

TEACHING SCIENCE TO LEARNERS OF AN INTROVERTED TYPE

by

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ABSTRACT

Last year the principal team at the high school where I teach made a rule that math classrooms had to organize student desks in cooperative learning pods. Students were seated in groups of three or four and teachers were encouraged to integrate group work in most lessons. Administrators even encouraged teachers to give mostly group quizzes. While this strategy has increased student learning in many students, particularly those of the extraverted personality type, I have found that many of the introverted students that I teach struggle to learn in such a stimulating environment. This year I identified the introverted students in my classroom with a personality type survey. I then offered these students an alternative to the highly social laboratory activities and group performance tasks. This alternative focused on the same material, yet provided a quiet environment with optional social interaction and lots of space to think, read, and theorize at their own pace. Using a pre-test and a post-test I was able to observe that introverted students who received my intervention made significantly larger gains than those who did not.

INTRODUCTION AND BACKGROUND

I teach one section of AP Calculus BC, one section of Academic Physics, three sections of General Science, and one section of Digital Electronics at McCaskey East High School in inner-city Lancaster, PA. I serve a racially and culturally diverse group of students. According to the school profile, 55.5% of students are Latino while 22.7% are African American with 19.5% of the population being Caucasian. Nearly 80% of the students are eligible for free or reduced lunch.

This past fall I walked past a student who was staring off into space during a lab exercise. I asked the student if everything was OK, and he responded with: “I’m just trying to learn...I can’t focus.” We talked more at another time and the student shared with me that “boards were clanking, the people next to me kept laughing, and my group just kept throwing ideas around faster than I could think...it was too much.” This student is one of the several students in my classes who seem to be utterly over-stimulated by the highly social and noisy environment that can be my physics lab. Some students just need some space to be alone with their thoughts.

This conversation came shortly after the leadership team at our high school made a mandatory ruling that all math/science teachers had to organize the desks in their room into “pods” of four in order to support a more collaborative environment for learning. This mandate is all part of an initiative to implement an engaging and relevant curriculum. Over the last three years I have observed my school district push for more and more collaborative learning. In fact, the research indicates that many “schools are employing more interactive learning strategies into their curricula which may

disproportionately challenge introverted learners” (Davidson, Gillies, & Pelletier, 2015, p. 99). While I have personally seen the benefits of this push toward collaborative learning with my extraverted students, my introverted students have really struggled to learn in this environment. My project is going to focus on adapting some current “group focused” activities to fit the needs of introverted students and then measuring the results of these changes against results from group focused learning. My primary research question is: How does a low stimulation environment impact the learning of introverted students in my science classroom? A secondary research question I investigated was: How do students of the introverted personality type perceive low-stimulation learning environments? I also asked: What is the impact of a low-stimulation learning environment on the productivity of an introverted learner?

CONCEPTUAL FRAMEWORK

At the end of her 2012 TED Talk, Susan Cain (2012) emphatically begged the audience to “stop the madness for constant group work.” An introvert herself, Cain wrote a book called *Quiet: The power of introverts in a world that can't stop talking* (Cain, 2012) in response to the growing national tendency to cater learning and working environments to extraverted personality types. Cain claims that despite the fact that between thirty and fifty percent of the population is introverted, American culture shows a strong ideal for the extraverted personality type. Cain advocates for the value of introverts in society and argues that social and collaborative learning environments are not conducive to learning for the introverted personality type (Cain, 2012). In the following paragraphs I will discuss the qualities of the introverted personality type, the

typically preferred learning styles of introverts, and specific strategies for creating a suitable learning environment for introverted students.

Over the years psychologists such as Carl Jung, Hans Eysenck, and Raymond Cattell have developed theories about personality types in people. Their work has influenced many psychologists and has been instrumental in developing the widely known personality test called the Myers Briggs Type Indicator (MBTI). Much of the educational research that has been done in the context of personality type has utilized the MBTI to identify introverted tendencies in a person. The MBTI places people into one of 16 categories by deciding to which side of the spectrum they fall on four different preferences. The first preference is extraversion or introversion (EI), the second is sensing or intuition (SN), the third is thinking or feeling (TF), and the last is judging or perceiving (JP). This study will primarily focus on a person's natural preference for extraversion or introversion (Myers, 1998).

It is important to note that introversion in people occurs on a spectrum. The opposite of introversion is extraversion, which is often characterized as "outgoing, participating and socially oriented." An introverted person is then considered to be "preoccupied with inner ideas and emotions" and to have "a preference for covert and symbolic as opposed to overt activities" (Henjum, 1982, p. 39). Commonly, introverted types are perceived by others to be "quiet" or "shy" and this can be poorly interpreted as "anti-social" and even disinterested or rude. On the contrary, healthy introverts "enjoy personal interactions" and simply do not feel a strong drive to initiate such interactions (Davidson, Gillies, & Pelletier, 2015, p.99). Jung (1923) defines the subject as the person

and the object as their environment. He then says that introverted type “thinks, feels, and acts in a way that clearly demonstrates that the subject is the chief factor of motivation” (p. 567) while the extraversion is “the transference of interest from the subject to the object” (p. 542).

As it turns out, the apparent qualities of extraversion and introversion often have their roots in physiological differences that can be identified from a young age. Jerome Kagan of Harvard University began a longitudinal study in 1989 by giving five hundred four-month-old infants a series of new experiences. He observed how the children reacted to the new experiences and placed them in one of two groups. The first group of babies reacted strongly to the new experiences with kicks, screams, and general expressiveness. Kagan called these babies “high-reactive”. The next group of infants did not seem to react at all to the new experiences. Kagan called this group “low reactive”. The last group fell somewhere in the middle of the spectrum. Remarkably, it turns out that the “high-reactive” infants turned out to be some of the most introverted teenagers while the “low reactive” infants grew into extraverted teenagers. The high-reactive infants were so reactive because they were the most sensitive to stimuli. With this work, Kagan confirmed what many other personality psychologists had theorized: there is a significant connection between the introverted personality type and high sensitivity (Cain, 2012). The placement of a person on the introversion spectrum has much to do with how readily neurons can carry information from the senses to the brain. Put simply, “because it takes very little stimulation for introverts to perceive a stimulus, their brains become easily over-stimulated” (Schmeck & Lockhart, 1983, p. 54). Davidson, Gillies, & Pelletier

(2015) note that introverts typically try to “regulate their reactivity by introverted behaviors (i.e., shy, reflective, anxious, and timid)” while extraverts with “a lower sensitivity to stimulation are more likely to exhibit behaviors associated with extraversion (i.e., outgoing, exploratory, and risk taking)” (p. 100).

Given that the tendency for introversion is at least substantially hereditary in nature, it is important for educators to understand that introversion is not something that we should attempt to un-teach. On the contrary we would do well to remember that introverted personality types play an extremely important part in our world and even show promise to excel more than their extraverted counterparts in many of society’s most crucial roles. Eysenck says that, “introverts have a greater capacity for sustained and concentrated work” (as stated in Henjum, 1982, p. 40). Cain (2012) reports that in a study of the world’s architects, engineers, mathematicians, scientists, and writers, “the more creative people tended to be socially poised introverts” (p. 74). Even in the field of sales, where extraversion is certainly the norm, it is the stable introverts who continually outperform their extraverted peers (Eysenck, 1973). Figures such as Mahatma Ghandi, Steve Wozniak, Warren Buffet, Albert Einstein, and many more were all self-proclaimed introverts. As educators, we would be remiss if we did not seriously consider the educational needs of the introverted personality type.

When considering the design of an educational environment we should have in mind that introverted students have a much lower tolerance for stimulation than their extraverted peers who tend to seek out stimulation. That said, it is worth mentioning that “introverted children do not dislike people, they are over-stimulated by too much contact

with people and thus prefer to study alone” (Schmeck & Lockhart, 1983, p. 55). Ramsay, Hanlon, and Smith (2000) agree that it is typical for introverted types to “focus their energy inward on ideas and concepts” instead of seeking social interaction to validate their thoughts through sharing (p. 647). Now that we have a baseline understanding of what an introverted type is like, we can begin to consider what successful pedagogy might look like for this group.

Research suggests that introverted types “profit from repeated emphasis on the main topic of the presentation with as little unnecessary distraction as possible” and that they are best served by “highly structured learning environments, lectures, expository, and deductive modes of instruction”(Schmeck & Lockhart, 1983, p.55). Although lecture is at times helpful for all students (and efficient for the instructor), it is important to clarify that lecture is not always ideal for the introverted type, especially if the lecture moves too fast. If an introverted type feels like they are being bombarded with more and more information without a chance to think about what they just heard, overstimulation is inevitable. Space to sort out what they have heard and compare it with what they already know is essential for an introvert. These students should be allowed to work alone or with one other like-minded person where they will be able to be most creative (Felder, 1988). Since educators also must serve extraverted personalities by providing environments with much higher levels of stimulation, “introverted students might need periodically to be sheltered from others so they can find the peace they need in order to learn” (Schmeck & Lockhart, 1983, p. 55).

Introverted types tend to be most interested in the theoretical nature of subjects. Especially in science; we should capitalize on their ability to define problems, place mathematical models around phenomena, and even propose solutions. From a science teaching perspective, this means that an introverted student may learn more from getting a copy of the lab handout, a few challenging questions, a textbook, and ninety minutes in a quiet room than they would from spending ninety minutes in a collaborative laboratory environment with constant talking and distractions. It also means that an ideal lecture happens slower with enough time to think and ask questions. Introverted students will benefit from more focus on a conceptual understanding of the topic than on the mechanics of actually solving the problems. (Felder, 1988).

When it comes to class discussion, many introverts report that they “struggled to get a word in conversation” and even resented extraverted types for being so quick to speak and dominating conversation (Davidson, Gillies, & Pelletier, 2015, p. 99). To support introverts, instructors could make discussion questions available to students well before a response is expected. Breaking students up into smaller groups or even setting up an online discussion forum also helps introverted students to have a voice and engage in the collaborative learning process (Cain, 2012). When group discussion is taking place in real time, instructors should take the opportunity to encourage the extraverted types to “ponder longer” and expand their “active listening, reflection, and mindfulness” in order to provide space for the introverted types (p. 105).

To summarize, past research has found the thoughtful, careful, creative and dedicated approach that introverts take to life is integral to the health of our society. We

should not try to help introverts be more extraverted. A lower tolerance for social interaction, noise, and general stimulation is a physical reality and not a changeable temperament. To meet the educational needs of an introvert, begin by remembering that an introverted type will require more space and time to reflect and respond. As Cain (2012) notes in the beginning of her TED Talk, going to school is a profoundly extraverted thing to do. “All day long, you are in a classroom full of people with constant stimulation.” When considering the design of an educational environment for the introverted type, it is important to provide some level of shelter from all the stimulation. Instruction needs to be structured and focused on a deep conceptual understanding of the material. A space needs to be created for extended thought and idea formulation. The theoretical approach of an introverted type should be celebrated. To this end, less social alternatives to the laboratory may be helpful at times. Above all, it is imperative that we understand and welcome these differences in our students.

METHODOLOGY

The purpose of this study was to test the hypothesis that introverted students will show higher learning gains if they are educated in a low-stimulation learning environment. I also sought to investigate the introverted type’s perception of a low-stimulation educational environment. Finally, I was interested to see how the productivity of an introverted type changes when the environment becomes low-stimulation.

I chose my general science course for this study, as I felt it would be the most fitting. These classes not only provided a cross section of the low-to-average achieving student demographic at my school, but they also represented the largest sample size opportunity.

The majority of my students were of non-Caucasian background. The diversity in ethnic background was quite large, including a large percentage of families with roots in Puerto Rico, Dominican Republic, and Haiti as well as various nations in Africa and the Middle East. About 80% of my students received free-and-reduced lunch. The average grade over my three sections of general science was a 75% and homework completion was under 50% on any given night. I served about 50 students between those three sections.

My method of teaching generally involved a lot of cooperative learning in the laboratory setting. Many days included performance tasks, experiments, group activities, and group discussions around demonstrations or discrepant events. The class had been very hands on and social. We had not spent a lot of time taking notes or drilling the main points. My intervention involved removing the identified introverts from 4 to 6 of the high-stimulation classroom events in each unit to complete alternative tasks in a low-stimulation environment. This environment was a small cubby in the hallway directly outside my classroom where I could see the students through the glass in the door. Here, among only a few of their more introverted peers, the introverted types had the space they needed to think, process information, and develop theoretical models for understanding. I was still available for help during these times and they would still have had the ability to consult their peers when interaction was needed. Alternative assignments included online simulations with guided questions, online videos with guided questions, note taking from text/video, completion of flashcards and peer quizzing with flashcards, and participation in online discussion with their peers and myself.

Using an adaptation of the informal survey that Cain (2012) suggests in her book *Quiet: The Power of Introverts in a World that Can't Stop Talking*, I began by identifying a portion of my students who most clearly displayed characteristics of the introverted type. They were identified as introverts if they scored above 14 on a 0-20 scale where 0 indicated an extravert and 20 indicated an introvert. At this point I asked the most introverted students if they would like to be part of the intervention. I reminded students of the survey they had taken recently and told them that they scored in such a way that I thought they might benefit from a learning environment that was a little different than normal class time. After explaining what their time in the intervention would be like, I informed them that they did not have to participate and a few decided that they did not want to participate. Once I had enough students for the study I split this group of students in half. In the first unit, half of the introverted types received the intervention while the other half was educated in a normal collaborative laboratory setting. In the next unit, the half that first received the intervention was now educated in a normal collaborative laboratory setting and the group that had been educated normally received the intervention.

For the two units of study over-which I completed this research, all students received pre- and post-assessments of knowledge. Since this study was really about the growth of introverted students when they have access to a low-stimulation learning environment, I mostly focused on their pre and post data. I was able to measure student growth within each individual unit and contrast the growth of the introverted types who received the intervention against the growth of those who did not, in that unit. Furthermore, I was able

to look at a single student's growth while they were receiving the intervention and contrast that against their own growth during the unit when they did not receive the intervention. In this way I was able to isolate growth data for each student and for each unit, just in case a particular unit or student would be an outlier in the data. In order to answer questions about productivity, I collected samples of students' work while receiving the intervention and samples of students' work while in a regular class and scored them on a scale of 1 to 10, where 10 meant they totally completed the work and 1 meant they did not complete any work.

I also collected qualitative data in the form of interviews and Likert item surveys. I interviewed all the students who were identified as introverts and participated in the study with me. I also gave these students Likert item surveys to measure their perceptions of: their learning in the normal classroom environment, their learning in a low-stimulation environment, their productivity in the low-stimulation setting, and their enjoyment of each type of environment. Table one summarizes my data collection approach.

Table 1
Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: How does a low stimulation environment impact the learning of introverted students in my science classroom?	Pre Test	Post Test	Teacher Reflection
Secondary Question: How do students of the introverted personality type perceive low-stimulation learning environments?	Student Interviews	Student Survey	Teacher Reflection
Secondary Question: What is the impact of a low-stimulation learning environment on the productivity of an introverted learner?	Productivity Checks	Likert Item Survey	Student Interviews

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

DATA AND ANALYSIS

In following sections I will give an overview of the data I collected in an effort to answer the above questions. The two units of study that I taught while conducting this intervention were “Energy Resources” and the “Rock Cycle”. Since the very nature of a low-stimulation learning environment implies a small number of people, the sample size for this study is only twelve students.

Impact of Low Stimulation Environments on Introverted Learners

The first question I asked was: How does a low stimulation environment impact the learning of introverted students in my classroom? Out of the twelve students who were identified as most introverted, 10 students showed higher learning gains on a pre- and post-test when they were educated in a low stimulation environment. The mean gain for all students while they were educated in the classroom was 15.4% while the mean gain for all students while they were educated in a low stimulation environment was 39.6%. The above results follow all students across two units of study, one in which they were educated normally, and the next in which they were given comparable exercises in quiet area with only one partner (Figure 1). I also tracked scores across each individual unit of study (Figure 2).

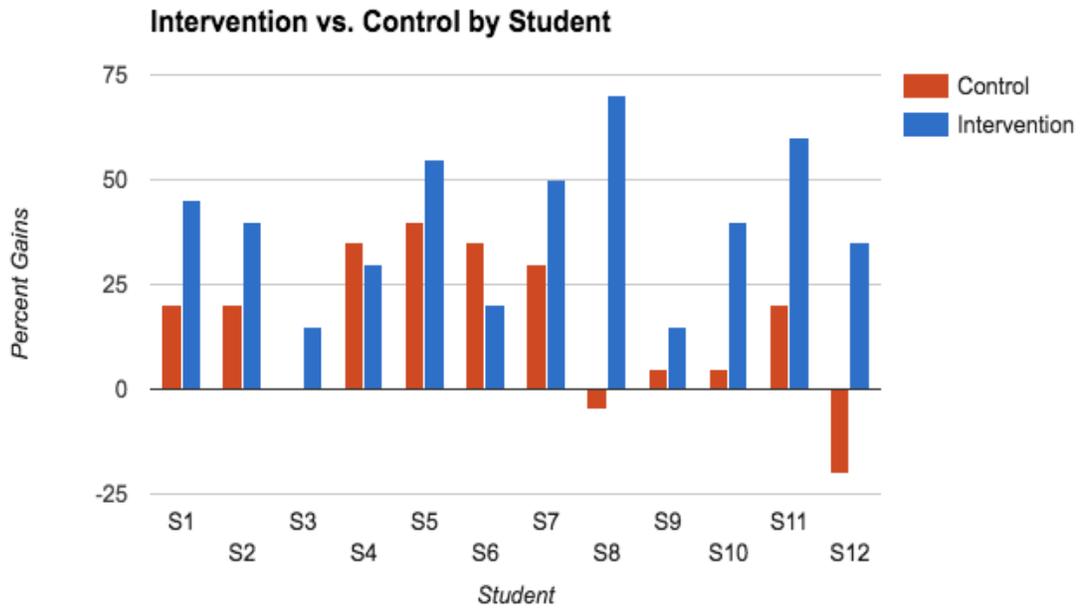


Figure 1. Comparison of student learning gains by student, ($N = 12$).

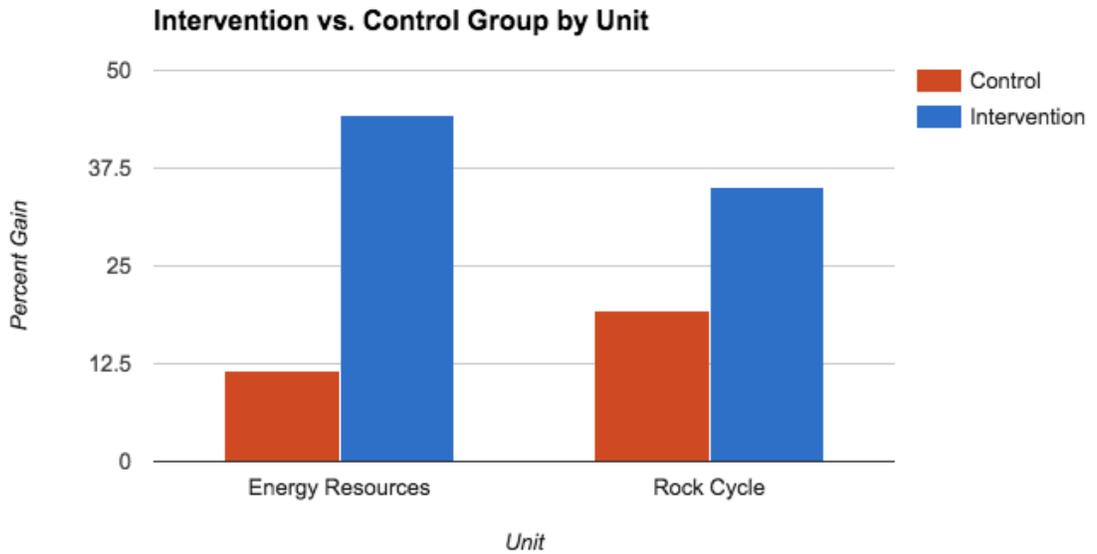


Figure 2. Comparison of student learning gains by unit, ($N = 12$).

While I taught the unit on Energy Resources and Transformations, the mean gain for the control group was 11.6% while the mean gain for the test group was 44.2%. While I taught the unit on the Rock Cycle, the mean gain for the control group was 19.2% while the mean gain for the test group was 35%.

In my personal reflections during the intervention, there were a few instances where I made note of the types of questions students asked while they were participating in the intervention. While completing a simulation about energy conversions a student asked “why do so many more red energies (thermal) fly off the bulb when I use the bulb with the filament?” Another student in the intervention asked, “What is the difference between magma and lava?” while we were learning about the rock cycle. In my reflections I recorded being surprised by such good questions from these students that I don’t normally hear much from.

Student Perception of the Low-Stimulation Learning Environment

My second question was: How do students of the introverted personality type perceive low-stimulation learning environments? First I would like to focus on the students *enjoyment* of the intervention. In my Likert item survey, I asked students to respond to the statement: “I enjoyed the days when I got to learn independently in smaller groups outside the classroom.” The responses to this statement were mixed, with most students giving a favorable or neutral response (Figure 3). In my interviews, a few students expressed a feeling of “isolation” or being “singled out” when they received the intervention. These were the same students who chose “strongly disagree” on the survey.

Many students noted in their interviews that it was “quiet”, that they were “less distracted”, and that they could “get the work done better” during their time with the intervention. When I asked students if they would like the option to work like they did during the intervention in the future, all but one of them said “yes.”

I enjoyed the days when I got to learn independently with smaller groups outside the classroom.

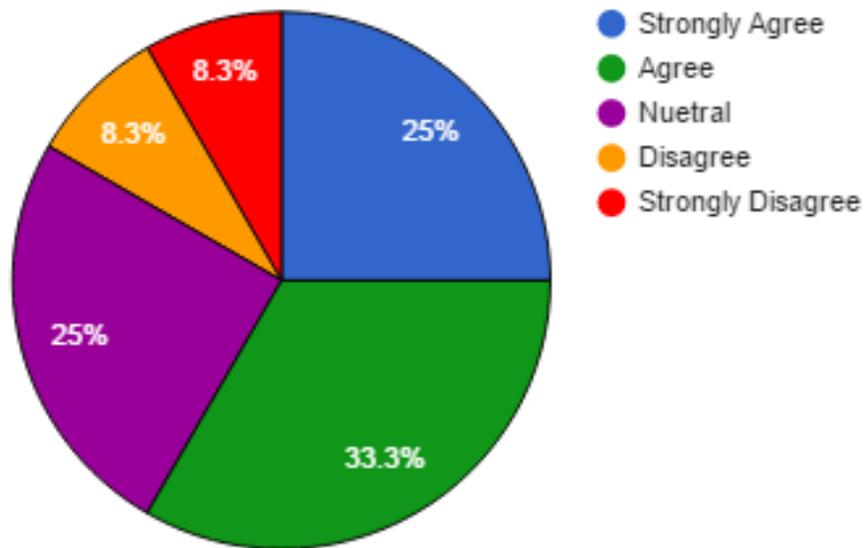


Figure 3. Student response to Likert item 3, ($N = 12$).

I would also like to address the student’s perception of their learning during the intervention. I asked students to respond to the statement, “I thought it was easier to learn outside the classroom with one other peer.” Over half the group either agreed or strongly agreed with this statement while another sixth of the group were neutral. The remaining students did not feel that it was easier to learn within the intervention. I then took the difference between student’s percent learning gain on the intervention test and the percent learning gain on the control test and compared it to their response to the above Likert

item (Figure 4). Interestingly enough there appears to be no correlation between student's perceived learning and their actual performance on the test given.

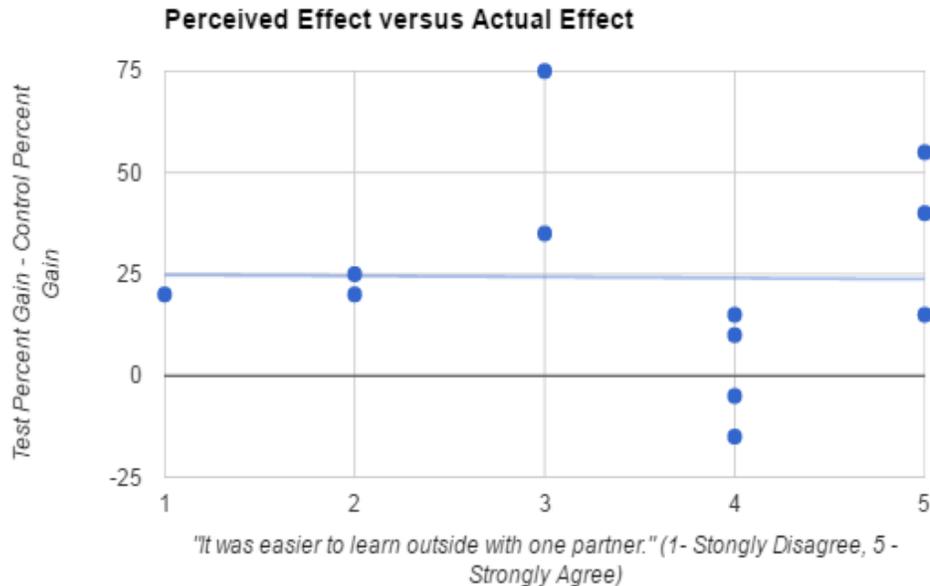


Figure 4. Correlation of perceived learning versus test scores, ($N = 12$).

Productivity in the Low-Stimulation Environment

My third question was: What is the impact of a low-stimulation learning environment on the productivity of an introverted learner? I asked students to respond to the statement: "I was able to get a lot of work done while I was working independently, while still having the option to ask my peers or teacher for help when I needed it." Responses indicated that almost all students perceived themselves to have been more productive during the intervention (Figure 5). From my personal observations I found that, with the exception of a couple students, all students participating in the intervention were extremely productive. In roughly 90% of my reflection journal entries, students finished the assigned work. When I did productivity checks on the students participating

in the intervention, they were found to be on task 21 out of 24 times. Furthermore, my teacher reflection journal indicates that on six different occasions, introverted students who were working in the standard classroom setting did not complete the assigned work. Personal experience with these students tells me that this was largely due to the distractions created by their neighboring peers. When interviewing students, I asked them: “Do you feel like you were more or less productive when you worked independently with only one peer?” In this case, all but a single student said they were more productive outside the normal classroom setting. While the students in my study reported that they did not always enjoy working in a low-stimulation environment, they were almost always more productive.

I was able to get a lot of work done while I was working independently, while still having the option to ask my peers or my teacher for help when I needed it.

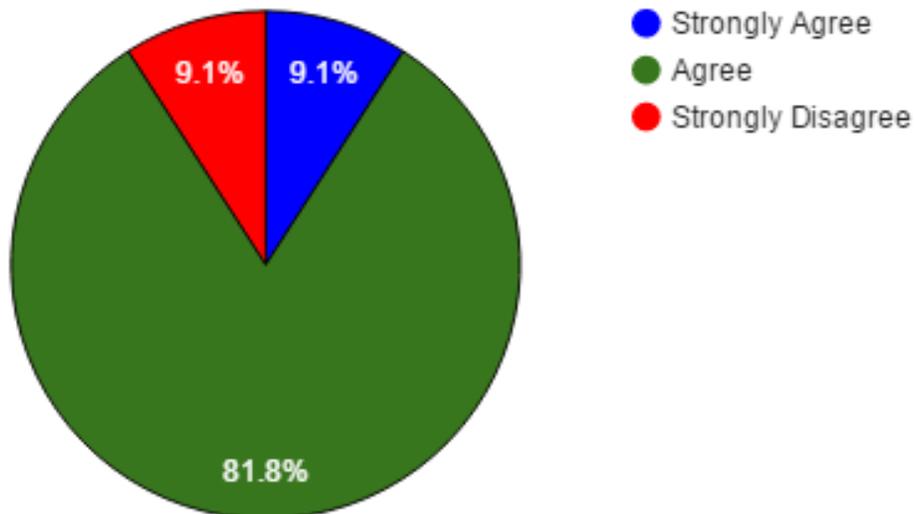


Figure 5. Student response to Likert item 5, ($N = 12$).

INTERPRETATION AND CONCLUSION

The results of this action research conclude that students of the introverted type *did* benefit from a low-stimulation learning environment. Not only did the pre- and post-test data demonstrate a clear trend toward higher learning outcomes when introverted students received the intervention, but the majority of introverted students who received the intervention reported enjoying the experience and having an easier time learning. Furthermore, over 90% of participating students reported, when interviewed, being more focused, productive, and even learning more. These results make a great case for considering a low-stimulation learning environment for students who demonstrate the personality and reliability to thrive in such an environment. That said, I believe the importance of taking the education of students on a case-by-case basis is more crucial than ever with this type of intervention.

For example, consider one of my students who had among the most introverted personality profile scores. This same student actually demonstrated higher percent gains on her pre- and post-tests when she was educated normally. Furthermore, she reported low productivity during the intervention and responded with a “Strongly Disagree” to the statement “I enjoyed the days when I got to learn independently with smaller groups outside the classroom.” It is not surprising that this is the same student who reported feeling “singled out” when she participated in the intervention. As we work to provide the best possible learning environment for our students, it is important to continually seek their input. Interventions that we try, especially for only a select group of students, need to be optional.

Several other students who had highly introverted personality profile scores opted to not even participate in the survey. This was initially shocking to me, but then I returned to Kagan and Eysenck's theory that introverted students have a higher sensitivity to stimulation, particularly new stimulation. In this light, it actually makes sense that some of my more introverted students may have perceived this change in environment as aversive, even though it was created for their benefit and they may have benefitted from it in the long term. For students who may find it stressful to be singled out, I still recommend strategies suggested by Davidson, Gillies, and Pelletier such as "providing advanced notice of the discussion questions", using online discussion boards, and "having breakout sub-groups discuss issues first and then meet as a whole group for discussion" (p. 103). These habits will likely benefit the entire class, but I believe introverted students will especially appreciate this processing time.

VALUE

Every year that I teach, there are always a few students in each class that I just do not seem to reach. They usually look overwhelmed and like they just cannot keep up with the incessant stimulation in the room. I always feel for these students, but cannot come up with a good way of reaching them within the confines of running an engaging classroom for the rest of the class. Reading Susan Cain's book in 2013 completely changed my perspective on teaching students of the introverted type. Using her work to guide my action research, my eyes have been opened to some new strategies that can clearly work in my room. With some discretion and trial and error, I think these techniques can help reach a few kids in every class each year. Some of these techniques include allowing

introverted students to work in pairs in the cubby outside my room on computer simulations, online discussions, and self-paced notes via PowerPoints that I upload to our learning management system, and focused review of material through constructing flashcards or reading over notes.

During my research, several limitations to this project became apparent. The first is that my sample size was quite small. Even though this was unavoidable given the limited resources I had available within the constraints of my time and space, I think this research is repeatable and would benefit from further work. Furthermore, I would be very interested to see how this study applies to students who attend cyber-school or attend online classes. What is the impact of online learning for introverts compared to extraverts and how does each perceive this type of learning?

It also occurred to me that I did not include any students in my study who were found to be on the extroverted scale. This was intentional because my reading of the research led me to believe that the introverted types would benefit from this type of intervention, not the extroverted types. I did not wish to conduct any study with a hypothesis that predicted poorer scores for any student during the intervention. As I thought more about this, however, I realized that I do the converse almost every day when I teach a high stimulation lessons that are full of movement and personal interaction. Previous to this study, I believed that I was teaching the correct way when I taught mostly to the extraverts. Now I have a broader perspective that will encourage me to differentiate more of my lessons and consider equally the needs of both the introvert and the extravert.

As I work to grow in my ability to differentiate lessons to cater to type of learner, I think it would be worthwhile to continue researching how students of different personality types learn in various environments. Specifically, I would like to include extraverted *and* introverted learners in my studies and seek to innovative ways to cater to students on both sides of the spectrum.

This project has introduced me to the importance and power of action research within my own classrooms. I believe my students benefitted from the thought that I put into their intervention learning environment and I benefitted greatly from the conversations I was able to have with them.

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APPENDICES

APPENDIX A
PERSONALITY PROFILE

Personality Type Survey

Answer only TRUE or FALSE to each of the questions below. You must pick one or the other.

1. I prefer one-on-one conversations to group activities.
2. I often prefer to express myself in writing.
3. I enjoy time by myself.
4. I seem to care less than my peers about wealth, fame, and status.
5. I dislike small talk, but I enjoy talking in depth about topics that matter to me.
6. People tell me that I'm a good listener.
7. I'm not a big risk-taker.
8. I enjoy work that allows me to "dive in" with few interruptions.
9. I like to celebrate birthdays on a small scale, with only one or two close friends or family members.
10. People describe me as "soft-spoken" or "mellow."
11. I prefer not to show or discuss my work with others until its finished.
12. I dislike conflict.
13. I do my best work on my own.
14. I tend to think before I speak.

15. I feel drained after being out and about, even if I've enjoyed myself.
16. I often let calls go through to voice mail.
17. If I had to choose, I would rather have a weekend with absolutely nothing to do than to have a weekend with too many things scheduled.
18. I don't enjoy multitasking.
19. I can concentrate easily.
20. In class, I would rather take notes or do an activity by myself than work with other students on a lab or project.

APPENDIX B
ENERGY RESOURCES PRE- AND POST-TEST

Energy Resources Quiz

Instructions: Circle the correct multiple choice answer. There is only one correct answer per question.

- A gas mixture made from wheat or corn is:

A. Petroleum	B. Ethanol	C. Geothermal energy	D. Kerogen
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- Energy contained in water and steam that is heated by the earth's internal heat is:

A. Biodiesel	B. Geothermal Energy	C. Solar Energy	D. Nuclear Energy
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- Which of the following is Pennsylvania's main source of energy production?

A. Coal	B. Nuclear	C. Natural Gas	D. Hydro
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- Which of the following is NOT true about fossil fuels.

A. Fossil fuels are cheap to produce.	B. Fossil fuels are easy to transport and use.	C. Fossil fuels are renewable.	D. Fossil fuels can be used with current technology.
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- What is the main and original source for most the energy we have on the earth?

A. Uranium Decay	B. The Sun	C. The Earth's Core	D. The Ocean
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- What does it mean for a resource to be non-renewable?

A. Once we use it, we will never get it back again!	B. We are using it faster than it is being formed.	C. We have an unlimited supply of it.	D. It is a sustainable form of energy to use.
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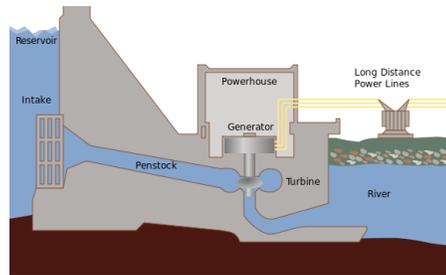
16. Chemical_____

For 17 – 20, match the picture to the type of energy production it represents.

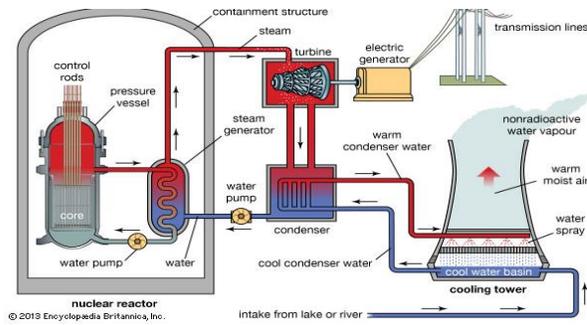
A.



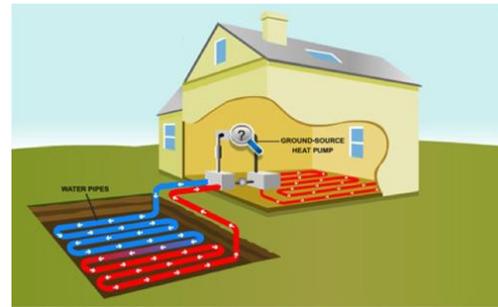
B.



C.



D.



17. Geothermal Heating/Cooling System_____ 18. Nuclear Power Plant_____

19. Photovoltaic Cell_____

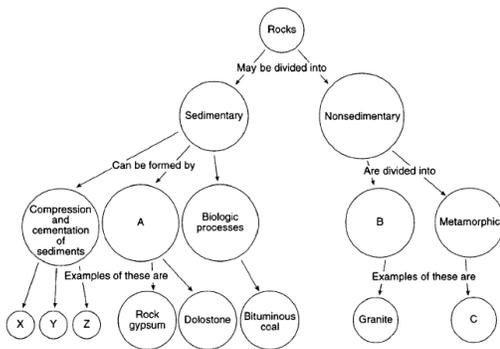
20. Hydroelectric Power Plant_____

APPENDIX C
ROCK CYCLE PRE- AND POST-TEST

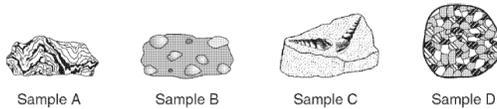
Rock Cycle Quiz

1. The picture below shows the breakdown of how we classify rocks. The rock type in circle B would be formed by which of the following processes? Which processes would form the type of rock that is represented by circle B?

- A. deposition and compaction
- B. weathering and erosion
- C. melting and solidification
- D. faulting and folding



1. The accompanying diagram shows four rock samples.



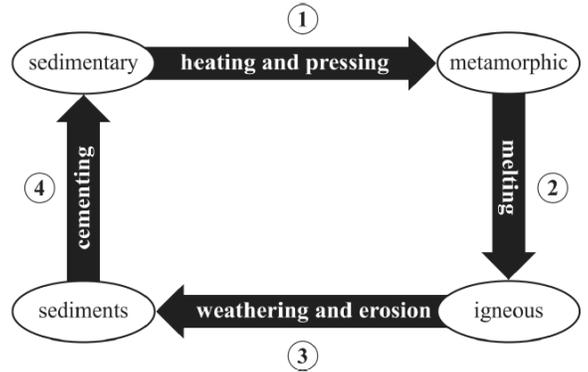
Which sample best shows the physical properties of a metamorphic rock?

- A. A
- B. B
- C. C
- D. D

3. When granite melts and then solidifies, it becomes

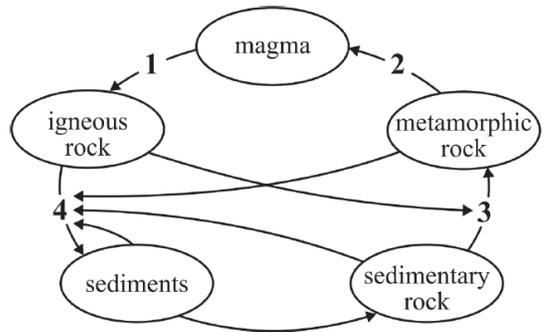
- A. a sedimentary rock
- B. an igneous rock
- C. a metamorphic rock
- D. sediments

4. The picture below shows a model of the rock cycle. During which part of the rock cycle does water break rocks apart?



- A. Part 1
- B. Part 2
- C. Part 3
- D. Part 4

5. A rock cycle diagram is shown below.



What happens to rocks at location 3 in the diagram?

- A. heating and pressing
- B. melting and cooling
- C. weathering and eroding
- D. compacting and cementing

6. Shale is a sedimentary rock that can be metamorphosed into slate by...

- A. cementation.
- B. chemical weathering.
- C. sedimentation.
- D. increased pressure.

7. In an area where a river has cut deep into Earth, there are several layers of very different rock exposed. The oldest rock layer is most likely to be the layer that is...

- A. below the other layers.
- B. the thickest layer.
- C. the most rich in fossils.
- D. igneous intrusive rock.

8. The table below shows how four different rocks were formed and gives their composition.

Rock	Formation	Composition
1	Sand Particles cemented together	Silica and sand particles
2	Shallow marine precipitate	calcium minerals and fossils
3	Cooled quickly from lava at the surface	Iron and magnesium mineral
4	Cooled slowly from the magma deep in earths interior	Quartz and other silica mine

Which rock described in the table is most likely granite?

- A. 1
- B. 2
- C. 3
- D. 4

19. A rock sample will most likely contain

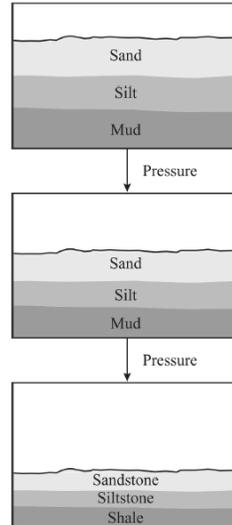
- A. plants
- B. minerals
- C. water
- D. wood

10. Ricardo has an igneous rock in his rock collection.

Where did this rock most likely form?

- A. in a volcano
- B. on a forest floor
- C. on a coral reef
- D. at the bottom of a river

11. The diagram below shows how a type of rock is formed over time.



This diagram represents the formation of which of the following types of rock?

- A. igneous
- B. metamorphic
- C. sedimentary
- D. volcanic

12. Which of the following areas is most likely to form metamorphic rocks such as gneiss and schist?

- A. a sea floor
- B. a windblown desert
- C. a site deep underground
- D. a site covered by a glacier

13. Some magma cools slowly under the surface. This slow cooling magma forms which kind of rock?

- A. Intrusive Igneous Rock
- B. Extrusive Igneous Rock
- C. Sedimentary Rock
- D. Metamorphic Rock

14. When rocks are affected by weathering and erosion, they change into which of the following.

- A. Sediment
- B. Magma
- C. Igneous Rock
- D. Metamorphic Rock

15. The Lincoln Memorial is made out of white Georgia marble. What type of rock is marble?



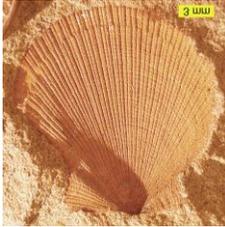
- A. Igneous
- B. Metemorphic
- C. Sedimentary
- D. Magma

16. Identify the set of processes that can take igneous rock into sediment into sedimentary rock...into metamorphic rock...into magma.



- A. Weathering and erosion...compacting and cementing...heating and pressure...melting
- B. Compacting and cementing...Weathering and erosion...heating and pressure...melting
- C. Weathering and erosion...heating and pressure...compacting and cementing...melting
- D. Melting...weathering and erosion...heating and pressure...compacting and cementing

17. This fossil was found in a slab or rock. What type of rock was this fossil most likely found in?



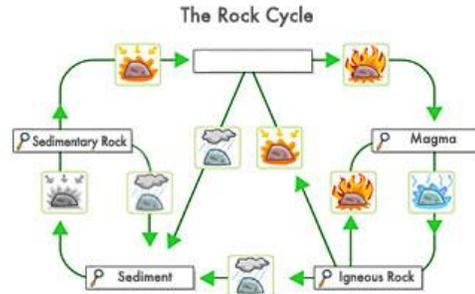
- A. Metamorphic
- B. Igneous
- C. Sedimentary
- D. Gemstone

18. This rock has a glassy surface. How was it most likely formed?



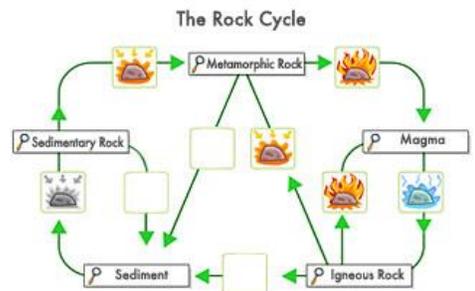
- A. Magma slowly under the earth.
- B. It cooled quickly after magma ran out the top of a volcano.
- C. It was compacted and cemented over thousands of years.
- D. It was under great pressure and heat under the earth.

19. Which element is missing from this rock cycle picture? (Hint: its what belongs in the empty box!)



- A. Melting and Cooling
- B. Sediment
- C. Heat and Pressure
- D. Metamorphic Rock

20. Which process of transforming rocks is missing from this picture? (Hint: the same process belongs in all the empty boxes!)



- A. Heat and Pressure
- B. Melting
- C. Cooling
- D. Weathering and Erosion

APPENDIX D
LIKERT ITEM SURVEY

Independent Learning Survey

Choose the statement and number the most closely matches how you feel about each statement below.

- 1. I often feel like there is too much going on in class for me to focus on learning.**

5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree

- 2. I thought it was easier to learn outside the classroom with only one other peer.**

5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree

- 3. I enjoyed the days when I got to learn independently with smaller groups outside the classroom.**

5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree

- 4. When I was outside I felt like I couldn't get enough help on the assignments.**

5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree

- 5. I was able to get a lot more work done when I was working independently, while still having the option to ask my peers or my teacher for help when I needed it.**

5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree

APPENDIX E
INTERVIEW QUESTIONS

Interview Questions

1. Compare and contrast the way you felt while you were working outside the normal classroom to the way you normally feel inside the classroom.
2. Do you feel like you learned more or less than normal when you were working outside the normal classroom?
3. What was the best part about working outside the normal classroom? How about the worst?
4. What did you do when you were confused about something that you were supposed to do?
5. Would you like to have the option to work like this in the future?
6. How often did you take the opportunity to discuss the topic with your peers who were also outside? When did this happen?
7. Do you feel like you were more or less productive when you were working outside the normal classroom?
8. Do you feel like a computer with internet access helps you learn?
9. What did you think about discussing things with me on Schoology? How does this compare to discussions we normally have in class.
10. Which types of independent learning opportunities did you learn the most from?
11. Was there ever a time that you wished you were working in the room instead? When was that?