority in their senior year, indicates that most students are open to hearing their teachers' views, and some see it as necessary for their learning (Hess & Gatti, 2010). However they are skeptical and resentful of teachers who try to force their own views on students and are critical of teachers who promote a climate in which competing views cannot be aired. This study brings to light the importance of distinguishing between neutrality and balance.

Neutrality, as discussed prior, is assuming a position of non-disclosure in a conflict. Balance, on the other hand, is giving each position its due, in allotted time and in critical analysis and assessment. A teacher, of course, may express a personal position on an issue and still establish a balanced forum. This requires that teachers establish a classroom atmosphere where students are encouraged and feel "safe" in airing their views and openly questioning their teacher's views. That is, a teacher must practice the same level of tolerance for thought and ideas that is expected from his or her students. This may be easier said than done, but when it is done what is created is a powerful model for learning. Further, it would seem that promoting and ensuring such balance would be a legitimate defense against claims of indoctrination, especially for the social studies teacher willing to stray from the neutral path.

Conclusion

Nobody would argue the importance of preparing young people to take their place as informed, active citizens in our democratic society. A large part of this civic role includes the deliberation and public discourse of important political and social issues. We need to think and talk before we can create solutions to the problems we face. A great way to get students talking is to incorporate teaching with controversial issues in the social studies classroom. By their nature, such issues are engaging and promote thought and often strong, varying opinions. The teacher, too, is likely to hold such opinions. I have attempted to challenge the widely held doctrine of neutrality as the best, if not only viable, choice for the social studies teacher. Picture a classroom where the teacher practices what he teaches and implores of his students. Both teacher and student openly discuss and question each other, pursuing learning through exchange and tolerance of varying perspectives, modeling civic responsibility. Some may call this controversial; I call it conceptual.

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Learning to Teach

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