Why Do We Hate Math and How Do We Teach It?

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Abstract

In this thesis, I am going to discuss teaching methods and practices that lessen anxiety, due to Math Phobia, in an adolescent setting. I first discuss that students develop Math Phobia, from ineffective teaching strategies, lack of success, and mathematical mindset. To reduce anxiety, effective teachers, must teach how we learn mathematics, using the 3 learning principles and the BDA lesson format. The teaching method, problem-based learning, serves as platform which students learn through discovery, in which teachers create a positive classroom culture, through discussion. I will discuss strategies inside PBL that promote a growth mindset, such as the power of a mistake, differentiation, and formative assessments. Jo Boaler (2016) serves as the main source of research in this thesis, providing insight towards Math Phobia. I argue that these teaching strategies and mindsets are effective in lessening anxiety to allow all students to succeed in the classroom.

Keywords: Adolescent Education, Mathematics, Math Phobia, math anxiety, teaching strategies, mathematical mindset growth mindset, fixed mindset, success, prior knowledge, conceptual understanding, procedural fluency, problem-solving skills, metacognition, BDA format, essential question, learning objective, learning through discovery, problem-based learning, direct instruction, positive classroom culture, discussion, power of a mistake, memorization, differentiation, multiple modalities, scaffolding, student choice, heterogeneous grouping, homogeneous grouping, assess for learning, formative assessment, summative assessment

Why Do We Hate Math and How Do We Teach It?

Why do we hate math? In some point in your life, you have probably experienced hatred towards mathematics. “85% of students in an introductory college level math class claimed to have experienced anxiety when presented math problems” (Furner, 2016, p. 4). This sense of anxiety is also prevalent in students who were proficient in mathematics, like engineers, which I can confirm as well, during my undergraduate studies in Mathematics. Whether it be from studying long hours just to pass an exam or getting frustrated on that one problem you just can’t seem to figure out; Math Phobia is a widespread national problem, that causes stress and anxiety to many. Math Phobia can be defined as the “inconceivable dread of mathematics that can interfere with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations” (Buckley & Ribordy, 1982, p. 1). Math Phobia hinders student learning causing a sense of anxiety where students feel they are not capable of doing math. Students will say things like, “I’m just not a math person”, but, is there really such thing as a math person? In Jo Boaler’s *Mathematical Mindsets,* she states “I *am* saying that there is no such thing as a “math brain” or a “math gift”, as many believe. No one is born knowing math, and no one is born lacking the ability to learn math” (Boaler, 2016, p. 5). Students develop what we call to be a fixed mindset towards mathematics, when they do not think they have the capability of learning math. Boaler (2016) states, “The new evidence from brain research tells us that everyone, with the right teaching and messages, can be successful in math, and everyone can achieve at the highest levels at schools. There are a few children who have a very particular special educational needs that make learning difficult, but for the vast majority of children—about 95%-- any levels of school math are within reach” (Boaler, 2016, p. 4). Since 95% of students are capable of success in math, why does this sense of math anxiety exist in the first place?

Math Phobia can be developed through various factors but the ones I will be focusing on are ineffective teaching strategies, lack of success, and mathematical mindset. Some ineffective teaching strategies that cause anxiety can be assigning the same work for everyone, insisting on only one correct way to complete a problem, and assigning math problems as punishment (Furner, 2016, p. 6). These ineffective teaching strategies can lead students to be unsuccessful in mathematics. This sense of failure causes students to develop anxiety, where they continue to feel that they are not capable of doing math. This can then lead students into a downward spiral of low confidence which advances into a fixed mindset. This goes back to the thought of a "math person", where students with fixed mindsets believe that intelligence is a gift that they just don't have (Boaler, 2016). This fixed mindset can also be passed down from former teachers or parents. Elementary school teachers usually have this same perception of math, therefore at a young age, students are taught these views. This can happen just as easily with parents. If parents do not feel comfortable with mathematics, they can pass their views of Math Phobia onto their child. It is important to know that this mindset of math is not permanent. It needs to be teachers' mission to stop this national problem and promote a growth mindset, where students feel capable towards mathematics. Boaler (2016) says it perfectly, "With a design and mathematical mindset, teachers (and parents) can create and transform mathematical tasks, giving all students the rich mathematics environment that they deserve" (Boaler, 2016, p. 91). I argue that with effective teaching methods, such as problem-based learning, teachers can promote a growth mindset through the power of a mistake, differentiated instruction and formative assessment, where all students can succeed in mathematics.

Now, how do we teach math? Before I begin to discuss effective teaching strategies, I must first discuss how people learn math. There are 3 learning principles that define how students learn math, the first one being engaging prior knowledge. In the mists of learning a new topic it has been said that “new understandings are constructed on a foundation of existing understandings and experiences” (Donovan & Bransford, 2005, p. 4). Therefore, all new information gathered by students is based upon prior fundamental knowledge they have already learned. For example, when students are learning the order of operations, they are using their previous understanding of addition and subtraction to solve the problem. Engaging prior knowledge is essential in the learning process, but can pose several issues, especially if there are misconceptions from the past. This can prompt a problem for teachers causing them to fix a preconceived notion of a student, which they already expected students to know. Since it is necessary for preconceptions to be addressed for a connection to be made, teachers must be aware of this dilemma. Teachers must also have the ability and skill to lead students to the correct understanding. It is common that students may not even know they that they contain this “prior knowledge”, therefore making it extremely important for teachers to address it in the beginning of a new topic. Students may have it stored into their long-term memory, which will not be brought up unless the teacher makes them conscious of it.

When activating prior knowledge, teachers need to make sure to elicit students’ preconceptions instead of just testing to see if they know it. Through various and constant assessment, teachers should have a good understanding of what students know and any misconceptions they have. Allow the students to explore their brain to find the knowledge that as a teacher, you are looking for, which can be done using an acknowledged method or problem. This should be more than just a warmup, though. Handing out prerequisite problems that they already know how to solve doesn't really activate their brain. This can be used as a great review technique but does not cover engaging their prior knowledge. There are multiple ways that a teacher can go about this, broken up into categories consisting of concept, skill, universal experience and prior knowledge (Hollingsworth & Ybarra, 2017). The first step is to design lessons in a way that engages students' prior understanding or relatable experience. Secondly, teachers should evoke the students' already existing knowledge of a specific skill or concept, ideally involving both conceptual and procedural knowledge. Next, teachers must facilitate the students' interaction, which can be done through a group discussion. This allows the students to search for relevant ideas and participate in the exploration of a new topic. This allows students to take hold of their learning through discovery, which will lead them to get a deeper understanding of the topic. Most importantly, teachers then must explain the connection to the students. Without this, engaging prior knowledge will have no conceptual background. Students will not be able to put together their preconceptions to the new lesson (Hollingsworth & Ybarra, 2017). This is a great chance for teachers do a check in, to ensure that all their students are on the same page before moving onto the new material. This is also where teachers can correct any misconceived notions. Prompting open-ended questions is a great way for students to reflect on this knowledge and get ready to move onto the next part of the lesson. Encouraging students to make predictions can add creativity and discovery into the lesson, while also making it fun.

The second learning principle relates to factual knowledge and conceptual understanding. Procedural fluency, in factual knowledge, refers to when students excel at a certain skill in a precise and efficient way. This goes hand in hand with estimation and calculations. While students can gain this proficiency through ample practice, this does not necessarily translate into a student's conceptual understanding -- it is important for students to have a strong base in their factual knowledge for them to deeper their mindsets into conceptual understanding. To gain the "big picture", problems must be looked at in a way that they are seen as various topics instead of just an individual lesson (National Research Council, & Mathematics Learning Study Committee, 2001). On the other hand, conceptual understanding is when students understand why a certain mathematical method is used and how they can relate it towards other problems. Once students have fully grasped a concept, they then are prepared to move onto a deeper topic, which is also addressing why prior knowledge is important to develop conceptual understanding. A student's conceptual understanding can be demonstrated in many ways like explaining methods to others or representing knowledge in a different terrain. Once students have the whole idea, they are more likely to retain the understanding of this information rather than just memorizing it.

Procedural Fluency and conceptual understanding go hand-in-hand when it comes to problem solving skills, which is how we use and apply math to real life. According to recent studies, "memory of factual knowledge is enhanced by conceptual knowledge, and conceptual knowledge is clarified as it is used to help organize constellations of important details" (Donovan & Bransford, 2005, p.7). In order to teach for understanding, factual knowledge must be brought to a new level where core concepts are revealed. It is obvious that a combination of both conceptual understanding and factual knowledge is needed but separating the two can be detrimental to a student. Without both, problem solving skills will be lost, therefore negatively impacting the use of mathematics. Because students with strong factual knowledge display themselves with high levels of intellect, it may be hard for teachers to distinguish between procedural fluency and conceptual understanding. Teachers must recognize the differences for students to obtain both. This difficulty causes teachers to overlook conceptual knowledge and only focus on the students' skills, which is usually demonstrated through tests and quizzes. Using various types of assessments can allow students to demonstrate procedural fluency, conceptual understanding, and problem-solving skills or mathematical reasoning. One way to look at this can be a student who is extremely proficient in their mental math skills therefore making it easy for them to do algorithms. Students who have great procedural fluency may be conducting the operation mindlessly without understanding the concepts behind it. For example, just because a student knows how to calculate the area of a triangle, by plugging values into the formula, does imply that this student understands the reasoning embedded in the formula or topic. Group discussions and projects are a great way to facilitate conceptual understanding. Teachers must incorporate lots of questions to get the students thinking about what they are learning. Proficiency in both conceptual understanding and factual knowledge is necessary for students to make connections of their methods to real life situations.

The last principle to learning math is metacognition, or self-monitoring. This is when students take learning into their own hands, defying the norms of instructional learning. Students must be conscious of how they learn in order to properly self-monitor. A critical element of metacognition is the ability to self-explain, which plays an important role in the development of students' conceptual understanding of their mathematics (Donovan & Bransford, 2005). It is important for teachers to encourage their students to be active learners and be conscious of "why" or "how" they are doing it. When given a difficult problem, research has shown that students who lack metacognition will not be able to efficiently solve the problem due to their lack of awareness. This is where a strong background in conceptual understanding and factual knowledge comes into play. Students who are active learners will the assess the situation, by mathematically reasoning using problem-solving skills (Schoenfeld, 2009). When students are often confronted with problems, then tend to latch onto one idea. This idea can be the most recent strategy they learned or a formula or procedure they are familiar with. Because of this, students will just start calculating without even thinking to stop and reflect on what they are doing (Schoenfeld, 2009). This seems to be a common theme among students, which distracts from the true purpose to doing these problems. Students need to question what they know and what they don't. A lot of times, conceptual framework is lost, leading students to blindly fall into procedural tendencies. Teachers must be aware of this situation in order to decipher those who are truly self-reflecting. Students with fixed mindsets probably will not reflect on their learning in a positive way. The best way to get students to demonstrate they are reflecting is to have them communicate with others through group work. Taking a step back as a teacher and allowing your students to lead the lesson is a great strategy to force your students to really think about a certain method. As the facilitator, teachers should moderate questions and lead the students into the right direction, in a way that the students still get the sense that they are dictating most of the learning. Most importantly, teachers most appropriately close out a lesson to reinforce what was just discovered. Making connections allows students reflect and deeper their thinking of the new information. The hardest part for teachers is saving time for this at the end of the lesson. Without closure, students will leave the classroom confused and unable to make connections. Metacognition is necessary to promote active learners to be efficient problem solvers.

The quote “if a child can’t learn the way we teach, maybe we should teach the way they learn” (unknown) accurately describes what it means to be an effective teacher. Having all three learning principles of how students learn math incorporated into a teacher’s lesson can lead to student success. There are many ongoing studies as to which method is considered the “best” for teaching. This question is one that may never be answered, as each student is unique and learns in his or her unique way. Is there even a “best” way? Teachers must understand that there may be many methods that can lead to student success. My question is which one of these methods is the most effective? There are many factors that go into a teacher’s method of choice, but before that is discussed we must talk about how these methods are structured. How a teacher arranges their method affects how it is taught, therefore making the lesson plan format they choose to be crucial. The Before-During-After, also known as BDA, format is one that perfectly intertwines with the 3 learning principles. It is extremely organized, being separated into 3 parts, allowing students to constantly be engaged in these three principles. From recent studies, “brain research indicates that students are mentally primed to learn during the first fifteen minutes of a typical forty-five-minute class period” (Wilburne & Peterson, 2007, p. 209). This means that students are more apt to lose motivation and concentration during the middle part of a lesson. Structuring the lesson into three sections allows students to remain engaged

The first section, the *before* phase, is where the teacher is going to try to allure the students into the lesson and get them mentally prepared for what they are going to learn. This is a teacher’s perfect opportunity to engage the students’ prior knowledge and should be completed within the first 5-10 minutes of the lesson. Prior knowledge relates directly to *before* because students will be working on the necessary information needed to know before the lesson. This can be done in various ways such as a review of previous lesson in a Do Now (Wilburne & Peterson, 2007). Do Now’s are a great opportunity for students to work and discuss their prior knowledge, while the teacher gets a formative assessment of the students’ progress. This also gives the teacher the opportunity to multitask, on things like attendance and passing out papers, while the students are working. The *before* phase, can allow the teachers to highlight students’ mistakes, while going over the Do Now, which is essential to creating a positive classroom culture. This lets the students learn from their mistakes before they continue onto the next topic.

Next, the *during* phase, is where the majority of the lesson will take place, being about 20-30 minutes. The core mathematical context will be covered here making it easy to address conceptual understanding and procedural fluency, the second learning principle. According to Wilbrune & Peterson (2007), “this phase engages the students in experiments, exploration, or guided discovery of a concept either individually or in small groups” (Wilburne & Peterson, 2007, p. 210). Students will be able to learn new concepts or procedures in an activity that leads them to be active learners. The teacher can take many approaches to how they want to demonstrate their information. This should be determined based upon the topic and the students’ needs. Some examples of these methods are problem-based learning and direct instruction. It is important for a teacher to make an educated decision to allow conceptual understanding and procedural fluency to be successful. In the *during* phase, it is especially important to use both conceptual understanding and procedural fluency to develop problem-solving skills. Significantly, the students should be able to make connections throughout the *during* phase that relate to what was covered in the *before* phase. It is necessary for a BDA lesson to be cohesive to demonstrate conceptual knowledge for the students.

Lastly, the *after* phase is where reflections are made by both the teacher and the students. Connections are finalized with further reasoning in problem-solving and conceptual framework (Wilburne & Peterson, 2007). Metacognition is necessary in discussion regarding the lesson that was just covered. A great tool to achieving this can be an Exit Ticket that contains both conceptual and procedural questions that further the students understanding of the lesson. This can further metacognition by having students place Exit Tickets into corresponding folders on how they thought they did. Students should be encouraged to be active learners during this phase, especially if there is a class discussion at the end reflecting the notions made. Teachers should pose questions that further discussion and answer anything that the students may be confused about. It is crucial, while wrapping up the lesson, for there fluency between all 3 stages therefore conveying a major theme of the lesson. These themes can also be called the essential questions or objectives of the lesson. The BDA lesson format contains a section where teachers can come up with these ideas so students can get a grasp of what they are learning. By the end of the *after* phase, all essential questions should be able to be answered by the students. BDA format effectively pushes students to be active learners and engaged throughout all phases while touching on the 3 learning principles, allowing methods to be structured in an organized manner.

It is important for teachers to understand that essential questions or learning objectives are the focal point while designing a lesson. This is where the main idea is conveyed to the student to create a clear understanding of what they are learning. It is important that these are addressed at both the beginning and the end of a lesson to ensure what was just covered is straightforward to the students. When creating learning objectives or essential questions, teachers must be concise and specific to what the students will examine and learn. Learning objectives are statements that are observable and measurable where essential questions are more about learning than teaching. Learning objectives can be generated using a format that includes a combination of the statement “the students will be able to do...”, a power verb, and a specific measurable description of what the students will know or be able to do. Power verbs are used as specific language to decipher what students are able to do. For example, solve, compare, graph and predict are all power verbs that can be used. According to studies done by A. Susan Gay, “In particular, my preservice teachers needed to be aware of how their use of vocabulary contributes directly to students' understanding or misunderstanding and to learn some vocabulary strategies for use with their future middle and high school students" (Gay, 2008, p. 218-219). Vocabulary, such as power verbs, can create clear language for students to deepen their mathematical thinking and learning. It is necessary to consider that some verbs, like understand or learn, can be too vague and difficult to measure. Essential questions can be formatted just using a couple of steps because it is important for students to be able to know what the goal of the lesson is. First, the teacher must identify the standards that need to be learned and turn it into an objective. Then use that objective to write an essential question using "kid friendly" language, like using words like how or why. It is important for teachers to understand that these questions should not be able to be answered with a yes or no. Therefore, making a question too specific may not be an ideal essential question. If making more than one question, teachers should order them that they flow naturally into one another. To reiterate, at the end of the lesson, all learning objectives and essential questions should be covered and answered by the students. An ideal BDA lesson plan should include at least one learning objective and one essential question to create a clear and concise concept of what was covered.

Learning Objectives and Essential Questions can affect a students' mindset towards mathematics. It is important for teachers to take the effort and time explained before to create a goal for the students that is attainable. If teachers create objectives that the students do not reach at the end of the lesson, what kind of message is that sending? Students may start to get a belief that they are not capable of reaching the standard or objective, influencing Math Phobia. In my student teaching experience, at J Watson Bailey Middle School in Kingston, NY, teachers created their learning objectives using an "I Can" philosophy. This promoted a growth mindset where students were reminded every day that they CAN do math. We would have a student read the objective every day to set to scene of a positive classroom environment.

Other than learning objectives and essential questions, BDA format also includes sections for standards, assessment, accommodations, key vocabulary, and materials. When listing the standards, teachers must include all that are addressed and be specific if only one part of a standard is covered. Assessment should be done during each phase of the lesson. This is can simply be a Do Now, Exit Pass, or even class discussion. A good way to get a quick assessment is using checkpoints, such as the students putting their thumbs up or down if they understand what is going on. Accommodations will be discussed more in detail later regarding teachers differentiating the classroom. This section is primarily used for the supports needed for IEP/504 students but can address any modifications needed for any students. It is necessary for key vocabulary to be the communication necessary for students' participation. The materials needed for the lesson should be included as well as attached after the lesson. In each phase, the teacher should include the time allocated for each section. This is to help the teacher stay on time to ensure all phases are completed in the given period. Lastly, the homework assignment should be included at the end of the lesson, if there is any given. BDA format is structured to provide teachers with a clear foundation to present information with their method of choosing.

Let's go back to the question, which is the "best" method for teaching mathematics? Or in other words, what method promotes effective teaching? As previously discussed, when introducing BDA, there is no right answer to these questions. A teacher must go with their instincts to determine what is best for their students. Knowing which method to use, at which time, and for which students, is a skill that most teachers are still mastering. Each method contains their own unique aspects that differentiate themselves from each other, providing different components necessary to be an effective teacher. Based on the three learning principles and BDA format, a teaching method that allows and encourages discovery and engagement can be beneficial when teaching mathematics. According to research done by George Polya, a distinguished Stanford professor and mathematician, “You cannot learn just by reading. You cannot learn just by listening to lectures. You cannot learn just by looking at movies. You must add from the action of your own mind in order to learn something” (Polya, 2001, p. 3). When students are given the opportunity to learn through discovery, student’s motivation and understanding changes, making the math more exciting because students get to use their own ideas and thoughts (Boaler, 2016). The method that best demonstrates this is problem-based learning.

Different from most methods, problem-based learning, otherwise known as PBL, can be defined as “a classroom strategy that organizes mathematics instruction around problem-solving activities and affords students more opportunities to think critically, present their own creative ideas, and communicate with peers mathematically” (Ha Roh, 2003, p. 1). Problem-based learning poses a problem in a way that students must gain new information in order to solve that problem. This allows students to learn through discovery using their problem-solving skills to take on the problem, instead of just looking for a single answer. This leads students to assess the problem, gather information, identify options, and make conclusions (Ha Roh, 2003). Students are forced to be active learners through discovery. For example, a PBL lesson can contain a problem that has various parts to it, each of them leading the student to discover a new part of information that will lead to their result. This can be useful when deriving formulas, allowing the students to take on the teacher’s role and try to define it themselves. They will use their problem-solving skills to think critically and make conclusions that will help better their mathematical reasoning and conceptual understanding. This encourages students to collaborate through discussion. Implementing PBL can be difficult as it is very time consuming for teachers. Creating a positive classroom culture is important when launching PBL because it encourages students to be active learners. This classroom culture should be one where students feel comfortable learning and discussing topics, especially when making mistakes. It is a teacher's responsibility to make students comfortable, when making mistakes, to ensure that they grow from them. Another way to create a positive classroom culture is through the use of discussion, which can engage students in their own thinking. Problem-based learning requires extensive planning towards the teacher's role particularly in facilitating discussion. "By having opportunities to confront such issues as being specific about the conditions of the numbers, critiquing the claims of others, and considering unfamiliar claims confidently, students gain a conceptual understanding of the arithmetic properties, rather than only a procedural understanding" (Rumsey & Langrall, 2016, p. 419). Discussion is extremely important in a math classroom because it allows students to share and justify their ideas and thoughts, which will be introduced through PBL.

When constructing classroom culture, teachers must first look at how they are facilitating discussion, before they look at how students are communicating. Planning discussion framework is something that may be challenging for some teachers. There are many steps that need to be taken, while planning the lesson, as to decide what can be a successful discussion. Fostering classroom discussion can permit important information to be highlighted, discovered, and questioned. The first step to planning discussion is analyzing the problem. Teachers must assess the task and see what is deemed worthy enough for discussion. While doing this, teachers need to anticipate student thinking. For example, this can be knowing the common misconceptions in a given problem. Common misconceptions can benefit students' procedural fluency and conceptual understanding in discussion, giving students the opportunity to discuss and learn from their mistakes. After these steps are completed, the teacher must plan its enactment. This includes launching the problem and monitoring student work. It is important to engage the students while launching the discussion to elicit their initial thinking. This can be done through a probing question or example. A good idea can be to relate to the students' interests to get them intrigued in the problem. This can easily be done during the *before* phase, where you are engaging the students' prior knowledge. Although the major part of the discussion might not be covered here, it can be helpful to include some. How a problem is presented must be thought about beforehand? A teacher must be able to engage their students in a way that their work can be monitored, which can be include students' strategies and mistakes. A teacher can promote this type of discussion by having a student explain a method to another student. Another example can be students having a debate on which is the correct answer.

Once discussion is planned, the teacher will then launch, orchestrate, and conclude the discussion. Teachers can launch the discussion by drawing students in with a question or problem. Orchestrating classroom discussion involves many tasks such as figuring out student strategies, focal mathematical ideas, and interactions. To figure out what students are thinking, teachers can ask probing questions to facilitate discussion. This can simply be asking the student to justify their reasoning. During the lesson, probing questions encourage students to be active learners and have a voice in their own discovery. These types of discussion are especially important in a PBL lesson because this is where the students learn and make their own conclusions. Once they have developed their own ideas, it is then both the teachers' and students' job to conclude what was just discussed. Metacognition and reflection are very important when wrapping up lessons. This is where mathematical connections and conceptual understandings may be made. To ensure these ideas accomplished, teachers must be specific when highlighting these findings. Teachers must also guide students to extend their thinking, usually through a form of assessment, like an Exit Ticket.

It is extremely important that teachers are organized while facilitating discussion. Since it is student oriented, there is a lot of room for error, causing a weakness in PBL. While planning a lesson, it is important for teachers to include all their discussion questions to ensure they are covered. Even though discussion is not necessarily a planned thing, teachers must have an idea of the lesson's implementation. This includes strategic design on grouping. I will discuss later the benefits of specific grouping techniques. It is important for teachers to recognize which students will be productive and work cooperatively. This involves the teacher to have a good grasp on classroom management as well. The classroom must be structured in a way that students know to stay on the task at hand. When things go wrong, a teacher must assess the situation. This can simply be redirecting the conversation back on track or separating students who have been distracting. Classroom discussion takes constant reflection on the teacher's end. As said before, when creating this positive classroom discussion culture, students must feel comfortable enough to share their ideas through discussion. This can work best by starting the students off working in pairs, this way they can develop a personal relationship with one person before moving on into big groups. Once a teacher feels that their students are comfortable, they can create a classroom open for discussion constantly. This means that a class discussion can arise from a single student's thoughts. For example, if a student shares an answer that is wrong, the teacher can open the floor to the rest of the students to discuss what went wrong and what the right solution is.

This then leads us directly into creating a classroom culture that allows students to feel comfortable making mistakes. Let's first talk about why making mistakes are so important, especially to students. According to recent studies on brain plasticity, when learning a new idea, our brains fire a synapse that creates connections forcing our brain to grow (Boaler, 2016). Therefore, “Every time a student makes a mistake in math, they grow a synapse” (Boaler, 2016, p. 11). According to Moser (2011), a synapse can happen even when we aren't aware of the mistake we made. People who are successful are known to make more mistakes to those that are less successful. It is clear that making mistakes are essential to the brain's growth, especially in education.

Making mistakes is the first step to brain activity. For the brain to be challenged the most, when it grows the most, individuals must have a growth mindset regarding their mistakes. According to Moser’s (2011) study, “brain activity was greater following mistakes for individuals with a growth mindset than for individuals was a fixed mindset” (Boaler, 2016, p. 12). A growth mindset, allows the student to develop the most brain activity, therefore making it more likely that they will go back and correct their mistakes. All students spark synapse when making a mistake but having a growth mindset allows those students to realize their mistakes. Since, students who make mistakes are known to be more successful, those students with a growth mindset outperform those with a fixed mindset. Therefore, creating a classroom culture where students fail productively is equivalent to creating classroom full of students with a growth mindset.

Before getting into detail on how to create a growth mindset, we must first clarify the difference between a fixed and growth mindset. According to Carol Dweck (2015), the main difference was that individuals with a growth mindset believed that their intelligence was developed whereas individuals with a fixed mindset believed it was fixed. A fixed mindset leads to the discouragement of students, thinking they are not capable of doing math. As discussed in the introduction, this is a huge factor in math phobia and students hating math. Students with a Math Phobia will not take the opportunity to learn from their mistakes, due to their fixed mindsets. Mistakes are perceived in a negative way causing students to receive less brain activity and growth (Boaler, 2016). Dweck states “Finally, we found that having children focus on the process that leads to learning (like hard work or trying new strategies) could foster a growth mindset and its benefits” (Dweck, 2015, p. 20). Although effort plays an important role in a student’s mindset, it is not the only aspect that defines a growth mindset. Students with a growth mindset will put in the effort necessary to be an active learner. For example, they will try various methods for a problem and discuss their findings or struggles with classmates. Encouraging students to only put in effort, without them learning creates a false fixed mindset for the student. Teachers play an important role in the creation and maintenance of student’s mindsets. Teachers need to be aware of students with fixed mindsets and understand that their mindset can be changed. Teachers must not fall into the trap to use a student’s mindset as an excuse as a justification as to why they aren't learning. In no way shape or form, does a student's mindset determine their ability. It crucial for teachers to promote a growth mindset, through the power of mistakes, to lessen math anxiety in the classroom.

The key to students developing a growth mindset is to make them think differently about their mistakes. So now the question is, how do we get students to feel that comfortable. According to Boaler (2016), “One of the most powerful moves a teacher or parent can make is in changing the messages they give about mistakes and wrong answers in mathematics” (Boaler, 2016, p. 15). There are many methods a teacher can use to create a positive outlook towards mistakes. One strategy can be for teachers to highlight their "favorite mistake". This mistake though should be conceptual, rather than a numerical one. This can be done while going over a Do Now or Exit Pass where the teacher picks their "favorite mistake" from the students' work. When highlighting the mistake, teachers can reinforce the important message-- that when making a mistake, the student's brain was growing and actively learning. This will allow students to feel good about their mistakes, also highlighting that others probably made the same mistake. Students then can start a discussion about the mistake, causing ever more synapses to fire. Over time, sharing common misconceptions will become a regular thing, making students feel even more comfortable. Boaler (2016) also highlighted another great idea that shows the effect of mistakes towards their brain growth. Teachers can have their students crumple up a piece of paper and throw it at the board, using their feelings towards their mistakes made. Students usually react with frustration and hate by chucking the crumpled-up paper. The teacher then asks the students go retrieve their paper, open it up, and draw all the crumpled-up lines. The teacher would then explain that all the lines represent their brain growth when they made mistakes (Boaler, 2016). This and other activities can be done in the beginning of the school year for students to become aware of their mindsets. These projects can be displayed around the classroom to have students constantly reminded of their capabilities. Thus, teacher approach can impact student learning through encouraging the reflection of their own mistake.

Boaler (2016) also adds that teachers should abandon testing and grading as much as possible, as it portrays a negative message towards mistakes and growth mindsets. This is something that I do not agree with. I will explain further in detail later when discussing assessments, why testing is necessary in our educational society. Although for purposes of mistakes, students, as well, can learn from their mistakes on tests and quizzes. For example, students can be allowed to retake these assessments, if they come in for extra help and go over their mistakes with the teacher. This allows the student to assess themselves, as described before as metacognition, but also delve deeper into their own mistakes. Math Phobia can be heightened by unsuccessful assessments if students do not fail productively. Testing can still aid to a student's growth mindset, if portrayed with a positive message behind it.

Although, PBL is not the only method that can be used with a growth mindset, it is one in accentuates the positives in mistakes through classroom discussion. With the strategies explained above, creating a classroom culture that highlights mistakes and productive classroom discussion, can be done by teachers through PBL. Since problem-based lessons contain problems that challenge the students both procedural and conceptually, they will most likely make mistakes. This is a goal though, since making mistakes leads to brain growth. Problem-based learning encourages problem-solving, mistakes, and class discussion, which are all necessary to develop a growth mindset and be active learners.

While PBL serves as the method that contributes most to a growth mindset, it is unrealistic to be the only method that is used. PBL takes a lot of time for teachers to develop, therefore making it hard to base every lesson off this method. This is when direct instruction comes in, which is probably the most common method teachers currently use in a math classroom. Direct instruction, otherwise known as DI, is skills-oriented where the instruction is teacher-directed, unlike PBL which is student-directed. According to researchers, "Direct instruction emphasizes the use of small group, face-to-face instruction by teachers and aides using carefully articulated lessons in which cognitive skills are broken down into small units, sequenced deliberately, and taught explicitly" (Carnine, Silbert, Kame'enui & Tarver, 2004, p.11). Direct instruction is a great way to convey information in a clear and concise way, which may be necessary for certain topics. For example, DI can be used to show the process of combining like terms in an equation. This also gives a visual aid for students to refer to. Using technology, like SMART boards, are a great way for teachers to present their information with DI.

Since direct instruction is teacher-oriented, it can easy to lose students' interest. Teachers must ensure that their lessons are engaging to keep the students' attentions. For example, short videos can be used as supports for the teacher when explaining a formula. Each teacher interprets their own way to use direct instruction, therefore causing room for problems to occur. For direct instruction to be effective, the teacher must know their students' interests. The BDA format can be used when planning a DI lesson, allowing the 3 learning principles to be covered. The before and after phase in DI is very similar to those in PBL. In the *before* phase, it is the teacher's responsibility to engage the students, using their prior knowledge, in the topic that is going to be covered. Similarly, this can easily be done with a Do Now. The *after* phase is where students will have guided practice, like an Exit Ticket, and where the teacher will give closing statements regarding the newly learned topic. The *during* phase is where direct instruction really differs from problem-based learning. As said before, DI will be teacher-directed where as PBL is student-directed. Since the teacher is the one relaying all the information, they must ensure to highlight concepts or mathematical relations for the students to gain conceptual understanding (Hollingsworth & Ybarra, 2017). This will be when the teacher is introducing the new topic. Once the information has been presented, the students will then be taught the procedure that goes along with the new information. For procedural fluency to occur, teachers must have a timely lesson where they present models with effective problems with minimal classroom disruptions (Hollingsworth & Ybarra, 2017). As you can see, for direction instruction to be effective, these needs may not be able to be met in every classroom. Direct instruction is an effective tool, but only used when necessary.

Since direct instruction is mainly teacher oriented, students lose the ability to be creative in a math classroom. If DI was used all the time, information would be conveyed to them constantly without discovery, therefore making PBL a great option to be the primary method in a math classroom. Direct instruction can also lead to a fixed mindset, or in other words, depressing a growth mindset. Because students are not doing the learning on their own, it leaves less room for error. Although, this does not imply direct instruction does not lead to student mistakes. There is plenty on misunderstanding through the relaying of information of concepts and procedures in DI. In problem-based learning though, students are introduced to more obstacle, which lead to mistakes, through the discovery of their own conclusions. It is easy for students to feel discouraged when they cannot understand information that was relayed to them. This can lead to a fixed mindset of them thinking they just don't understand math. Because DI contains teacher given instruction, it can be harder to differentiate within the classroom. Students can easily be assigned the same work, which was one of the factors discussed that lead to Math Phobia. A lot of time teacher will also only relay information in one way. This takes away the creativity in mathematics, where teachers may even insist there is only one “correct way” to do a problem. I have experienced teachers that made me do problems “their way” even though the method I created on my own was just as effective. These issues, that can be prominent in direct instruction, contribute to math anxiety.

Another issue regarding a fixed mindset is teachers blaming the students for having one. It can be easy for teachers to justify why students aren’t learning in direct instruction, especially since student learning reflects on their own teaching techniques. According to research done by

Carol Dweck (2015), a fixed mindset is determined by how you react to obstacles or challenges (Dweck, 2015, p. 23). If students are not faced with these challenging problems, that are constantly introduced in PBL, they can become more anxious or feel helpless when they are occasionally introduced in DI. As educators, we want challenge our students as much as possible in a way that encourages a growth mindset. With the use of problem-based learning, and the occasional use of direct instruction, a growth mindset is possible.

One of the pitfalls to mathematics in education, is the reliance on memorization. This can be especially prominent in direct instruction. Teacher-directed instruction can lead to students to memorize the information that was given to them, instead of them learning it. Memorization can aid towards procedural fluency, but mathematical reasoning and conceptual understanding will be lost, which both are essential to develop problem-solving skills. Because students are not taking a hold of their own learning in direct instruction, memorization is a cop out method to get out of full comprehension, especially in those struggling students. According to Boaler (2016), "there are some math facts that is good to memorize, but students can learn math facts and commit them to memory through conceptual engagement with math" (Boaler, 2016, p. 37). Math facts can be useful, but it is possible to learn them without the use of memorization. A great analogy Boaler (2016) uses is the comparison between the subjects of Mathematics and English. She states "In order to learn to be a good English student, to read and understand novels, or poetry, students need to have memorized the meaning of many words. But no English students would say or think that English is about fast memorization and the recall of words. This is because we learn words by using them in many different situations-- talking, reading, and writing" (Boaler, 2016). The way that we look as English as a subject should be the way we look at Mathematics.

One of the reasons memorization is a popular strategy to "learning" math comes from the stigma that speed is necessary to prove that you are a strong mathematics student (Boaler, 2016). This shows that timed assessments, like multiplication tests, can provide more harm than good. I will discuss later the impact of ineffective assessments strategies that cause math anxiety. Researchers have studied the brain have found out that we learn math facts in two ways, strategies and memorization. They have concluded that each of these ways of learning go through separate pathways to the brain but "superior performance" is achieved through strategies rather than memorization. An example of a strategy to learn a math fact is looking at multiplication problems like 17 x 8 is the difference between 17 x 10 and 17 x 2 (Boaler, 2016). Other researchers have concluded that "Mathematics learning and performance are optimized when the two sides of the brain are communicating. The left side of the brain handles factual and technical information; the right side of the brain handles visual and spatial information" (Boaler, 2016, p. 39). Optimal learning of mathematics can be done with the combination of using strategies to learn math facts, which can be used during direct instruction, and hands-on activities done in problem-based learning.

Using these strategies to learn math facts are tools teachers use to deepen student learning. Each of the different strategies can be considered a form of differentiation. According to Tomlinson & Allan (2000), "Differentiation is simply a teacher attending to the learning needs of a particular student or small groups of students, rather than teaching a class as though all individuals in it were basically alike" (Tomlinson & Allan, 2000, p.4). All students have different needs in a classroom and it very important for teachers to understand those needs. Planning the same exact lesson for each of your students, without any sort of differentiation, will just simply not allow all students succeed. As discussed in the introduction, this leads to Math

Phobia as it is one of the ineffective teaching strategies that causes this problem. When students have a sense of failure, they can develop anxiety towards mathematics. For teachers to give students the best opportunity to succeed, they must differentiate using multiple modalities.

Going back to teaching how we learn, there is a more basic way people learn, not just in mathematics. This theory was originally developed by Howard Gardner in 1983, who states there are intelligences that people prefer to learn or demonstrate their knowledge. He created a list of eight intelligences: Bodily-Kinesthetic, Interpersonal, Verbal-Linguistic, Logical-Mathematical, Naturalistic, Intrapersonal, Visual-Spatial, Musical, and Existential (Gardner, 2011). Let me first clarify, that this does not mean that people can only learn one-way, but instead a specific way in which people learn best. To support this theory, teachers must make sure that students of all intelligences can succeed in their classroom. According to Gardner, "Instruction which is designed to help students develop their strengths can also trigger their confidence to develop areas in which they are not as strong" (Gardner, 2011). This can reduce levels of anxiety in the math classroom, where students will feel more confident in their work, promoting a positive classroom environment. There are many ways a teacher can meet to these student's needs. For example, a visual-spatial learner may benefit from watching a video, where a bodily kinesthetic learner may succeed in a hands-on activity. This can be easily done in mathematics as the course itself has key concepts that are displayed in different ways. For example, we look at equations through symbols of variables, numerically in an x-y chart, and graphically. Of course, it is unlikely to reach all the intelligences in one lesson, it is important for teachers to demonstrate and convey information in multiple representations throughout all their lessons. Using multiple modalities in the classroom can also deepen mathematical understanding. According to research, "Mathematics is composed of concepts that are interconnected through a variety of relationships.

Learning a concept usually entails not just knowing the meaning of the concept but also understanding the multiple relationships that connect the concept to other ideas (Tripathi, 2008, p. 439). This idea displays that mathematics must be represented in multiple modalities to allow all students, of different levels and intelligences, to succeed, in a way that lessens anxiety.

Specifically, in problem-based learning, there are forms of differentiation that are both necessary and helpful to teachers and students. Because PBL is so student orientated, it is easy for teachers to differentiate, usually in the *during* part of the lesson. Like discussed before, differentiation to take place by using multiple representations to display information. For example, a PBL lesson on quadratic equations can be shown in various ways. This lesson will cover how each coefficient in the equation affects the graph, like how having a negative in front of the x^2makes the graph open downwards. Since this a graphing lesson, it will already help those visual learners. This lesson can be done though, using various tools and strategies to meet to multiple intelligences. A great tool, especially in PBL is technology. There are so many resources out there that help students remain engaged and make math fun, like GeoGebra. Technology can ease the pressure of mathematics, causing less anxiety in the classroom. A lesson created by Dan Meyers (2010), allows students to manipulate an image of a basketball being shot into a basket. Students can discover what each coefficient does to the graph, through this software. This demonstration would again benefit visual learners. To address kinesthetic learners, a great differentiation strategy is stationed learning. This allows students to get up and move throughout the class, which can encourage excitement. For this topic, a stationed activity can have each group focusing on a specific part of the equation. This can then contain a hands-on activity where students can graph these equations, using pipe cleaners. This allows students to be engaged in various parts of the lesson. In both lessons, students can work together in groups where they discuss their findings. Group work will benefit verbal learners. In just this one lesson alone, there are various methods and strategies that teachers can use to meet the needs of all students.

Group work is another form of differentiation that can specifically assist PBL. Since students are constantly discovering concepts and knowledge, it is helpful to do this with their peers. Groups can be formed either homogeneous or heterogeneous. Homogeneous grouping is when students are grouped similarly, usually based on their level, and heterogeneous grouping would be the opposite where students are grouped from multiple different levels. Boaler (2016) encourages teachers to stray away from homogeneous grouping because students end up getting tracked and labeled. This can create and deepen a gap between those students who have a growth and fixed mindset. Boaler (2016) then adds that heterogeneous grouping promotes a growth mindset, which allows all students to feel capable of the math they are working on. I do understand her points regarding these groupings, but I do feel homogeneous groupings can as well promote a growth mindset.

In my student teaching experience, I had a class that contained a lot of struggling students. When teaching a lesson on word problems, I noticed that some of my class could still not solve two-step equations algebraically. I know that if they moved onto word problems, they would become extremely discouraged and get anxiety about how much they were struggling. This would only push students towards a fixed mindset, I was trying so hard to change. On the other hand, I had students ready to move onto word problems, who would not benefit from working on solving equations yet again. I decided to create a differentiated lesson, where I created homogenous groups based on their current level in the topic. I gave the struggling students more problems on equations, where those students who were proficient moved onto the word problems. I implemented these groups in a way that students did not know they were based on levels. Each group would eventually move up to word problems, since this was a two-day lesson, just having certain students start before others. My reasoning behind this grouping was to allow me to assist the groups who were struggling where I could again highlight important concepts and procedures. I needed to get these students caught up with the others and I felt best to do in small groups where I could do more one-on-one assistance. In doing this lesson, I was also able to push those proficient students to do challenge problems and deepen their learning on the second day. I would not have been able to reach all students to meet the standard in this lesson with heterogeneous groups. My students were able to go through this lesson, without enabling a fixed mindset by introducing them to topics they were not ready yet to cover. Homogeneous grouping can be a helpful tool in situations like this but should not be used on an everyday basis. This will then lead to what Boaler (2016) was discussing regarding tracking and labeling. The point of these groupings is to promote a safe environment where students can develop a growth mindset. If grouping is not done properly, tacking and labeling can promote Math Phobia in those struggling students. When deciding which type to use, teachers should reflect and see which one best benefit both the students' needs and growth mindset.

When implementing PBL group lessons, teachers want to continue to encourage a positive classroom culture that happens through discussion. From my experience, students enjoy working with their peers, making the topic more enjoyable. Being able to converse with others allows students to learn and grow together. This can reduce the feeling of anxiety and being alone, especially when making mistakes. When students are discussing amongst themselves, they may need structure from the teacher that gives them support to ensure they aren't straying away from the main idea. A type of differentiation that can pose useful is scaffolding. Scaffolding can be defined as “a teaching method that enables a student to solve a problem, carry out a task, or achieve a goal through a gradual shedding of outside assistance” (Pinantoan, 2013, p. 1). This method can be especially useful when students are first discovering a topic on their own. A teacher can design the lesson that contains scaffolding questions, which lead the students to discover the main point through a series of questions that get higher in difficulty. This method can also minimize the level of frustration that can take place in the learner (Pinantoan, 2013, p. 4). This frustration will be high in students with fixed mindsets and Math Phobia. If these students were just given the hardest questions, they would feel defeated and probably give up on trying to do it. With scaffolding questions, Problem-based learning can easily promote a growth mindset where all students are capable of answering higher-level questions.

Problem-based learning sets as a method that promotes a growth mindset to allow students to learn in a positive learning environment. There then comes a times where students must demonstrate their learning. It would only make sense to continue to promote a growth mindset and positive environment during assessment as well, otherwise all this hard work has gone to waste. Assessment is where math anxiety reaches a new level of intensity. This can come from a series of components mostly on how assessments are perceived. Its todays education, a lot of times assessment as seen as a punishment. This can easily be demonstrated by a teacher giving their class a pop quiz because they were misbehaving. This is an ineffective teaching strategy that can lead students to experience anxiety because they have not had proper notice of assessment. This can also be done in the form of homework. Teachers can assign loads of homework, which ends up just being busy work, that overwhelms the student. I reflect on my own educational experience and try to think of the type of assessment that caused me the most anxiety. My mind went straight to the timed multiplication tests we had in elementary school.

Those assessments directly tested my memorization skills, instead of the important concepts behind multiplication. A lot of students feel the need to memorize information because they do not grasp the concepts behind the topic that is needed on an assessment. This is their way of “getting by” to receive a decent grade on a test. A lot of times memorization seems easier than learning a topic, therefore making it a tempting option for students when preparing for assessments. Therefore, it is very important that teacher design and plan their lessons accordingly. If teachers “teach for the test”, it will be easy for students to get away with just memorizing information. The goal of assessment to get a grasp of where students are at; not to punish them or test their memorization skills. It is important for teachers to assess for learning, not a grade to ensure they are still promoting a growth mindset.

Assessment for learning is a term coined by Black and Wiliam (2002), who discovered this innovative approach towards assessment. In Boaler’s (2016) take on this idea, assessment of learning is broken down into three sections: where students are now, where students need to be, ways to close the gap. The goal of this type of assessment is to encourage and promote students to become active learners, like in the learning principal metacognition. Boaler (2016) adds “Students are given information about their flexible and growing learning pathways that contribute to their development of a growth mathematical mindset” (Boaler, 2016, p. 149). It is important that teachers give assessments that encourage students rather than discouraging them. Getting a bad grade can discourage students to have a fixed mindset towards mathematics. Once they see on paper a grade that “so-calls” reflects their knowledge of mathematics, they give up and stop believing they are capable of learning. The best method to encourage this idea of assessment for learning is to use formative assessment.

The two types of assessment are formative and summative. Formative assessment is used to monitor student learning where summative assessment is evaluating student learning (Boaler, 2016). Formative assessment usually takes form in a way that students do not feel like they are being assessed, like through Do Nows, class discussions, and Exit Tickets. Summative assessment is what you usually think of when you think of assessment in a math classroom, which is part of the problem. A lot of math teachers will only rely on summative assessments to grade and reflect students' knowledge. Summative assessment causes a lot of anxiety, especially when it is the only form of assessment. That's where formative assessment comes into play. With a combination of both assessments, a teacher a constantly monitor student progress, without giving them anxiety. Because students do not feel like they are being assessed, formative or informal assessment poses as a great tool to lessen anxiety in the classroom.

Assessment should as well be differentiated to minimize anxiety. Following the differentiation techniques discussed previously, assessment should be given in various forms and modalities to allow all students to succeed. Giving student choice during assessment gives students the opportunity to demonstrate their knowledge in a way they feel comfortable. According to Research, "Teachers can reduce this anxiety and help learners engage with—and possibly even enjoy—test-taking by giving clear directions, using prompts to support success, and providing students choices about test items" (Salend, 2011, p. 55). For example, students can create a poster, video, presentation, or graph for a project in class. It can also be as simple as a student answering 8 of the 10 questions on a test. This can reduce anxiety because students will feel more comfortable and confident in what they are doing. According to studies "Student choice makes students active participants in their educations, thereby increasing levels of engagement. Notably, researchers highlight the fact that such autonomy is generally associated with greater personal well-being and satisfaction in educational environments as well as in terms of academic performance" (Hanover Research, 2014, p. 3). Student choice is one tool that can be used to promote a growth mindset in assessment.

Continuing to follow the method of assessing to learn, a big part of learning is from your mistakes, as discussed earlier. Teachers needs to give students the opportunity to learn from their mistakes in assessment as well. According to research, "To become an integral part of the instructional process, assessment cannot be one-shot, do-or-die experience for students. Instead, assessment must be part of an ongoing effort to help students learn. And if teachers follow assessment with helpful corrective instruction, then students should have a second chance to demonstrate their new level of competence and understanding. This second chance helps determine the effectiveness of the corrective instruction and offers students another opportunity to experience success in learning" (Guskey, 2003, p. 10). Giving students the opportunity to learn from their mistakes on an assessment is a crucial part of their education, which plays a key role towards promoting a growth mindset. In my student teaching experience, students could make corrections on their Exit Ticket, one-on-one, with the teacher. In doing so, I was able to highlight important concepts and procedures and closely monitor this students' progress. This encourages students to learn from their mistakes by the time the next assessment or topic came around. Raising their grade was an incentive to get them to come but by the end, my students would understand and have a better grasp on information. As a teacher, it helped me prevent those students from slipping into the cracks of a fixed mindset. I always told my students that it didn't matter when you learn it, if you learn it in the first place. If all teachers and students have this outlook towards assessment, anxiety can be lessened because students are developing growth mindsets.

Assessment should be given often to allow teachers to closely monitor students' progress and allow students to constantly learn from their mistakes. It is important to highlight though, that this assessment should mostly be formative. Boaler (2016) makes a point that constant assessment causes anxiety so teachers should rarely assess. I disagree with the point because realistically in our education, standardized tests and regents surround us. If we never give assessments, how do we expect students to do well on or even pass these tests? Also, students will probably be more likely to develop anxiety if they are given this huge test with no practice in test taking. Personally, I know I get more anxious if there are two huge tests that count for my grades instead of a bunch of little assessment. In my student teaching experience, I constantly assessed my students, mostly formatively, where they experienced little anxiety when doing so. Although the push for no assessments might sound like an ideal situation, it is very unrealistic for how our educational system is set up. In the future, if standardized tests are eliminated, Boaler's (2016) idea could be put into full effect.

These ideas of removing testing, a fundamental part of our educational experience, proves the extent of where researchers and teachers are willing to go to eliminate Math Phobia in the classroom. This sense of anxiety causes students hate math in most of their daily lessons, especially for struggling students. As teachers, our goal is to get our students to succeed in a positive learning environment. Since the lack of success is a possible factor to cause Math Phobia, it is crucial that students are able to succeed in a classroom. I have argued that students CAN succeed through effective teaching strategies that promote a growth mindset, to stray away from the perception that they are not capable of the levels on mathematics introduced in school. Using the strategy of teaching how we learn, using the three learning principles and BDA format, problem-based learning poses as a method that alleviates this sense of anxiety in the classroom.

PBL serves as platform to promote a growth mindset through discovery, while creating a positive classroom culture through discussion. In doing so, students will understand the power of a mistake towards mathematics, especially in assessments. Encompassed in these ideas, differentiation techniques strengthen the goals and benefits of problem-based learning. My hope is for teachers to use this research to change the mindset of their own classroom to eliminate the nationwide problem: Math Phobia.

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