5-31-2023

In Pursuit of Failure: A Project-Based Learning Approach to Introducing Generative Failure Into High School Physics

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IN PURSUIT OF FAILURE: A PROJECT-BASED LEARNING APPROACH TO INTRODUCING GENERATIVE FAILURE INTO HIGH SCHOOL PHYSICS

by

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SYNTHESIS*

MASTER OF ARTS

CRITICAL AND CREATIVE THINKING

UNIVERSITY OF MASSACHUSETTS BOSTON

May 2023

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* The Synthesis can take a variety of forms, from a position paper to curriculum or professional development workshop to an original contribution in the creative arts or writing. The expectation is that students use their Synthesis to show how they have integrated knowledge, tools, experience, and support gained in the program so as to prepare themselves to be constructive, reflective agents of change in work, education, social movements, science, creative arts, or other endeavors.

ABSTRACT

It is important that students encounter and learn how to respond to failure in their high school experience. In traditional education systems, failure (for students and teachers) is often penalized in a way that stigmatizes failure and disincentivizes intellectual risk-taking. In my experience, as a high school physics teacher, I have witnessed firsthand the impact of the stigmatization of failure in the science classroom. Educators in the science classroom can use projects, lessons, and reimagined grading systems to cultivate a different mindset around failure for their students. As a conceptual physics teacher, I believe that my classroom should be a classroom that promotes project-based learning with real-world relevance that stresses authentic learning through intellectual risk-taking, the resulting failures, reflection on the experience and revised understanding. Based on my research, I will launch new projects in my classroom this spring that promote a culture of positive, generative failure in my classes. Key materials developed and piloted in pursuit of this work include new project-based challenges for physics class, post-lab reflections, and a transparent analysis of the current grading system paired with recommendations for different grading approaches that promote a generative view of failure rather than stigmatizing failure in the classroom.

Introduction

Last spring, I was called into the office of our school's president, where he asked me to make a drastic change as an educator. I was asked to switch from teaching just 9th grade biology to teaching 11th grade physics and 9th grade biology. He asked me because he felt like there was a need for a change in how we teach physics to our juniors. The president of the school was previously an English teacher, so it felt like he was unaware of how difficult of an ask this transition would be. Throughout our initial conversation, I discussed my hesitation to take on such a monumental switch due to not having taken a physics course since 2005 and not being familiar with the math involved in physics. To make matters even more difficult, he wanted me to reinvent the whole course to make it more engaging and appealing to the junior class. Because he wanted such a drastic revision, he asked me not to collaborate with the previous physics teacher to avoid falling into old patterns. He wanted me to breathe new life into a revamped physics curriculum. I was left at a crossroads of how to create a brand new, non-traditional physics curriculum that would be exciting and challenging to my students. That was my overarching goal for the CCT 692 class, and I investigated the process of designing a creative, non-traditional physics class for the 22-23 school year. Throughout last semester, I continued to reflect on how my journey was going, and one of the topics that kept recurring was failure at both the teacher and student level.

While perusing websites dedicated to quotes about failure from history's most successful figures, a quote from Henry Ford stood out to me because it shows the intention of growth. Ford famously stated, “Failure is simply the opportunity to begin again, this time more intelligently.” This quote is relevant to the scientific method due to the idea that our initial hypotheses are often wrong. I have taught science classes to every grade level of high school students and the only

constant has been the scientific method. Unfortunately, our typical science curriculum does not allow for students and their hypothesis to fail. Students have been creating hypotheses after an observation and told that at the end of the experiment they should be able to produce data and give analysis and present their conclusion. High school curriculums are packed with activities that allow students to follow clear instructions that should lead them to the exact results the teachers were always intending, due to the time constraints in the classroom, there is not much room for error. These activities are too rigid and do not allow students to fail, revise their initial hypothesis, and, begin again, this time more intelligently.

Failure is a necessary part of life that is too often demonized in schools today. While I noticed that I ended up with more questions than answers when I attempted to try a brand-new lesson plan, I was thinking about going down this rabbit hole and seeing how to balance the idea of taking risks properly. Many students have been drilled by parents and previous teachers that failure is unacceptable in a classroom. I was left wondering, is it possible to design projects that will introduce an example of failure and then have students demonstrate resilience and grit as they overcome work to reflect on and react to failure? Teaching in this way would force me to take the "guide on the side" (King 30) role more seriously, allowing them to take more time as they work through these projects. This would naturally bring complications such as projects being unattainable for certain students unless scaffolded perfectly as well as having an undefined timetable since students would have to be given the flexibility to work through assignments at their own pace. In this approach, I would look at failure being a useful tool for teachers and students alike, with an understanding that failures from teachers are positive tools for teacher growth as well as students learning how to approach failure from a positive role model.

When confronted with failure, Thomas Edison noted, “I have not failed. I have found 10,000 ways that don’t work.” As a science teacher, I have a tremendous opportunity to repeatedly fail and find ways not to run a physics class each day. This journey I have embarked on is a never-ending process of learning and tweaking assignments, as I find new strategies to connect with my students.

As I grapple with what failure and project-based learning can look like in a physics class, I am preparing to develop and implement a new physics curriculum centered around project-based learning challenges. In these challenges I will introduce failure into my lessons as a beneficial step in students’ learning process. “There are several advantages of the Project Based Learning (PJBL) model in physics learning, which accommodates students' positive attitudes towards learning, fosters curiosity, stimulates the enjoyment of learning, guides active and creative involvement in learning, encourages collaborative independent learning” (Santyasa 492). To glean the benefits of PBL emphasized by Santyasa, while centering the experience of learning from failure, I will design projects that are collaborative, challenging and have multiple potential solutions. These projects would be open enough to allow students to realize that flexibility and success can look different in each class or group and that these different paths can still lead to meaningful learning. Each PBL challenge will look at a different aspect of failure with a focus on how to interrupt failure, learn from the failures of others and learn how to change the parameters after experiencing failure.

Thesis

Traditional assessments and grading systems stifle authentic learning and promote “1950s” “school” learning in which students all must learn in the same way and do not learn to

engage with new ideas or new content the way that they will in the real world. Our broken grading system perpetuates the stigmatization of failure creating an environment where students are afraid to take learning risks and make public mistakes. For them, failure to earn the desired grade in our flawed grading system may hinder their ability to advance academically and make them look/feel "dumb" in front of peers and teachers. Rather than stigmatizing failure, educators must model for students and invite them to engage in generative failure. Productive failure, where students engage in the scientific method and amend earlier ideas based on experience, is an important mindset for them to develop in school before being asked to engage in generative failure in the real world. Educators in the science classroom can use projects, lessons, and reimagined grading systems to cultivate a different mindset around failure for their students. As a conceptual physics teacher, I believe that my classroom should be a classroom that promotes project-based learning with real-world relevance that stresses authentic learning through intellectual risk taking, the resulting failures, reflection on the experience and revised understanding. Based on my research, I will launch new projects in my classroom this spring that promote a culture of positive, generative failure in my classes.

How grading works at Catholic Memorial

I have taught nine different science courses while at Catholic Memorial, and I have attempted to change the grading system to mirror the class structure. While I have experimented with weighted sections and participation heavy sections to total points for, it all leads back to a 65% is passing and below that is considered failing. For a student to fail for the year, they must get a yearlong average below 65. This has happened for several reasons over the years, but each quarter there are always students, parents, and administrators inquiring about the odds that a specific student will get a high grade on the final assignment or two to pass for the quarter.

Catholic Memorial has always used numbers for grades which leaves little doubt on where a student stands at the end of the quarter. Very similar to handing back quizzes, students do not care about what they got wrong on a quiz and how to not make that mistake in the future, they only care about the percentage.

Students will have four marking periods (quarters) along with a final exam or project. There used to be a midterm exam as well but that disappeared during the pandemic. Due to that, the quarters have become unbalanced, where the first and second quarter are 25% and the third and fourth quarter are 20% with the final exam being 10%. During the quarters, parents and students tend to care more about the grades at the beginning and the end of the quarter.

At the start of the third quarter, I got pushback from parents and administration when I attempted to use a group project as a model to improve group learning across the entire class. While learning about potential and kinetic energy, students were asked to create a marble roller coaster out of cardstock. As the students built the roller coasters, they were asked to continuously calculate the velocity and the acceleration of the marble. During this process, groups would routinely have one student collect their data instead of making sure the entire group understanding happened. Students were told that they were all expected to be equal and active participants in this project, so they would not be allowed to ride the coattails of the other group members.

The final week of the project, students were told that they would be receiving the group average of the quiz to help reflect the understanding of the entire group instead of the work shown by just the top students in each group. Each student was given a large packet of equations involving kinetic energy and acceleration to work through and the students were suggested to

help each other through this process to make sure they all understood the material. The project idea came from the idea that a rising tide lifts all boats, where students would be encouraged to work through the project together. After the project demonstrations, students were individually given quizzes based on roller coaster energy. As a class, the average went up over 15%, which helped demonstrate that the students did a great job helping each other work on the project and learning the material at the same time.

The issue came from parents and administration because at the start of the 3rd quarter, there were only a few grades input and that meant the group quiz grade lowered the average of a few students who performed higher in the class. While the grading system is not perfect at Catholic Memorial, and too often students and parents are focused on only getting high marks, sometimes the goal of learning and working with each other is lost during that process. I can sum up my project as a success, but the administration quickly informed me that I needed to remove that grade. Issues like this have made me consider if grading is the root of the problem holding back the authentic learning that was happening between the students.

Does grading inhibit learning and therefore inhibit failure?

One of the most interesting articles I saw came from the New York Times, where Stephanie Saul wrote a piece looking at who is to blame for poor test scores at NYU as students struggled while taking organic chemistry. While the grades continued to get worse through the pandemic, it ended with Dr. Jones being let go by the university. "Dr. Jones, 84, is known for changing the way the subject is taught. In addition to writing the 1,300-page textbook, 'Organic Chemistry,' now in its fifth edition, he pioneered a new method of instruction that relied less on rote memorization and more on problem solving" (Saul 1). Dr. Jones had a high standard for his

students and expected them to meet that bar but when students did not put the work into reaching that spot. He stated that he felt it was important to have high standards due to organic chemistry being a natural steppingstone for students applying for medical school. Students needed to be accurate but when they focused more on their grade as opposed to learning the material, they started a petition to get their professor fired.

My investigation to this point led to several different problems and even more potential solutions, but it all comes back to grading. Students started the petition because they received low grades, this showed that low grades helped to galvanize students, but they aimed their effort in a different direction. If they looked at their failure as a sign that they did not understand the material yet, they could have spent more time preparing to relearn the material. The teacher could have seen these failures as an opportunity to slow the class down and refocus the students on the aspects that caused the low grades as well. This story did not have a resolution that helped the students learn the material, while their grade might be higher with a new teacher, it does not guarantee that they would learn this information better. With that in mind, there are different grading systems that could be used to ensure that learning and not grades are the focus of each class.

Grading on a curve?

A traditional bell curve will ensure that students all receive different grades with most of them getting grades in the B's and C's with only a small percentage of students receiving A's and D's/F's. While a traditional bell curve has been used in college courses, it has plenty of flaws when it gets moved into a high school grading system. One of the benefits is that grades could receive a boost if there is a quiz that does not go well for an entire class. On the other

hand, if a large percentage of students do well, only a small percentage would receive the top scores and some of the other students would fall back into the B range.

While a traditional bell curve does not work for an entire grading system, there are connections that can be made to real world situations. “Social Darwinism and normal distribution patterns have provided justification for norm-referenced standardized tests, grading on a curve, detection of ‘at risk’ students, and the whole concept of an intelligence quotient.” (Fendler 64) A traditional bell curve might be able to help explain a single instance of information. Running and swimming-based competitions can have a similar connection to a scaled grading system. The all-state cross-country championship this year was held on a cold day so while the athletes had better times throughout the season, it only mattered what place they finished that day. While an athlete or student could have been dominant leading up to the race or a quiz, it all depends on how well they perform that day against the competition. This grading style can have real world applications, it still would not be fair to grade students based on how successful the other students in the class are. This would not promote students taking risks and potentially having the worst project/ design in the class for that lab. While challenge labs would bring out the students’ competitive nature, it would promote competition but at the detriment to students taking creative risks.

Skill based grading/ Standard based grading.

To start each school year, teachers immediately want to know what skills their new students are entering the classroom with. There are national standards that are expected to be followed so the students are prepared for the next year in their development. At Catholic Memorial, students enter a junior year physics course, already having taken biology and

chemistry. While there is some crossover between those topics, a student could take physics without knowing biology and chemistry. Therefore, it is important to consider what skills are learned that are not content specific.

Standards based grading and science go hand in hand when looking through the lens of project-based learning. Within project-based learning, students are expected to show understanding or mastery of topics to complete the project, this can be directly tied into a grading system that would help show their understanding and mastery of the topic. Objectives are given at the beginning of the quarter and students are expected to work through all the objectives. This can lead to students going at their own pace, with the understanding that students will learn the information before moving on.

Unlike traditional grading, students are given scores 1-4 where they get updated as students' progress through the topics. "Mistakes are an important part of the learning process and students should be encouraged to make mistakes and learn from those mistakes. Students should not be penalized for making mistakes, but rather rewarded for success" (Zimmerman 47). Within the grading system of standards-based grading, students can continue to improve their score starting at a one and moving up as they get closer to mastery. This allows the topics to be brought up multiple times, which will help reinforce the idea that these topics and standards do not go away after finishing them.

Is there a clock in learning?

While different grading systems are used across schools, students are quick to inform you if they have a grading system that favors them. A common example of this is a colleague of mine, who uses the phrase, "there is no clock in learning." Where the only due date for his class

is the end of each quarter, with the goal of eliminating stressful deadlines that can pop up out of the blue for our students in their daily lives. The emphasis is placed on the learning of the material instead of when it needs to be due by. This naturally can be a double-edged sword, allowing students to complete work at their pace gives the flexibility of prioritizing other schoolwork or life outside of class instead of rushing to do the work on time. This could also allow students to spend more time on the work as they could take their time or seek out extra help before finishing the assignments for better understanding.

The “no clock grading system” could become a problem if students fall into the natural habit of procrastination. The harsh reality of the fact that there are four clearly defined marking periods, and the teachers must have all the work submitted to assign a quarter grade. Any document that has not been submitted would become a zero and hinder the student’s grade. This causes the end of the quarter to become a high stress moment for all students that have not submitted work at the correct time throughout the quarter. These high stress end of the quarter situations could lead to students copying other students' work to just get the assignments in and skip over the goal of learning the information at their own pace.

There are plenty of beneficial aspects of a grading system that allows late work for no penalty, but it also has its drawbacks. While it is true that there is no clock in learning, there is unfortunately, a clock in grading. Within my physics course, larger projects should follow a model like this, so students can go at their own pace which allows them the flexibility to take risks in certain areas. The hope would be that students would feel more comfortable with a grading style similar to this for projects that does not harp on mandatory requirements. Having

manageable benchmarks should allow students to feel like they are on task even though they could be off the suggested pace during these larger projects.

How do students attempt to wait out a teacher?

If students are told directly by the teacher how to achieve desired results, they are missing out on thinking critically, reflecting on if they are correct, and independent learning. I have asked my students, “if your car is stuck in the snow and you know there is no tow truck coming, do you just sit there hoping or do you attempt to get out of the situation?” I ask this question when my students inform me that they are completely lost and have no clue what to do next to solve the problem. While this might be true and the student is completely lost, I start by asking them “what parts of the question or project they do understand so we can start there.” More than 90% of the time students will state that they do not understand any of it and that is why they are stuck. In my experience, students are fishing for answers when they do not know which direction to go in or where to start. By the time students enter high school, they have experienced teachers being forced to move onto another topic, even if every student doesn't understand perfectly.

Students in math and science classes have practiced setting up questions by looking at terms they understand before attempting to answer the question. Going back to the question and listing the parts that you understand about the question will help you on the path to isolating the parts that you do not comprehend yet. This practiced strategy has put students in a situation where they should have the tools to succeed, yet they will still start by trying to get the answer given to them before attempting it on their own. By asking for help before they attempt the question, they are selling themselves short because they miss out on the opportunity to think critically about the question.

Are students afraid to answer out loud due to public shaming of their peers/ teacher?

Students that have experienced too many instances of stigmatized failure through their educational career feel trapped when they encounter a situation where they do not know what to do. They become fearful to raise their hand and ask a question due to being put down or mocked by their peers. This leads to students remaining silent and stuck while the rest of the class continues to move on throughout a project or lesson. "It is important to recognize that factors beyond the classroom are often associated with student fears, but instructors can help mitigate the negative stigma of failure by fostering a supportive and inclusive student-centered learning environment that encourages collaboration, discussion, and normalization of failure narratives, both within science and beyond" (Nunes 35). This fear of public shaming by making mistakes has led to the students shutting down until they get one on one attention from the teacher or a student they trust. The focus for every teacher should be creating an atmosphere where the students feel comfortable making mistakes. By introducing failure into my project-based physics class, I give the opportunity to see and experience failure, allowing students to take the stigma out of stigmatized failure.

Learning from the failures of others

Observation and reflection are the two most valuable tools a student can have in their skillset as they approach any project. As children, students learned by observing their parents, older siblings, and relatives. Likewise, observation is a vital skill in the classroom which allows students to learn from each other. While typically students attempt to learn from other students' success, they also have the ability to learn from other students' failures. It is difficult to try and observe other students during a project that only lasts one class period, they only can go around

the room and observe the competition if time permits. For projects that take over a week, students have more time to plan and therefore, more time to observe other students in their efforts. This leads to students typically seeing the positives of students' projects and reporting back those aspects they want to try, but unknowingly, they also file away ideas that are not working or they foresee it not being successful for the other groups.

One of the best aspects of group projects is how students start to passively learn from each other through observation. If a classroom setting has removed stigmatized failure, then students will be more comfortable speaking up when they see errors and mistakes from their peers. “The term ‘fail fast’ has appeared in higher education, but failure is not a concept that we in higher education readily admit to or accept as part of the process of achieving and sustaining success. We do not have a culture that is comfortable admitting failure. Yet, failure is a normal and expected part of our experience” (DiPiro 1). If students are comfortable with failure, then they will be comfortable pivoting in a project when they realize they are on the wrong path. The students best mentor becomes the other students in the classroom as they can freely express ideas.

How to interpret failure

Michael Jordan famously said, “I’ve missed more than 9,000 shots in my career. I’ve lost almost 300 games. Twenty-six times I’ve been trusted to take the game-winning shot and missed. I’ve failed over and over and over again in my life. And that is why I succeed.” When hearing a quote like this, my students, especially those that are athletes, are filled with visions of them handling the ball right as time expires and making the play. The reality is Michael Jordan’s goal is trying to convey the fact that it is impossible not to fail during the process of attempting

anything. This is a natural process of life where we are given an opportunity to change and improve ourselves. After failing to make the game winning shot, Michael set a goal to make sure he practiced the right way to give himself the opportunity to make the shot the next game.

Often teachers use sports as an analogy to have students see the importance of practicing and learning skills. Presentation or quiz days can be seen as game days where they have practiced all week to prepare for. Just like with Michael taking the game winning shot, the coach/ teacher might have drawn up a great plan all week, but it is on the student to perform that day. And at that moment, it is up to the student to show how prepared they are to handle that pressure. After the quiz or presentation, students naturally want to know how they did. But like the NBA today, they are only concerned about the final score. Students routinely do not want to get feedback on what went wrong on a quiz, they simply want to see their grade and then move on.

This is the fundamental flaw with failure today; people do not want to look at the root of their failure and see how they can make improvements to correct the mistake in the future. When quizzes or rubrics are returned, students will take a quick look at the grade, and then be ready to move onto the next topic. Michael Jordan on the other hand, would use that feedback like game tape to see what errors they made and see how they can prevent it in the future. Students need to spend more time reflecting on errors and failures to be prepared to prevent them in the future.

If students are not satisfied with their grade, they may ask to do quiz corrections or ask if there is a way to get more points on their presentations. Using the analogy of an assignment like this being a game, Michael Jordan probably wanted those 26 missed game winning shots back the next day to try it again, but unfortunately that is not how sports or life works. He was forced to accept failure and learn from it by working on it even though it did not change what happened

the night before. Students who want to receive credit for completing quiz corrections are missing the importance of going through the process of learning from their mistakes without a grade incentive.

There are times in life where you will not get feedback after failure and therefore must learn how to go through this process yourself. A job interview is the perfect analogy to give a student during a presentation, where passing is getting a follow up interview, or a job offer and failing could be as bleak as never getting a return phone call. As students get too used to always getting a chance to fix their mistakes after the fact, they fail to learn to how grow from the failures and mistakes that occur before the game, when they have an opportunity to get feedback. Students need to continue to see connections between what and how they learn in school to prepare them for life outside of the classroom.

Kobayashi Maru

I think the Kobayashi Maru would be an interesting case study to look at when looking at the purpose of failure. The Kobayashi Maru is a test simulation that is from the story of Star Trek in which every new cadet must take a test that is by definition a no-win situation. The simulation is set up where the ship must decide whether to try and save the civilians asking for help on their damaged ship called the Kobayashi Maru and potentially be attacked or to avoid the situation thus keeping their own crew members safe. The goal of the test is not to succeed but for every potential new commander to understand what it's like to go into a no-win situation or a failing situation and understanding the importance of character while faced with a no-win situation. The goal is not to succeed but struggle with failure as those cadets try to do the best for their ship in the attempt to preserve or save as many lives as possible.

Creating a challenge with a no-win situation would allow for two main options, where the students could choose to act and face the consequences of trying to save the crew on the Kobayashi Maru. It would be interesting to see how students would react to an exam or challenge that has the same parameters as the Kobayashi Maru in which by acting, failure was inevitable for the students. While students would struggle throughout this process of taking that challenge on, they would never really fail as the most important aspect would be understanding their character as they go through the process of failing. For students that go through the process of failing the greatest benefit would be during the reflective process. Focusing on their actions and reactions, they can improve in the future. The main difference during the Kobayashi Maru is that no matter how well they prepare or how much they improve for a future task they would still inevitably fail during that challenge therefore their understanding of how their attitude and their perseverance throughout a tense or pressure situation would be the greatest benefit for them going forward.

The problem with creating a no-win situation like the Kobayashi Maru is that the students could also choose to do nothing, their own crew is safe because they do not choose to act. If students were to take this strategy, the assignment would have to have a clever process where they would have to examine the pitfalls of the project and why they are choosing not to act. Therefore, they would be laying blueprints for how to avoid the obstacles that they would be facing. With that blueprint in mind, they would have gone through the process of the assignment by observing the failures of the other students instead of trying it themselves. This can be a beneficial process as the students could then work together and see ways to teach each other possible solutions.

Finally, the assignment would have to finish with a move similar to James Tiberius Kirk (the only individual to beat the Kobayashi Maru), where students would be given the flexibility to change the parameters of this project to change it from a no-win situation to a task that can be completed successfully. If the students understood the assignment and reflected on where they failed during the challenges, they would be able to understand how and which parameters to change to accomplish the previously impossible task. This added layer to this project would help demonstrate the student's ability to understand the assignment and how to make it conform to their benefit.

This project would allow students to experience failure while constantly searching for solutions as they work through it. These no-win situations would be an important life lesson that would not only have to be in a physics curriculum but could also fall into other subjects in school. A project like this could force students to get frustrated early and quit after failing to complete the task. Positive reflection would become a focus of a project like this, therefore the need for students to understand a real-world situation could aid a student's drive to keep going. The intention of adding failure into this project would force students at all levels to go through the reflective process after attempting the challenge. Finally, the students would get the ability to understand and change the parameters of their constraints, which has the potential to be an important life lesson for students, that they have more power to change their surroundings if they can understand their surroundings first.

Mars soft landing failure project

In an attempt to create parameters for the Kobayashi Maru, I modified a previously used challenge lab in an attempt to see how students reacted. The Mars soft landing challenge is

meant for students to look at free fall and kinetic energy as they attempt to find ways to prevent their Mars rover from crash landing in the wrong area and/ or sustaining too much damage during landing. I show a quick video (Resource 2) of the actual options that the Mars rover can employ if their pod is working properly. After a quick look, they are told that they only have option one due to technological issues with the pod, it will be forced to crash down on the surface with nothing more than the airbags deployed. In this fictitious scenario, their team (working on Mars) is told that they must create a structure on the surface that will help brace the impact of the pod and prevent it from rolling away from the intended landing zone. Their main objective is to ensure that the pod will land in the desired grid and therefore cannot roll away as it lands. The secondary objective of the structure is meant to nullify or limit the bounce created by the pod as it hits the ground. Less bounce should ensure less damage to the pod. And finally, the tertiary objective should be using the least number of materials that allow them to be used across Mars while limiting the dimensions vertically.

Since this was a challenge lab, the students were told that the most successful group would receive the highest grade in the lab. All attempts that do not land inside the target landing grid would automatically be discarded, so they will have to start by finding ways to keep the pod within the landing grid even if it is bouncing. To ensure that there would be a solid bounce (making it more difficult) the pod was a lacrosse ball which has a consistent bounce and can easily roll away. The second aspect of the project was attempting to limit the bounce of the pod. Students had to film each attempt and measure the apex of the first bounce after the pod hit the surface. This would give them a height to ensure the rover would not be damaged within the pod.

My goal was to do this project over two days, the first day being the introduction of assignment and allow them to attempt the challenge, with the knowledge that I am purposely withholding half of the supplies in which to create the structure on the surface of mars to catch the pod. I started by writing down all the parameters on the board and making it clear that any breach of the parameters would be considered a failing attempt. Students were told they could attempt as many times as they wanted since each had their own unique landing spot throughout the classroom, but they needed to film it to ensure their data on the height of the bounce was accurate. During the first day, students struggled to keep the pod from bouncing away as there was not enough material to accurately slow down the pod and to keep it from rolling away after. Towards the end of the class period, I handed out our typical post lab report sheet and asked them to reflect on which aspects of the project were difficult since almost the entire class failed to have a safe landing for the Mars rover.

To start day two of this lab, students were asked to recall the parameters set the class before and discuss amongst themselves which of the parameters were holding them back from being successful. They were informed that as a class, they could be like James Kirk and change one aspect of the parameters that would allow the entire class to become more successful during the project. The class concluded that doubling the building materials made more practical sense than doubling the landing grid. By doubling the building materials, students were able to display an understanding about the problem they were facing and show a logical solution. This gave the students enough materials to create a higher tower for the pod to hit while still having additional material to surround the outside of the landing zone. These higher towers resembled crumble zones in the back and front of a car allowing for the tower to take the brunt of the damage and allowing the pod to almost roll away slowly instead of bouncing over their walls for the landing

zone. The second day was seen as far more successful with all but one group succeeding and students who completed the challenge going back to lower the height of the bounce to beat other groups. Once again, the class ended with students receiving the typical post lab review sheets with them being asked to pay special attention to what happened when the parameters were changed in this assignment.

All Lab Write Up Worksheet

After every lab is complete, the students will download the same basic write up sheet to help show what they learned during the lab and to show connections between other units covered throughout the year. There are six simple questions that should allow students to understand the questions but approach them differently based on what they did during the lab or experiment. The first question is, "what happened in the lab?" Here students should be able to summarize the lab in four to five sentences, this should give the students an opportunity to show basic understanding of the lab. Writing out a summary of the lab will help students reflect on the lab and be their template for the following questions.

Question two is, "what do you know now?" Building off the previous question, students are asked to give clear examples about what they have now learned during this lab. This could stem from a complete failure, where students now know how to not create a project or where a student can elaborate on a skill they have just learned. Question three asks the next logical question following numbers two: how do you know that you know? Question three asks' students to reflect on their information from question two and defend it. If a student can articulate their thinking process behind their claim for what they know now, they will help create

a deeper connection to that information. While each lab and experiment are different, the ability to defend what they are writing is an important skill that should continue to cultivate.

Question number four asks students to reflect on past experiences and lessons learned as they are asked, “How does it connect to what I already know?” This question asks students to think about previous projects, not just in physics class but in previous years. Since this is the same question for each lab, answers can vary from students describing how it connected from a previous lesson that we did the day before, to connections that students have experienced outside of the school. Since physics labs should have real world relevance, students might make those connections to experiences that they have done or observed before. The fifth question, which is unsurprisingly the most difficult is, “why this lab should matter to others?” This question forces students to look beyond the classroom and make connections to the outside world. This question is more difficult because the materials used in the lab could be vastly different from the proper items. If students can make connections on why other people should care about this topic and therefore science, they are bridging the gap between understanding for a grade and a real-world connection.

The final question is “did you like this lab? why/why not?” This often leads to generic answers from students that were not helpful to start the school year. Danny Douchette’s Ted Talk discusses the major problem with science labs today. They are usually fantastic demonstrations trying to trick students into liking science. He states, “We do not teach students how to use scientific ideas to make meaning in their lives” (Doucette, 2017). The difficulty with inputting authentic labs that have a chance for authentic failure is students might default to saying they do not like that lab because it was more difficult when compared to the demonstrations, they

experienced the year before in chemistry class. The six questions remain the same with every lab but throughout the year, the connections made should continue to build making this assignment more familiar. While students have the potential to fail during these labs, this post lab worksheet allows students to prove that while they did not get the results they were looking for, reflection and understanding still took place in a lab that had real world relevance.

Changes to the all lab write up sheet

A teacher must continue to adjust and adapt each lesson as they continue to endlessly hone their craft, it is time that I add a few more questions to my all lab write up sheet. The original idea was to not change the all lab write up sheet to ensure consistency from year to year, by simply adding questions and not changing the others, I can continue to compare. The goal of the changes is to reflect the fundamental difference I want to introduce with labs going forward. By allowing students to fail and get authentic results, my new questions should reflect the potential for struggle and failure. The first question that I want to pose is which parts of the lab did you struggle with and why. There are two goals with this question. First, I want to take stock on what difficulties the students had to see if there are issues with the lab that I did not expect or foresee. This will allow me to make changes to the lab or give the students the flexibility to change aspects of the lab that would allow it to run smoothly. The second part allows for more reflection as students are asked to write down when and where they struggled with the lab. This could also help show if there is a connection for the students to where they hit setbacks.

The second question that I am adding to the all lab write up sheet is if presented with the same lab again, what changes would you make to your approach. The expectation is that students would see the connections to moments they struggled and how they can approach a solution in

the future. The reflection on how students can see the issues that they faced and plan out how they would fix the problem next time is something that has been used in science classrooms before. This reflection is important but typically it is associated with students learning ideas that can be transferred to another lab, however, the goal would be for students to put their ideas directly into practice by attempting the same lab the following week. This would help the students see the correlation between their reflection and putting it directly into practice. The bond between answering that question and having a better understanding and plan for the lab the following week will allow the students to take this question more seriously throughout the school year. While there is no guarantee that these two new questions will cause the students to become more reflective after each lab, hopefully, the students will see this lab write up sheet as a launching point for more inquiry and meaning in their lives instead of just another assignment.

Conclusion

Our society needs to revisit the way that we teach students to experience and think about failure in schools. The language of stigmatized versus generative failure is a useful tool for educators in considering this conundrum. On a nationwide level, schools have experienced positive culture shifts around perception of failure and increases in intellectual risk taking by implementing project-based learning and shifting/reimagining grading systems. As a conceptual physics teacher at CM, I will address the problem of stigmatization of failure by implementing a hybrid grading system that encourages intellectual creativity and risk taking and promotes failure as an opportunity for authentic learning. My hybrid model centers around project-based learning and standards-based grades.

In their lifetime, current high school students will be confronted with numerous failures. They need to have experience reflecting on and learning from failure before they leave high school. They need to see mentors and peers fail and then return to the problem, armed with the reflection and new information that they gained from their failure. Failure is not the enemy in schools. Uninterrogated failure that is stigmatized and is finite is the enemy. I am hopeful that a new approach to teaching physics centered around project-based learning and focused on learning rather than a numerical grade can give students experiences with failure that will prepare them to be engaged learners and successful problem-solvers in their futures. As a school, and as a greater educational system, we should continue to further consider and wrestle with the lessons that our students take away from the curriculum and the grading systems that we use to evaluate them and ourselves. My research has assured me that rather than mitigate and avoid student experiences with failure, we should actively seek out and pursue opportunities for students to encounter and grow from failing. Ford's words continue to ring true for educators and for our students, "Failure is simply the opportunity to begin again, this time more intelligently." With adapted grading systems and classes centered around project-based learning, students can do just that.

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APPENDIX: SAMPLE ACTIVITIES AND MATERIALS

All lab write up Worksheet

Name: Teacher:

Date: Block:

Science Lab/ Activity Write Up

Name of Lab:

Describe what happened in the lab: (4-5 sentences)

What do you know now?

How do you know that you know?

How does it connect to what I already know?

Why should this matter to others?

Did you like this lab? (why/why not)

Soft landing video**:** https://www.jpl.nasa.gov/edu/learn/video/mars-in-a-minute-how-do-you-land-on-mars/

4. Stress Reduction

Many people will experience heightened levels of stress at certain points in their lives. With increasing responsibility, new living situations, constant change, and the overwhelming presence of digital and social media, feelings of instability can lead to stress, anxiety, and even panic.

Practicing mindfulness may help to anchor you in the present, where you can observe your thoughts and feelings without chasing them and without assigning judgment or attaching emotions to them. In this way, mindfulness is a tool that has been shown to reduce stress, manage symptoms of anxiety, and allow people to live in the present moment with more ease.

Researchers reviewed more than 200 studies of mindfulness among healthy people and found mindfulness-based therapy was especially effective for reducing stress, anxiety and depression. Mindfulness can also help treat people with specific problems including depression, pain, smoking and addiction.

- American Psychological Association. (2019, October 30). Mindfulness meditation: A research-proven way to reduce stress.

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5. The Breath

The Breath is everything. If we are not breathing, we are not living. When experiencing feelings of anxiety, it is common to find you are holding your breath or taking shallow breaths. The physical impacts of holding or restricting your breath can symptoms of anxiety and panic, whereas controlling your breath through various exercises can have a calming, anxiety-reducing effect.

Deep breathing increases the supply of oxygen to your brain and stimulates the parasympathetic nervous system, which promotes a state of calmness. Breathing techniques help you feel connected to your body—it brings your awareness away from the worries in your head and quiets your mind.

- The American Institute of Stress. (2012, August 10). Take a Deep Breath.

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6. Stress Reduction Exercises

I invite you to try practice some of the breathing exercises in the following section. If you are able to, read the written instructions first, and then follow the steps as you color the illustrations. If you practice these breathing exercises regularly, you will have a resource to call upon whenever you are experiencing heightened levels of stress.

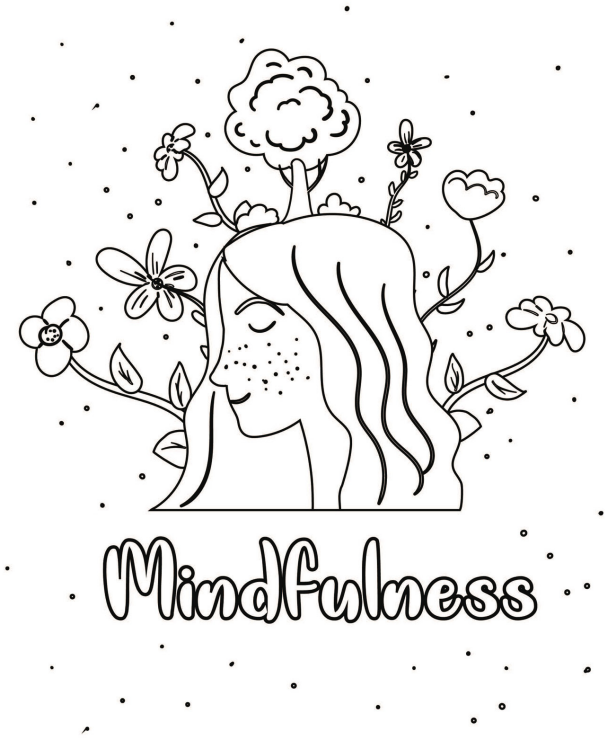
These methods are not quick fixes to mental health issues, but they can be effectice tools to help manage and reduce symptoms of stress, anxiety, and panic.

Breath is the bridge which connects life to consciousness, which unites your body to your thoughts.

Whenever your mind becomes scattered, use your breath as the means to take hold of your mind again.

-Thich Nhat Hanh

The Miracle of Mindfulness: An Introduction to the Practice of Meditation



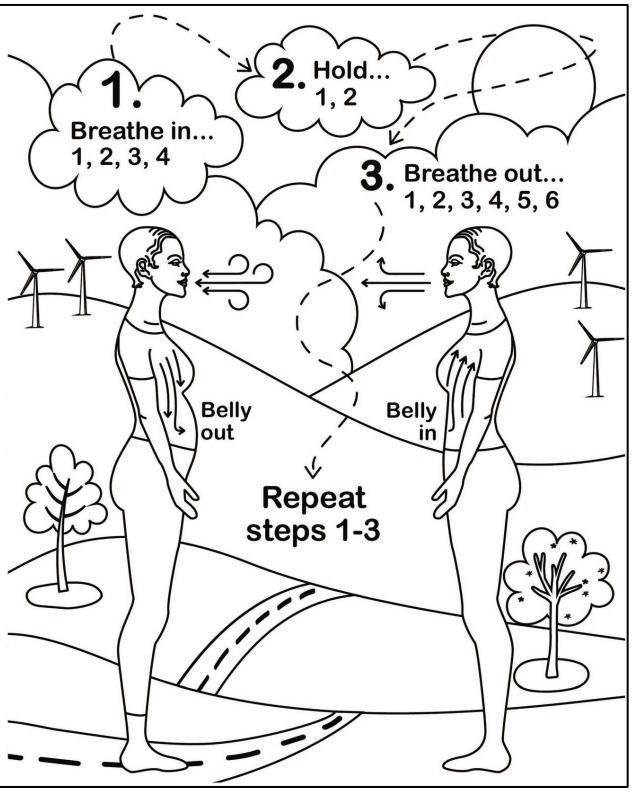
6. Stress Reduction Exercises

4-2-6 Breathing

4-2-6 breathing is something you can consider a "rescue" breathing method that can be in times of stress to quickly increase the supply of oxygen to the blood and bring about feelings of relaxation. This can also be practiced when you are more relaxed, so the exercise can be recalled at will.

1. **Inhale deeply and slowly count to 4, expanding your belly as you do so**
2. **Hold that breath for a count of 2**
3. **Slowly exhale though your mouth for a count of 6**

Repeat steps 1-3 for 3 to 5 minutes.



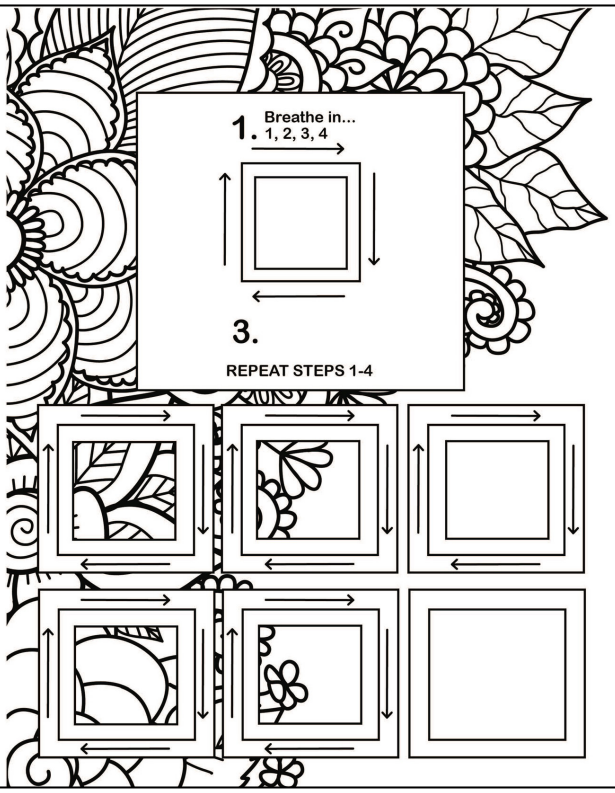
6. Stress Reduction Exercises

Box Breathing

Box breathing is sometimes also referred to as square breathing. It is an exercise that can help you slow down and gain control of your breathing. It works by distracting your mind as you count to four, calming your nervous system, and decreasing stress in your body.

1. **Inhale steadily to a count of 4**
2. **Hold that breath for a count of 4**
3. **Exhale steadily to a count of 4**
4. **Hold that breath for a count of 4**

Repeat steps 1-4 for 3-5 minutes.



6. Stress Reduction Exercises

Mindful Breathing

Mindfulness meditation involves focusing on your breathing and bringing your attention to the present without allowing your mind to drift to the past or future. Engaging in mindfulness breathing exercises serves the same purpose, which can help ease your anxiety.

One mindfulness breathing exercise to try involves choosing a calming focus, including a sound (“om”), positive word (“peace”), or phrase (“breathe in calm, breathe out tension”) to repeat silently as you inhale or exhale.

Let go and relax. If you notice that your mind has drifted, take a deep breath and gently return your attention to the present.

7. A New Way of Thinking

The introduction to mindfulness and sample exercises in this coloring book prototype offer a sampling of what is contained in formal Mindfulness-Based Stress Reduction (MBSR) program.

I hope this book has planted a seed that practicing mindfulness can lead to a new way of thinking that puts the power of managing symptoms of stress, anxiety, and panic into your own capacity. Please find resources on the following page to help you continue to explore mindfulness.

Please send feedback on your experience with this coloring book to the following email address: billiecharles@gmail.com

"Mindfulness increases the awareness of the Nature of the Mind. If we learn to Control our Mind and Listen to our Souls we can consciously choose to be Joyful instead of sad, Peaceful and Loving, Alert and Relaxed.

- Natasa Pantovic Nuit, *Mindful Being*

8. Free Online Resources

American Mindfulness Research Association
The American Mindfulness Research Association was founded in 2013 and is a website that brings together the latest research in Mindfulness.
https://goamra.org

East Coast Mindfulness
Online mindfulness programs for living authentic, healthy, happy lives.
https://www.eastcoastmindfulness.com/

Free Mindfulness:
A website which gathers resources from a community of mindfulness practitioners. There is a 'free resources' section with mindfulness practices to download.
http://www.freemindfulness.org

Greater Good Magazine Science-Based Insights for Meaningful Life
Greater Good magazine turns scientific research into stories, tips, and tools for a happier life and a more compassionate society. Within their library, there is a wealth of information and articles on the topic of mindfulness.
https://greatergood.berkeley.edu/

Mindful Communications
Mindful Communications is dedicated to sharing the gifts of mindfulness through content, training, courses, and directories—helping people enjoy better health, foster more caring relationships, and cultivate a more compassionate society.
https://www.mindful.org/

Pocket Mindfulness
Pocket Mindfulness is a website to help others learn about, understand and apply mindfulness in everyday life.
http://www.pocketmindfulness.com

UCLA Mindful Awareness Research Center (MARC)
The mission of the Mindful Awareness Research Center (MARC) is to foster mindful awareness across the lifespan through education and research to promote well-being and a more compassionate society.
https://www.uclahealth.org/programs/marc