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Science Stations and Executive Function
2013-2014

School Context

Situated in Rogers Park, Chicago, Illinois, my urban neighborhood school holds a rare pocket of diversity in an otherwise segregated city. Rogers Park is home to multiple refugee programs, is rated highly walkable, has an average of residents working in non-profits nearly twice as high as the state average, and is nestled between Loyola and Northwestern University, all of which contribute to a relatively high degree of liberalism and tolerance. Public street festivals, farmers markets, parks, beaches, mural-ed underpasses, and a rich history bring community members from all backgrounds together. Meanwhile, gang-violence polarizes parts of the neighborhood with high rates of drug use and crime.

Of the 382 students, 97.6% come from low income families according to federal poverty guidelines. School demographics include a large population (54.2%) of Hispanic students, 35.3% Black students, 6.5% Asian, 2.5 % multiracial students, and 1.6% White students in the 2012-2013 school year. The Hispanic population is largely Mexican, but represents El Salvador, Guatemala, Belize and other central and south American countries. The Black population is a combination of recent African refugees, long standing Chicago natives, and children of African immigrants. The Asian population is largely comprised of Nepali refugees very new to the English language, but represents families with roots from all across Asia. Race and ethnicity enrich the school's diversity, but the school also serves a variety of student needs with a gifted homeroom in grades 4-6, 34% English language learners and a 12% special education population. The teacher population is highly diversified as well with 40% Black, 22% Hispanic, 30% White, and 8% multi-racial, 57% female and 43% male who represent speakers of four different languages.

The school is departmentalized at all grade levels. The professional staff is highly collaborative, administration is very supportive with providing professional development opportunities, and space for both peer reviews, weekly grade level meetings, and weekly vertical content area meetings. This culture lends itself to teachers becoming experts in their content area. However, the departmentalization results in each teacher serving between 80 and 100 students, meaning constant, personalized teacher-parent contact for all students is a near impossibility.

Unlike most elementary schools, this Chicago elementary spans only 4^{th}-8^{th} grade, making my 5^{th} grade population not the typical "top-of-the-pack," but rather fighting for validity among the older students. Many parents are uneasy with their forth and fifth graders sharing a facility with older adolescents in a neighborhood where young people are confronted with the reality of gang violence. This unease shows itself in a 47% school safety rating on a parent survey.

The physical facility is large and brick and has high ceilings and long windows. While the space itself is very conducive to an elementary setting, the hallway floors are painted black, the walls are a murky brown, the building lacks general updates, and only eleven classrooms have air-conditioning units. Rogers Park is now becoming home to a variety of charter middle schools with new technology and flashy facilities. Enrollment drops from fifth grade to sixth grade as families move to these charter options. Some of the more challenging students return to this neighborhood school creating an imbalance between the upper elementary and middle school population in the building. With the exception of the gifted program, many of the most diligent students with the most involved families chose these charter options for grade six and beyond. Students who then need more individualized attention and support now comprise entire homerooms in the upper grade levels because there are not enough students to form more homerooms. The younger students see this shift, and the most invested in their education look for other options after fifth grade contributing to the ongoing cycle and challenge

facing neighborhood schools.

As a science teacher, I see all the fifth grade children for a coveted hour a day. All special education and English language learning children are included in science class, occasionally with only social emotional goals. My struggle is to serve their needs while not detracting from the general education high academic expectations. With this inclusion, my class sizes are larger than typical for my school averaging about 27 students, and I am provided an assistant for the homerooms with the most challenging special needs students who make up 30% of the homeroom population. During the day, I serve two special education homerooms, one gifted homeroom, and one general education homeroom.

The classroom culture of respect and engagement is generally high. Students recognize me as a Spanish speaking community member. I live within a fifteen minute walk to school, and am often seen with my dogs and Spanish-only speaking husband. I believe this contributes to student investment because I come with credibility, and I could run into families or parents at any given time—making the difficult task of constant parent contact in a departmentalized setting more feasible and natural. My 5th grade homerooms are a pleasant microcosm of the community. Overall, this urban school is a beacon of diversity that celebrates teachers. Although there are plenty of challenges, the opportunity for student success are abundant.

Literature Review and Rationale

Executive Function (EF) is a set of skills in the prefrontal cortex that weave together social, emotional, and intellectual abilities so that we can reflect, analyze, plan, and evaluate in order to reach our goals (Galinsky, 2010). Lezak (as cited in Peters et al., 2012) defines EF as "a collection of interrelated cognitive and behavioral skills that are responsible for purposeful, goal-directed activity," (p. 42). These interwoven abilities teeter around planning, organizing, and impulse control (Welsh, Pennington, & Groisser, 1991). Essentially we can break up EF into two core strands: metacognitive

regulation and social/emotional regulation (Kaufman, 2010). Individual facets of EF are closely interwoven. While Barkley (1997) argues that behavioral inhibition—suppression of behavioral outbursts—is the crux of EF without which other neuropsychological abilities could not function properly, Anderson (2003) contends the most salient facet is goal-directed behavior. Regardless of the debate among researchers as to the foundation of EF, "...most agree that the term 'executive function' is an umbrella construct for a collection of interrelated functions," (Peters et al., 2012, p. 169).

EF skills are both a predictor of success and unrivaled in malleability compared to other cognitive competencies. Tough (2013) notes:

> Among scientists who study children in poverty... executive function seems like a potentially promising vehicle for closing the achievement gap between poor kids and middle-class kids...The prefrontal cortex, [home to executive function], is more responsive to intervention than other parts of the brain, and it stays flexible well into adolescence and early adulthood. So if we can improve a child's environment in the specific ways that lead to better executive functioning, we can increase his prospects for success in a particularly efficient way. (p.77)

If we want to give our children an opportunity to break the cycle of poverty, we must target EF growth early.

Tough (2013) presents vast evidence for the need to develop executive function (EF) in low-income populations. One Chicago study cited in his book shows no statistical difference on scales of poverty, unemployment, and health risks between students who drop out of high school and students who get their GED. Meanwhile, students with their GED and high school graduates are indistinguishable on intelligence tests. Therefore, there is a third variable, not intelligence, correlating undesirable life outcomes and acquisition of a GED rather than a high school diploma. Allostatic load is a rampant term among literature (Blair et al., 2011; Danese & McEwen, 2011; Evans & Fuller-

Rowell, 2013; Vieta et al., 2013) identifying childhood poverty as a negative predictor of adult success. Allostatic load has been shown to negatively correlate with EF; developing these crucial EF skills is hindered by measurable effects of childhood poverty, (Evans & Schamberg, 2009). Allostatic load is essentially the biological marker of the cumulative effects of physiological responses to chronic stress--otherwise known as the "wear and tear on the body" due to stress. It is determined by purely medical measurements--blood pressure, cortisol levels, heart-rate, and body mass index. Thus, stress is not necessarily a problem; the real problem is our body's physiological response to stress, which is not only cumulative, but can be measured (Ogden, 2004).

While many bodies of research show correlations between childhood poverty and low ratings on scales of adult health, wealth, and happiness (Blair et al., 2011; Danese & McEwen, 2011; Evans & Schamberg, 2009; Vieta et al., 2013) they also show that not all children facing similar risk exposure suffer the same degree of negative consequences. Evans and Shaumberg (2009) were able to correlate EF deficit, poverty, and allostatic load. However, when they statistically eliminated allostatic load, the effects of poverty disappeared. Poverty is not the limiting factor of children's EF potential, rather the effects of poverty, such as physiological responses to chronic stress, are responsible for insufficient EF skills. In a more recent 2013 study, Evans isolated the self-regulatory capacity of EF through a delay in gratification test and found that these skills offered some protection from chronic stress to the prefrontal cortex (Evans & Fuller-Rowell, 2013). So not only is allostatic load—heightened physiological response to stress—linked to EF deficits, but building up EF can decrease the effect of allostatic load on a child's ultimate success.

Few schools implement direct EF interventions. EF skills include but are not limited to: planning, organization, goal setting, self-monitoring, task initiation, task persistence, adapting to unexpected situations, emotional control, response inhibition, and attention shift. As a science teacher, and especially under the release of the new Next Generation Science Standards, I believe science is the

perfect medium to harness EF capacity as science concepts and processes have their roots in executive function skills. My classroom practice of gradually giving students full ownership and responsibility in science seems to increase their engagement, organization, time on task, collaborative skills, and independence. The rationale behind this action research is to create formal, quantifiable observations of the changes in EF during a year in my science classroom. I have chosen to focus on a homeroom that includes a small percentage of special education students as it has the largest range of ability levels. Some students are integrated in this class with pure social goals, while others are held to high academic standards. I believe that with a focus on using science to build EF, needs of all students can be met.

In the age of No-Child-Left-Behind, Science is not always a valued subject as it holds no rank on school ratings and is rarely tested by national standards. Unfortunately, that means many schools skimp on Science instruction or equate it to informational text. I am privileged to have the opportunity to provide my students 60 minutes of science instruction daily. I serve nearly 100 students this year, and have baseline data for all, more extensive data for one homeroom, and zoom in on a few students as case-studies within that homeroom. If my findings show executive function growth as a whole, the implications could offer long needed validity to not only the science classroom, but student ownership within the science classroom. In other words, detailed findings from my practice could inspire other science teachers to work towards full teacher release and at the same time inspire principals to allow for daily, intensive science instruction with the purpose of building executive function and putting a dent in the cycle of failure in our low-income, urban communities.

As I sort through this body of relatively new research, I imagine the relationship between EF development and the effects of allostatic load is like a revolving door gaining momentum. As soon as EF gets its foot in the door, so to speak, as soon as that child facing high levels of allostatic load has an opportunity to develop an EF skill--say self-regulatory behavior--that piece of EF is going to offer some protection, a little boost to lighten that load, and it is going to make that door easier to move,

allowing for more robust and more frequent EF development to enter the turnstile and generate forward momentum towards success in adulthood. This is what I believe Tough (2013) was referring to when he said, “if we can improve a child’s environment in specific ways...” (p. 77) I think he meant, if we can provide an opportunity for that executive function piece to get its foot in the door, “we can increase his prospects for success in a particularly efficient way," (Tough, 2013, p. 77)

In an attempt to create such an environment in my classroom, my design of science instruction needs to work with the constant reminder that all EF skills are always driven by goals (Galinsky, 2010). My students must be given guidance and practice in creating goals, creating plans to reach their goals, initiating and maintaining focus on those plans, and managing both their time and emotions in response to their progress towards their goal. As I work through the facets of EF, I see character traits of a scientist. And I am not alone. Researchers have found not only that trouble with intuitive reasoning in math and science is related to poor inhibitory control mechanisms regulated by EF (Babai, Eidelman & Stavy, 2012), but that early engagement with testing and revising hypotheses depends on EF ability (Gropen et. al., 2011). Further research discusses the “potential bidirectional influence of EF and science,” as results indicate that “EF predicted gains in science to a significantly greater degree than math, and literacy,” (Nayfeld, Fuccillo & Greenfield, 2013, p. 81). We know that science skills and EF skills are uniquely connected. We know that one supports the other, and we know that both are responsive to intervention. I can think of no better classroom medium to access and build EF in poverty-ridden adolescents than science, and the stakes are too high not to.

Research Question

How can I use Science as a medium for developing executive function in my fifth grade, low-income, urban students?

Methods

Two standard methods operate for measuring executive function (EF) in children are behavior rating scales and performance tasks (for example, card sorting, Tower of Hanoi, and so on). McAuley et al. (2010) found that BRIEF, a well-recognized behavior rating scale for EF, scores were not correlated with scores on performance-based measures of EF. From these findings, the authors concluded that either behavior rating scales are not an accurate measure of EF or "performance based tasks do not engage the same set of skills that are required in naturalistic settings" (McAuley et al., 2010, p. 502). Therefore, measuring EF in the classroom requires some creativity. I need to couple self-reports and teacher observation with natural performance tasks in the classroom. Those natural performance tasks will be original as currently there is no existing research-based method for natural classroom performance tasks to measure EF.

Grit and Self-control Scale:

Grit and self-control (the suppression of impulsivity) both work to sustain effort and interest in a goal, and as such, are facets of EF. While grit describes the pursuit of a challenging goal over the long term, self-control describes the immediate, moment to moment battles for achievement (Duckworth, 2013). Grit and self-control measures for each student in the 5^{th} grade were collected based on student self-assessment surveys developed by the Duckworth Lab (Duckworth, 2009).

On-task, Off-task records:

Once a week, an assistant in the Special Education homeroom kept a tally of students on and off task throughout the class period. She took more specific notes about the activities of my students chosen for case study. These anecdotes include if the student is working in a group or individually, planning or revising work, maintaining a neat or messy work space, and also records emotional state and pacing (i.e. rushed, laid-back, active, and so on).

Adapted Marshmallow Test:

The Stanford marshmallow experiment offered children one small reward, often a marshmallow, immediately, or two small rewards if they were able to wait until the experimenter returned at an unknown time (Mischel, 1972). Children who were able to wait with the long-term goal in mind were found to have higher SAT scores (Mischel, 1989), educational attainment, average annual earning (Shoda, 1990), and a lower body mass index (Schlam, 2013). However, the University of Rochester (2012) showed that the Marshmallow test is not solely a marker of a child's self-control, but also of the reliability of their environment. Children who waited made rational decisions in a belief that waiting would produce the double reward. However, some children have experiences that are less reliable and a rational decision, then, would be to take the single reward while it is available.

In adapting this test of "self-control" in my classroom, I had to first provide a reliable environment. I made a promise involving candy for the following week. I made good on this promise to provide an experience of a reliable promise. Every child enjoyed his or her piece of candy. The following week, I brought in candy again, but told the students I had not bought enough. Each student could take one candy now, but if they waited until I bought more sometime the next week, I would give them two for their patience. I recorded which students took the candy immediately, and which students preferred delayed gratification and accepted two candies the following week instead. Of course there is the limitation that this one instance of reliability cannot possibly overcome a lifetime of unreliability,

so the conditions of the two experiences were kept as similar as possible.

Pacing Analysis:

As students complete a station, they receive a signature from me with a date. As they turn in their station sheets per the deadline, I track the number and spacing of signatures—whether they are evenly spaced, or clustered around the onset or deadline of the station round.

Student Grades:

Students had nearly 6 weeks of school before switching to stations after which grades were averaged. Students' original grades by homeroom were compared after the first unit of stations, the second unit of stations, and after three months of stations.

Teacher Journal:

Throughout the year, I maintained a teacher's journal with my personal observations of the class, pictures and videos of the classroom, student work, and one-on-one conversations with case-study students.

Case Studies:

For my case study students, I conducted Executive Functioning Semistructured Interview in the fall and again in the January. I also collaborated with their other teachers to create an Executive Function Skills Inventory, and am keeping portfolios of their work samples.

Findings and Discussion:

In the September videos from my teaching journal students are conducting their first experiments

with joy glimmering on their faces and slight gestures of independence seeping through the prescribed curriculum. However, students are at desks, in small groups, and each group is working on the same task. Memories of my frustration with beginning, middle, and end science instruction for a 50 minute block come flooding back. I, the teacher, was setting our goal with our daily objective, making our plan to achieve our goal, organizing our materials in baskets for each table, managing the time and pacing, telling students how to begin, redirecting their attention to persist at our goal, and monitoring their work and behavior. Essentially, the only executive function skill involved in our tasks that I was not executing, was their emotional control and perhaps working memory. As long as students could control their outbursts and follow my lead, they would be successful in my classroom.

Curriculums are written to general education norms and this one-size-fits-all approach is a disservice to students with EF deficits; typical interventions remediate the student, while more meaningful intervention would rehabilitate the curriculum (Metzler, 2007). While my students are not formally diagnosed with EF deficits, the environment a child grows up in dramatically affects his or her EF growth, and a child's EF can be predicted based on his or her parents' level of education (Ardila et al., 2005). Given this research, my school population, observation, and student work documentation, my students exhibit qualities and characteristics comparable to EF deficits.

I changed my instruction.

In remediating the curriculum, I parceled up the lessons, and re-wrote them with student friendly instructions. Each lesson became a station. Students were given a work plan with the different stations and deadlines. They chose what work they wanted to do, when they wanted to do it, and who they wanted to do it with, while I took small groups to the rug for mini-lessons or circulated the room to provide feedback on work. Under this model, students were given the opportunity to practice their EF skills: goal setting, planning, task-initiation, task-persistence, organization, time management, self-control, and self-monitoring. They have more ownership over their work, understand the process, and

hopefully are able to apply the skills they were using to life outside of my classroom.

Task Initiation and Task Persistence

My first worry in making the transition to stations was on-task activity. Suddenly, students would be asked to take on a responsibility they had never shouldered before that involved a great deal of choice, self-control, and goal-directed attention. Once a week, students' on or off task activity was tallied three times during the class period. I chose to zoom in on homeroom 203 for this data because, being a special education homeroom, all ability levels are present. I am representing on-task students as percentages because class sizes often fluctuate do to a transient population, absences, and changes in special education minutes. This homeroom fluctuated between 24 and 28 students, so one person is usually represented around 4%.

Task-Initiation/Task-Persistence Averages for Homeroom 203 for 7 weeks

Average number of students **on-task** for the *three weeks*	Beginning of class period	Middle of class period	End of class period
BEFORE switching to stations	86%	64%	68%
First week of stations	71%	67%	77%
AFTER switching to stations	82%	82%	70%

Before stations, students struggled with task-persistence, and needed constant teacher reminders of what they should be doing. In the first week of stations, task-initiation took a dip, but more students were on-task and engaged in their work at the end of class. After adjusting to stations work, there is evidence of higher task initiation and task persistence with many more students remaining on-task through to the middle of the class period, but by the end of the class period there is little change in the number of students on-task.

Two students in particular presented with clear, but vastly different, EF deficits. They serve as my case-studies moving through this process. The following descriptions are based on my September teaching journal notes:

> Khaled is a vibrant boy gushing with smiles and energy. Teachers, social workers, and the school psychologist agree that, although undiagnosed, he likely has ADHD. Barkley (1997) identifies strong deficits in behavioral inhibitions, working memory, regulation of motivation towards goals, and motor control in children with ADHD. The disorder and EF are clearly linked. According to his Executive Functioning Semistructured Interview, Khaled's EF strengths are materials organization and set-shifting. Meanwhile, he exhibits great deficits in goal setting, decision making and planning, attention, task initiation, self-monitoring, time management, impulse and emotional control, and working memory.
>
> Melissani, on the other hand, is highly controlled and conscientious. Tough (2012) unites varying bodies of research to define conscientious people as "orderly, hard-working, reliable, and respectful of social norms. But perhaps the most important ingredient of conscientiousness is self-control," (p. 73). Melissani's levels of self-control and conscientiousness are so extreme that she comes across as anxious and squarish. She will re-write her work if she cannot keep it neat and orderly with edits, she is hesitant to share her ideas even in one-on-one conversations for fear of making a mistake, and delays gratification unnecessarily. Her Executive Functioning Semistructured Interview indicates strengths in goal-setting and planning, attention, task-initiation, self-monitoring, materials organization, time management, impulse and emotional control while her deficits are in set-shifting, working memory, and decision making.

Khaled has an overwhelming number of EF deficits while Melissani has few deficits and many strengths. Not surprisingly, Melissani was 100% on-task during the three weeks before beginning stations and during the first four weeks of stations. Khaled's on-task behavior showed no clear patterns, hovered around 30%, and had no change before and after beginning stations work. For these two students on opposite extremes of the EF spectrum, there seemed to be no impact on their task initiation or task persistence by switching to the stations framework for these first four weeks. More typical students, those exhibiting more self-control than Khaled, but less conscientious tendencies than Melissani, showed an increase in task initiation and a prolonged task persistence after four weeks of implementation of the stations framework, however thirty percent of the students continue to struggle to maintain that focus through until the end of class three weeks after switching to stations.

Self-Control and Goal-Directed Attention

Khaled struggled with his choice in the Marshmallow test. He knew the wise choice would be to delay gratification, and initially, he said he would wait the week for twice the reward. However, he continued to contemplate his choice, changing his mind over and over, until finally he declared, “Fine. I will just have my candy at the end of class, so I am still being patient.” I told him that with this choice, he would still only receive one candy, but if he could keep that patience until the following week, he would have two candies, and he firmly stated he would still have it at the end of class. I offered, then, that he have it immediately as waiting would produce no further reward, but he stated again, “I want to be patient.” His focus was concentrated on that end of class reward. The moment class had come to an end, he rushed over to the desk, proud of his accomplishment and delighted in his candy. Khaled's work habits mirror this struggle. On December 5th, 2013 I wrote in my teacher's journal:

> Khaled very excitedly began collecting science fair data. After about 15

> minutes, I mentioned that he forgot to change his independent variable. He shut down, saying angrily, “Fine, I'm just going to go play then.” He went to the blocks. I spoke to him there about what he was feeling, reminded him that if he stopped where he was, he would fail, and if he continued, he would at least get a D. He perked up and said, “Oh, yeah, I'm going to work!” And within two minutes, he was casually back playing. I asked again if he was sure of his choice, and he laid, face down, on our bean bags, refusing to speak to anyone for about ten minutes. He is motivated and desperately hopes to accomplish his goal, but he is unable to maintain that goal-directed attention for any significant length of time.

Melissani, on the other hand, was very resolute. “I will wait,” she said calmly, and never asked about the candy again, happy to receive two the following week. Her work, similarly, mirrors this force of self-control. There are extra days built into stations work for self-exploration. Melissani often uses this time for further editing or organizing, but delights in her high grades.

Under the stations framework, “play” is the reward. When students finish their stations work before the deadline, they have shelves with games and building materials available to them. Similarly, students are granted one 25 minute break a week or one five minute break each day, which they have to record on their stations worksheet, but can use when they wish. Students like Khaled struggle with the self-control surrounding this option and often take their 25 minute break immediately. Off-task behavior reduces the students' likelihood of finishing early and having a more rewarding play, but many students struggle with that goal oriented attention. Duckworth and Oettingen (2013) argue that to overcome obstacles we must simultaneously concentrate on them and the positive outcome of overcoming them. This strategy they call Mental Contrasting. Specific plans in the form of if-then statements show

demonstrated effectiveness in overcoming obstacles and were therefore taught as a specific classroom intervention during goal-setting. For example, “if I get distracted when I sit with my best friend, then I will first try a partner who I work with diligently.”

My adapted Marshmallow test also indicates a marked difference between the gifted homeroom and the general education homerooms.

Adapted Marshmallow test

Homeroom	Immediate-gratification, 1 reward	Delayed-gratification, 2 rewards
Gifted	17%	83%
General Ed. + Special Ed.	48%	52%

(I include Special Education with General Education because I service 100% of SpEd minutes integrated with the GenEd population.)

Overall, it is not surprising that the gifted homeroom exhibits more self-control and can delay gratification with a goal in mind; however, the gifted homeroom's response to the shift to stations-based instruction compared to the other homeroom's is surprising.

% of students with each grade for the second round (4th week) of stations

Homeroom	Ave. Stations 1	Ave. Stations 2	A	B	C	D	F
Gifted	82%	78%	24%	24%	29%	0%	24%
218	72%	77%	26%	13%	44%	13%	4%
203	77%	82%	41%	18%	9%	23%	9%
219	69%	66%	0%	4%	40%	40%	16%
5th Grade	75%	76%	23%	15%	31%	19%	13%

The grades on stations are completion grade. For every station completed to 90% mastery, the student receives a signature on their station worksheet. If it is below 90% mastery, we go over the problems and the students revise their work for their signature. When the deadline approaches for their station, they simply turn in their station worksheet and receive credit for their signatures.

While 203 is the Special Education homeroom, it also has an assistant, effectively lowering

class sizes. Thus, it is not a surprise that 203 has the highest percentage of As, and the Special Education students comprise 30% of the classroom, roughly the D's and F's in the classroom. Homeroom 219 is my first room of the day. Class starts at 8:45, however, school policy is that attendance is submitted at 9:15. Families are aware of our lackadaisical tardy policy and many students arrive late, greatly impacting the grade distribution for this homeroom. Homeroom 218 is a more typical general education homeroom.

I found myself wondering, why was the gifted homeroom suddenly nearly indistinguishable from the other homerooms after the switch to a stations-model for teaching the curriculum? The gifted homeroom is certainly goal-oriented, and grades are important to these students. I had expected them to thrive under the stations model. I administered Duckworths's grit and impulsivity measures to all four homerooms.

Grit and Impulsivity Measures

	Grit	Impulsivity	Schoolwork impulsivity	Interpersonal Impulsivity
Gifted	3.4	2.1	2.2	2
203	3.3	2.1	2.2	2.1
219	3.3	2.4	2.7	2.2
218	3.1	2.5	2.7	2.5

The maximum score on the grit-scale is 5 (extremely gritty), and the lowest score on this scale is 1 (not at all gritty). Similarly, the maximum impulsivity score is 5 (extremely impulsive), and the lowest on the scale is 1 (not at all impulsive).

The gifted homeroom, again, is nearly indistinguishable from the other homerooms. This tells me that there is a fair chance my stations framework for teaching the curriculum is a decent measure of grit and impulsivity, and therefore teaching children to be successful in this framework should logically support EF growth. My next step, then, was to have specific conversations about goal setting and self-monitoring with all homerooms to explicitly teach the skills that would help make them successful in my classroom.

Self-Monitoring, Planning

In November, we discussed the added responsibilities of stations in depth. We modeled goal setting and planning for a goal, and we set up expectations for self-monitoring and asking for teacher assistance. Below is what the students helped to generate as our new classroom norms.

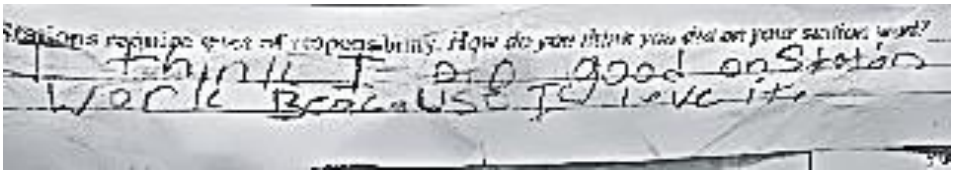
While I wait for the teacher I can ...	Before I ask for help I...	When I ask for help it sounds like ...	When I think I'm finished, I ...
-Break (5 min) -Start another station -Help myself or others -Discuss work -Synthesize "What did I learn?" "How can I use what I learned to be a better student?"	-Use my resources: friend, dictionary, google, science journal, science dictionary -Re-read directions and stop to think -Decide what I know and what part is confusing me -Remember "yet" if you're frustrated! "I can't (yet)!" "I don't get it (yet)!" "I'm not good at this (yet)!"	" I read _____ and I think it means _____ because I understand this part _____, but I'm still stuck on _____ because _____."	-Check my work! -Answer EVERY question -Restate question in my answer -Provide explanation of my evidence -Edit: full sentences neatness caps. & punc. name and date

We have been practicing these norms to provide some structure to their highly independent work. The students identified problems to help create these norms as solutions, and buy in is very high. At first they were frequenting the board, referencing for what they should do. Now, mid-January, I had a student, a refugee in his first year in America, come up to me a little nervous, "Can you look over my work, I already edited it, and there is only one question that I think I might have gotten wrong, but I tried my best." A student being unsure, but trying anyways, a student editing his own work before bringing it to the teacher, a student who at the beginning of the year was somewhat anxious and unsure of himself, tried his best even though he thought he might be wrong. I feel like his words are what developing life skills sounds like, for this student at least.

Students were more on task. Their grades weren't a reflection of not working hard, they were doing different work—training their brain to set goals and to plan and to self-monitor. They had to get used to doing these tasks simultaneously with their science tasks. At the bottom of their stations sheet are some reflective questions. I found in my teaching journal, dated December 7th, the following about a very troubled and academically struggling child.

> "This child struggles greatly in school, is recommended by teachers to be SpEd tracked, however, his family does not want SpEd services for him. He received a low D on stations round for only receiving 2 signatures, and was aware of this fact as he filled out this reflection at the bottom of his stations worksheet. He is truly finding joy in learning and a self-value outside of his grade. This is huge, as this child is highly emotional, prone to turn negative emotions inward, and has trouble finding his academic niche."

He was responding to the following prompt: Stations require a lot of responsibility. *How do you think you did on your stations work?* His response: "I think I did good on station work because I love it."



He may have been producing less work, but he was proud of what he did. His motivation was internal—his love of working—rather than external, his grade. Despite dropping grades, stations were an important framework to continue in our class. I prefer to have students finishing 70% of the work independently at 90% mastery, than 100% of the work at 70% mastery with my EF skills doing the heavy lifting.

Three Months Growth

After her third stations round, Melissani's signatures were evenly paced, but completed closer to the deadline. She commented, “In the beginning, we were playing the geography game because I knew I would still finish on time.” She evaluated her work and strategized to be able to engage in play as well as complete her work to her self-imposed high standards. This is in stark contrast to my notes regarding her rigid tendencies at the beginning of the year. When asked what she learned from these stations she answered, “I learned about microscopes and microorganisms and about working hard.” She is now able to adapt between working and breaking to optimize her potential.

Khaled's reflection sheet included clear goals, “I set a goal for the observation station to finish on time, and I took it a little serious,” and an honest evaluation of his work habits, “I get started right away now but I am still a little bit naughty.” While there is truth in Khaled's statements and reflections, often his interpretation of 'getting started' and my own differ. For Khaled, we made a plan together that as soon as he entered work time he would take out his paper, his pencil, and organize his work space. As one of his executive functioning strengths is , so we used this to foster a degree of task initiation. He is able to get started right away on organizing his work space, writing his name on his paper, the date, and deciding what he will do; however, his 'naughtiness' often kicks in before he begins the real task at hand.

Both case-study students, one with an initial high EF skill set and one with an initial low EF skill set, seemed to grow in two or three of their weakest areas, while maintaining EF skills in their strongest areas according to their semistructured interview. This interview asks students to evaluate certain statements as either, "definitely true about them, sort of true about them, usually not true about them, or unsure," each response receives a numerical score and students are prompted to provide "details" with their answer. The ranges of numerical responses are translated to low, mid, or high

executive functioning.

The two students grew in opposite EF areas although they received similar interventions. After nearly three months of the stations framework for teaching the curriculum, Melissani's Semi-Structured Executive Functioning Interview shows noteworthy growth in her working memory, set-shifting, and decision making skills. Interestingly, she seemed unaware of her growth in working-memory. In the fall, Melissani offered details that she, "usually can't remember what [she's] supposed to do so [she] ask[s] a lot so she doesn't make mistakes or [she] read[s] the direction again and try[s] harder," but in the spring she answered the same question saying, "I never really have trouble with directions because I always know what to do when I'm working. Directions are the easy part and if there are a lot, I just split it up a little." However, she did recognize her own growth in set-shifting as she commented, "math and reading are easier now because before I would get stuck on things and I couldn't do something else, but now I can just keep going, and it's okay if I need a little help later because I learned that youtube can show me things again in math and I can just try later in reading when I can take my time." Not only is she growing her executive function, but without recognizing the specific "set-shifting" skill, she acknowledges that the skill makes her content areas easier. Khaled, meanwhile, shows only minimal growth in task-initiation and greater growth in goal setting. In task-initiation he says his mind wanders but he can get started on work without too many reminders and that he "tries to rush and get it done fast." However, he also notes that he finds reading really boring, can't get started on homework, but needs someone to help him or he stops working almost right away. In terms of goal-setting, Khaled's responses were much more consistent. He notes that making decisions in school is pretty easy because he, "know[s] what [he] want[s] to do and make[s] a plan about it, but just mess[es] up the plan because [he] want[s] to get it done like real quick so [he] can play". He also says he makes plans for studying and likes to organize his work to get ready to study but then just doesn't follow his plan because he

plays instead. Materials organization was always Khaled's executive functioning strength, and according to this Spring interview, it began to permeate into his goal-setting as well. It is clear that the stations framework has been invaluable for Melissani, but Khaled, while making mild progress, still struggles deeply with maintaining focus and effort towards a goal.

Case Study Growth per Executive Function Semistructured Interview

Executive Function	Melissani		Khaled	
	BOY	MOY	BOY	MOY
Goal Setting	High	High	Low	High
Task initiation	High	High	Low	Mid
Task persistence	High	High	Low	Low
Time management	High	High	Low	Low
Goal Directed Attention	High	High	Low	Low
Planning/Strategizing	High	High	Low	Low
Self-Control	High	High	Low	Low
Working Memory	Low	High	Low	Low
Material Organization	High	High	High	High
Set Shifting	Low	High	High	High
Emotional Control	High	High	Low	Low
Adaptability	Low	High	Low	Low

Perhaps EF begets EF growth and Melissani was in a position to capitalize on the practice. How, then, had the rest of the 5th grade faired?

January Grit and Impulsivity Measures:

The following are average Grit and Impulsivity scores for each homeroom.

	BOY-Grit	MOY-Grit	BOY-Impulsivity	MOY-Impulsivity
Gifted	3.4	3.3	2.1	2.0
203	3.3	3.3	2.1	2.0
219	3.3	3.2	2.4	2.2
218	3.1	3.1	2.5	2.3

Where BOY=Beginning of Year and MOY=Middle of Year

The maximum score on the grit-scale is 5 (extremely gritty), and the lowest scale on this scale is 1 (not at all gritty). Similarly, the maximum impulsivity score is 5 (extremely impulsive), and the lowest on the scale is 1 (not at all impulsive).

After three months of stations, student scores for grit and impulsivity are largely unaffected, though there is a small dip in each for all homerooms. This is encouraging, because despite more freedom for off-task behavior, students are conducting themselves largely the same under their own self-monitoring as they did under teacher monitoring.

January Marshmallow Test:

There appears to be clear growth in the students' ability to delay gratification, however, it is unclear if this is a correlation to EF growth or increased reliability and trust in the classroom environment. Regardless, the change is positive and indicative of growth. One student is represented by about 4% in the gifted homeroom, whereas for the larger GenEd + SpEd population, every 5% represents about 4 students.

Adapted Marshmallow Test Growth

Homeroom	Immediate-gratification, 1 reward	Delayed-gratification, 2 rewards
Gifted	17%--Sept., 12%--Jan.	83%--Sept., 88%--Jan.
General Ed. + Special Ed.	48%--Sept., 40%--Jan.	52%--Sept., 60%--Jan.

January Grades:

Homeroom	Average Completion	A	B	C	D	F
Gifted	82%	44%	5%	17%	30%	4%
218	77%	13%	33%	37%	17%	0%
203	79%	25%	21%	29%	21%	4%
219	79%	12%	52%	36%	0%	0%
5th Grade	79%	24%	28%	30%	17%	1%

The table below condenses the homerooms to show averages for all students, in all grades, and groups As/Bs and Ds/Fs for ease in visualizing overall student movement.

	As and Bs	Cs	Ds and Fs
September 31, 2013	37%	31%	32%

January 15, 2014	52%	30%	18%

While students initially struggled with stations, they are showing continued growth and mastery of executing expectations and successfully completing work while planning, pacing, goal-setting, and self-monitoring independently bringing the average grade up slightly from 75% to 79% after three months.

January On-task Activity:

Most students are on-task and staying on-task after three months of the stations framework. From the on-task activity log, I was able to see that there is a 12% increase of students' on-task by the end of class compared to the beginning of the year data. While the class size changes with absences, we typically hover around twenty-four students. This means about four or five students in the class continually need teacher redirection to stay on-task throughout the class period, whereas before stations, with the same population, only about three to four students needed redirection in the beginning, but up to eight or nine students needed extra support with staying on task in the middle and end of class. In terms of task persistence, stations seem to benefit about half of the students who struggled with task persistence under typical curriculum instruction, as they no longer need that on-task teacher support with stations.

Date:	Beginning of Class	Middle of Class	End of Class
Week of January 13th	80%	82%	80%
BOY-September	86%	64%	68%

While my observations and intuition as a teacher have noted an improvement in on-task behavior, the week of January 13th students were engaged in a levers and pulley unit. After completing a station, they were invited to work on K'Nex engineering station for half an hour. I believe this

contributed to the task-persistence seen here—either students were on-task in the engineering station, or working towards it. The K'Nex work served as an immediate goal, and their goal-directed behavior manifests in on-task activity. What is interesting, then, are those 20% of students who remained off-task. There seems to be a plateau of task-persistence as both before and after stations implementation on-task behavior peaks around 80% of the class.

This 20% is comprised of five students in the class, both boys and girls, one of whom has an IEP. Their off-task behavior is not uniform. One of the students is frequently drawing comics with pixilated characters made from a series of squares or is showing his comics to friends. One of the girls is a wanderer, who will find any reason to wander around the room in a manner that appears rather aimless until she catches your eye and feigns to be frantically looking for a classroom material. The other girl and a boy and Khaled are hopelessly chatty and love to play; they tend to oscillate between various distractions that their classmates often find rather annoying.

Marien et al. (2012) highlight unconscious goal activation as highjacking EF. As described with Khaled, and likely the other 5 struggling students, it seems as if unconsciously activated goals with immediate gratification are highjacking the EF towards their pursuit thereby inhibiting on-task behavior. These unconscious activations are stronger when the goal had personal value (Marien et al, 2012), so a possible intervention may be to explicitly teach conscious goal setting in academia with personal value.

Conclusion: (*EF Skill Indicated <u>Underlined in Italics</u>)*

The beginning of the year (BOY) data was collected over the course of a month following typical curriculum and with teacher direction. The middle of the year (MOY) data was collected after three months of a stations-based intervention to the curriculum and with mostly student autonomy. The following tables show both whole group and case-study growth. The classroom interventions were

determined based on students' needs; however, the important take-away is that teachers should be monitoring EF and looking for appropriate interventions that are responsive to the students, not necessarily intervene in the areas where I chose to focus for this group of students.

Summary of Data

Executive Function	Classroom Measurement	Classroom Intervention in Conjunction with Stations	Student Response/Growth	
			BOY	MOY
Goal Setting	Student Reflections	Writing goal at onset of stations	62% report creating goals	78% report creating goals
Task initiation	On-task activity log	None	86%	80%
Task persistence	On-task activity log	None	68%	80%
Time management	Pacing Tracker	Student pacing reflection	32% evenly pacing work	72% evenly pacing work
Goal Directed Attention	Marshmallow Test, Student Grades	Mental Contrasting	52%	60%
Planning and Strategizing	Student Work Completion Grades	Classroom norms and expectations for stations work posted	37% As & Bs	52% As & Bs
Response Inhibition/Self-Control	Duckworth Grit and Impulsivity, Student	As-needed individual student conferencing	Grit-3.3 Impulsivity-2.3	Grit-3.2 Impulsivity-2.1
Working Memory, Organizing Materials, Set Shifting, Emotional Control, Adaptability	Case-studies: Executive function semistructured interview	None	See Table: Case Study Growth Per Executive Function Semistructured Interview	

On Task Activity Log

Task initiation took a dip from 86% to 71% of students on-task at the beginning of class during the very first week of station implementation for teaching the curriculum. In the following three weeks, task initiation jumped to 82% and remained at 80% after three months of stations work. *Task persistence* was a struggle for students under the standard curriculum with 22% of students off-task by the middle of the period. After three weeks of stations, there was virtually no drop in task-persistence

by the middle of class, however at the end of class 12% of students who were originally on-task were off-task. They were able to initiate their work, but not persist at it. After three months of stations task-persistence lasted for the entirety of the period, however, the data was collected during a particularly engaging unit. Regardless, there seem to be about 20% of students who are unable to remain on-task both before and after the initiation of stations framework. A curriculum intervention is not sufficient for these students who need more individualized support.

Student Grades

While this action research has no single measure for working memory, students are full engaged in simultaneously managing EF skills and science skills. Although grades initially took a dip with the immediate implementation of stations framework, after three months of handing full responsibility of *planning, strategizing, and ordering* work to students, there was a 15% increase in As and Bs and a 14% decrease in Ds and Fs also indicating a growth in *goal-directed attention* and *working memory*, which coordinate the big picture process of integrating the *planning and strategizing* that also grew.

Adapted Marshmallow Test

According to my adapted marshmallow test, there was a 5% increase in students managing goal directed attention in the gifted homeroom and an 8% increase in the general education homerooms. These results are further evidence of growth in *goal-directed attention*, however, they may similarly be a reflection of greater confidence and reliability in the classroom.

Grit and Impulsivity

There seems, however, to be little to no growth in student grit and impulsivity, but it is noteworthy that neither significantly decreased having handed over all curriculum management to

students. Students have learned to balance their grit and impulsivity independently on par with their management under stricter teacher direction.

Pacing Tracker

According to the pacing trackers, between 75% and 80% of students complete all their work by the deadline from the initiation of stations through the third month. While the first round of stations most students, 68% either front loaded their work or rushed their work in close to the deadline. By the second round of stations, there was a total shift with 72% of students evenly spacing their work. By mid-January 70% of students were still pacing the completion of their stations indicating growth in students' *time management* skills.

Stations framework for teaching the curriculum with accompanying intervention supported student EF growth to a large extent in areas of EF skills like, goal setting, task persistence, time management, planning and strategizing. Following stations implementation and congruent interventions, minimal growth in areas of EF like task initiation, goal directed attention, and grit and impulsivity were seen as measurements were similar under student autonomy as they were under teacher direction.

Policy Recommendations

Given the research introduced surrounding the imperativeness of EF for adult success and the deficits facing students in poverty, all policy recommendations are especially emphasized in low-income communities like the one I serve.

Classroom Recommendation:

Science teachers should remediate the curriculum to a stations-based framework with the intention

of providing EF support.

Science teachers should be intentional about providing added support for students with low EF who will likely struggle with stations.

School-level Recommendation:

As limitations to tracking student EF growth include possible researcher bias and measurement invalidity, teachers and school psychologists should work together to identify students with EF deficits and develop more efficient tools for teachers to measure EF growth.

District-Level Recommendation:

Science be recognized as a valuable subject worthy of 300 minutes a week for all school-aged children.

Educational Research Recommendation:

Science instruction should be further investigated as a medium for EF intervention.

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