Focusing On Mistakes: Pragmatically Implementing Growth Mindset

Zachary Patterson, University of Calgary, Canada

Abstract: As an early career educator looking for new and innovative ways to reform educational practice, I discovered the theory of Growth Mindset. Growth Mindset research has shown that interventions focused on neuroplasticity and the malleability of intelligence can have academic and behavioural benefits in classrooms where implemented. Missing from this research are practical classroom activities that can be used regularly to continue to promote a growth mindset in students. This paper critically examines the tenets of Growth Mindset and its merits, including the importance of error culture in a classroom. Based on this exploration, a suggested series of questions for an error correction task design are given, including implications of implementation.

Keywords: growth mindset, task design, neuroscience, error correction

Introduction

As an early preservice teacher, I recall learning about and creating assignments in curriculum classes that focused on continual growth. The goal was to find ways to promote students to not just stop at the end of a unit of study, but to keep working through and continuing to develop skills and understanding. This involved significant discussion about assessment practice, and task design. As a new teacher my work in this area has continued with attempts to demonstrate that learning is about improving, not about results on one-time assessments. I am not alone in this endeavour, as it is at the heart of meaningful assessment and teaching practice (Wiliam, 2011). Eventually, I attended professional development sessions where I learned about growth mindset. In learning more I sought to make connections between the work I was doing and this theory.

Growth Mindset Theory is an academic idea that is increasing in popularity in education circles across North America. Growth Mindset interventions are universal in nature. Currently, interventions involve instruction about neuroplasticity in an attempt to change beliefs about intelligence (Boaler, 2013). Neuroplasticity is the ability of neurons (brain cells) to make new and adjust existing connections in response to various experiences (Dan, 2019). Anderson et al. (2018) indicate that the missing piece in growth mindset work are tasks that can support the mindset in the classroom. They suggest that often teachers encourage growth mindset, but there will be no follow up or no tasks that support this mindset. There are some groups such as YouCubed (youcubed.org) providing some basic free tasks for mathematics, but overall, there is a shortage (Rattan et al., 2015). If the tenets of growth mindset are understood more completely, it will be easier for teachers to design and implement growth mindset focused tasks in other subject areas.

Dweck's (2006) theories of mindset discuss individual beliefs about the malleability of intelligence (defined here as academic ability) and serve as the foundation of growth mindset. Individuals who believe that intelligence cannot be improved are said to have a 'fixed mindset.' On the other hand, those who believe in intelligence as something that can be changed and improved are said to have a 'growth mindset' (Dweck & Legget, 1988). The theory teaches learners to examine their errors in a more positive and focused way as opposed to more traditional deficiency-based perspectives (Sun, 2018).

Teachers have latched onto this idea of growth mindset, with classrooms often adorned in posters with a brain split into colourful hemispheres representing growth and fixed mindsets. Another popular image is that of a plant being watered to indicate growth. Despite a clear belief in the concept, very little is done to facilitate the mindset shift in tasks due to limited research (Rattan et al., 2015). It is important to develop a full understanding of the concept, including its limitations, if teachers wish to maximize the impact.

Another concern is a lack of diversity in growth mindset research (Seaton, 2018) with most of the research being conducted by members of the Student Experience Network (studentexperiencenetwork.org). There are a few groups that offer various forms of curricula and training for teachers, parents and students. Perhaps the most well-known is Mindset Works (mindsetworks.com) but it has costs associated with it. Educators are therefore left to pay for Mindset Works, similar programs, or come up with their own activities. When looking for Canadian literature on this topic, a close idea is that of an Innovator's Mindset (Couros, 2022). This is similar in some ways but is a unique idea which promotes learners to be creators in their educational experience. It goes beyond growth mindset to a point where students can: "...discover and create new and better ideas" (Couros, 2022, pp. 1). The ACME (Alberta Consortium for

Motivation and Emotion) lab at the University of Alberta also conducts growth mindset research (e.g., Pelletier et al, 2021).

Growth mindset theory is presented as quite simplistic. If students are taught about neuroplasticity, they will be more motivated to work to improve. Its advocates similarly suggest that educators should change the language they use around students to be more growth and effort focused. If a student is not able to grasp a concept, educators are advised to speak as though they haven't learned that 'yet.' When a student finds success, the theory indicates that students should be praised for their effort as opposed to the result, because effort is something a student can control (Dweck, 2006). This is not to suggest that effort should be assessed but should simply be encouraged as a way to improve student mindsets.

Educators would be prudent to not simply follow this theory blindly, and instead understand how it works and the value of incorporating it in classroom practice. By diving deeper and exploring how classroom culture, motivation, and error noticing all play into this notion from a neuroscientific view, teachers can meaningfully enact aspects of growth mindset theory and promote continual improvement in students. The purpose of this paper is to critically examine current growth mindset research and suggest how it can be pragmatically implemented into classroom work. There are conflicting views on this educational theory, with research showing its efficacy and other research doubting it. Both sides will be examined alongside suggestions for how to bridge this gap in line with broader classroom assessment research.

Tenets of Growth Mindset

Tenet 1: Neuroscience

There is a growing body of work that is looking at the brain areas associated with a growth mindset. When considering the neurobiological aspects of growth mindset, Myers et al. (2016) indicate that an important brain area related to this mindset is the anterior cingulate cortex (ACC). Activation of the dorsal (rear) ACC is seen in individuals with a growth mindset, and is also seen when students engage in error noticing and correcting, thus connecting these processes. In addition to this, Schroder et al. (2017) show through electroencephalogram (EEG) imaging that students with a growth mindset performed better than fixed mindset students after errors were made in academic work. Schroder et al. (2014) also were able to point out differences between growth and fixed mindset individuals by their brain activity. It was found that attention was increased in those who were in the growth condition, which is an indication of focusing on process and mastery. Those in the fixed condition were more focused on results when given a task. The growth focused individuals had an easier time when faced with a problem-solving task.

Tenet 2: Errors and Error Culture

An important part of growth mindset work is how errors in work are identified and dealt with. The idea of creating a positive error culture is not specific to growth mindset theory, but it has obvious connections. Growth mindset theory views errors in academic work as learning experiences and encourages them to be handled as such (Dweck, 2006). Heinze (2005) illustrates the importance of making errors public by noting that when errors come up in public lessons or discussions, they are more likely to be identified, dealt with, and corrected in a way that can be learned from. Van Dyck et al. (2005) describe what is known as "error culture" or the atmosphere of learning that either encourages or discourages errors and the act of learning from them. Steur et al. (2013) outline the importance of the classroom error climate and how it can impact a student's ability to react properly to mistakes. Tulis (2013) outlines that confronting errors is the best way to create that positive climate where students can productively examine them. In addition, Tulis (2013) encourages teachers to not ignore errors, but embrace them, and to not direct incorrect questions or statements to another student for answering. These behaviours discourage students from bringing forth their errors because they are not being validated properly. Finally, Tulis (2013) also outlines the importance of not allowing other students to have negative behaviour towards their classmates by laughing or taunting. Based on these observations, the developed task will be something that causes all students to evaluate their own errors, not singling out anyone individually.

When focusing on errors, Lundquist (1999) illustrates the importance of not focusing on the result, but on the process. It is important to deconstruct an error and locate the correct response, but more important is identifying patterns and other ways to illustrate and connect the ideas together. This results in more knowledge creation.

Tenet 3: Behavioural Traits

Various behaviour traits connected to growth that are related to improved academic performance. One such trait is that of mastery goal setting. Mastery goals focus on mastering processes involved in learning. The opposite of this are performance goals, which tend to focus directly on quantitative grades and result in memorization instead of process (DeBacker et al., 2018). Mastery goals have been shown to improve learning and have positive impacts on student motivation (Harackiewitz et al., 2002). Students who engage in setting these positive forms of academic goals typically have a growth mindset (DeBacker et al., 2018).

Hong et al. (1999) illustrate the importance of effort and how it was related to incremental (growth mindset) theory. They disputed the popular notion that if you had ability, you didn't need effort, and if you had to exert effort you didn't have ability. They were able to show that with a growth mindset, effort and ability together produce results. Brown (2009) shows that growth mindset helped effort and persistence in academic work, despite poverty which negatively impacts academic progression. Burnette et al. (2012) indicate that growth mindset plays an important role in student self-regulation, another important behavioural trait.

Tenet 4: Motivation and Student Belief

Dweck and Leggett (1988) made connections between motivation and mindset. They contend that if you demonstrate a growth mindset, you are motivated intrinsically to improve and do better. They suggest that this mindset makes it easier to face challenges and setbacks are not discouraging. In the case of a fixed mindset, the opposite is true, leading to defeat in the face of opposition, and a decreased desire to pursue challenges. Intrinsic motivation is the desire to learn for the sake of learning, as opposed to extrinsic motivation which uses rewards or other incentives to motivate learning. Intrinsic motivation fosters important behaviours that are valuable in the classroom (Hardre & Reeve, 2003).

Academic achievement itself is closely linked with students' intrinsic motivation (Haimovitz et al., 2011). Having a growth mindset has been shown to foster intrinsic motivation in schoolwork (Cury et al., 2006; Stipek & Gralinsky, 1996). In addition, Haimovitz et al. (2011) point to fixed mindsets as a cause for intrinsic motivation loss in students who are finishing middle school and entering high school. Another thing that could cause this decline is poor academic performance. With persistent poor performance, students lose desire to continue trying in their academic work. This breeds more struggle (Rhew et al., 2018).

Tenet 5: Academic Achievement

Blackwell et al. (2007) showed that a growth mindset intervention improved student marks. They attributed this to increased motivation that students developed after being taught about neuroplasticity. This intervention was given multiple times throughout the school year in elementary school, with the best academic improvements seen in that transition time between elementary and middle school. Good et al. (2003) performed a growth mindset intervention and observed that students' mathematics grades improved. Romero et al. (2014) illustrate that students who started grade 6 with a growth mindset had higher academic achievement at the end of the school year, as well as during grades 7 and 8.

Yeager et al. (2014) examine the transition to high school. They performed an intervention and noticed that students who had a fixed mindset saw a decrease in marks over their first year in high school. They also noted that students with a growth mindset had higher grade point averages than their classmates. An additional experimental condition examined how students who initially had a fixed mindset changed as they developed more of a growth mindset. Their grades significantly improved as they developed this mindset from intervention. Stipek and Gralinski (1996) support this idea by showing that students who had positive beliefs about their ability to use effort to improve their grades did see higher achievement overall in their grades as well as higher marks on a variety of standardized tests.

Such interventions are also scalable. Using the online PERTS intervention (Project for Education Research That Scales, 2020), Paunesku et al. (2015) were able to show that two 45-minute interventions spaced weeks apart had the ability to raise grade point averages in core classes and caused a large percentage of low achieving students to reach grade levels that are deemed acceptable (A, B or C). An additional study found academic increases with just a single intervention and mindsets changes were sustained over a period of time (DeBacker et al., 2018).

There are criticisms of this tenet. The question lies in what determines statistical versus actual significance. There have been competing studies to the ones reviewed above that challenge the findings with respect to academic achievement. Sisk et al. (2018) indicated that they could not replicate many of the academic results claimed by other intervention studies. They did however indicate that their research did support claims that academically high risk and students in poverty did see good benefit from the interventions. Despite this they did not deem the results for typical students to be statistically significant. This was corroborated by Li and Bates (2019). These studies however did look at two different groups (university undergraduates and Chinese school aged students) than the previous studies, which looked at American school aged students. This work was continued by Burgoyne et al. (2020), where they claimed no evidence to support the strong and bold claims made by growth mindset supporters. Importantly however, they indicate that there were associations between growth mindset and academic success, just nothing of true significance in their academic opinion.

Implementation

I am not here to endorse the use of a growth mindset intervention in classroom practice. It is apparent however, that having a growth mindset does have benefits to learning, beyond just what is seen in student grade performance. It is important to note however, that the implementation (intervention or just growth mindset theory) needs to come with a degree of cultural awareness. Dr. Luke Wood (as cited in Ruth & Cavanaugh, 2017) outlines that the language premise of growth mindset could be problematic. The idea that putting forth effort will ultimately lead to success downplays other factors that influence marginalized youth, particularly African-American students. Some of these youth need to be told that they are successful beyond just habits. Some African-American students will never be complimented or told that they are successful, and the language endorsed by growth mindset advocates (i.e., praising effort, not results or skill) can encourage this to continue.

In response to criticisms of the interventions, Dweck (2016) outlined that it is important to not use growth mindset to promise things that a student is not capable of achieving. There are many factors influencing a student's academic and behavioural performance. These growth mindset ideas should be used to help students realize they can always improve. The learning process is the focus, not the destination or the final achievement (Dweck, 2016).

Most recently, a large nationwide study conducted in the United States (Yeager et al., 2019) found several important academic improvements when it comes to intervention use. The first is that the interventions are much shorter and inexpensive compared to other subject specific interventions, yet they yield similar results. With lower achieving students, these interventions had a large impact on their students' grade point average. This study also found that there was a sustained grade improvement, and it persisted after the intervention was over. This was a compilation of data from many researchers spread out over the United States and provides great insight into a large-scale implementation of the interventions. In addition, these authors indicate that the intervention used was the most developed of all given previously, and this continual improvement of the intervention helped contribute to its success. This large-scale boost in low achieving students in particular is very positive, and tempers some of the criticism of the interventions.

In support of this, Kraft (2020) outlines that it does not take a very large effect size for an educational intervention to have meaningful impact. A small change in grades can mean the difference between failing a course and passing a course, and that impact cannot be overstated. Kraft also was interviewed about the effect size of growth mindset and indicated that based on the cost and the effect size, growth mindset interventions were extremely cost effective and above average impact on student achievement when compared to other interventions (Denworth, 2019). Yeager et al. (2019) also discuss how sustained belief in one's abilities is important during the middle and senior years of K-12 schooling.

It is important to take a pragmatic approach to the implementation of growth mindset in the classroom. To do this, I suggest a classroom strategy that moves away from the classification of "intervention" and encourages a teacher to utilize the beneficial aspects of growth mindset theory on a regular basis. This suggested framework is based around the positive aspects of growth mindset, including properly addressing errors in student work, to motivation and neuroscience. These ideas are grounded in assessment research to encourage students to persist in their learning and be involved as a continual learner.

Good Assessment Practice

In order to implement a growth mindset-based program into teaching practice, teachers need to break away from traditional teaching methods. More traditional views on teaching have indicated that errors should be avoided, and this mindset persists in teaching today. Ausubel (1968) indicated that allowing errors in the learning process would encourage students to practice things incorrectly and be inefficient in their work. More recent work by Stevenson and Stigler (1994) contradict this by showing that using errors as a teaching tool can accelerate and strengthen understanding, using differences between Japanese and American teaching styles to illustrate. Japanese classrooms often begin by trying to solve math problems without any instruction. This process results in errors and failed attempts at solving. Discussion and feedback surrounding errors follows. The researchers suggest that there is a gap in academic achievement tied directly to these practices, and not other confounding variables that teachers may inadvertently focus on.

Tenet 4 illustrates how motivations change and become intrinsic as students develop a growth mindset (e.g., Cury et al., 2006; Stipek & Gralinsky, 1996). Dweck and Leggett (1988) tie these two ideas together by showing how changes in mindset foster changes in motivation which feeds back to continually improve mindset. This task is a practical application of growth mindset and when practiced regularly can have positive impacts on academic success through improved motivations. This mindset involves students continuing to persevere through tasks. When they reach a certain level of understanding, they continue pursuing the topic. It is not about reaching a destination (Dweck, 2006).

This framework can be used for task design in both formative and summative assessment. In a formative way, it allows a teacher to check in and see what part of the process a student is at. Learning can be personalized, as each student will be at a different stage of understanding. In summative assessments, students can use this framework to complete corrections after the assessment is over. This notion is supported by Kemp (2021) who indicates that this ability to make test corrections is a way to get people active in their learning, whereas normally students might disengage if things do not go well. The National Research Council (2001) indicate that as students continue to examine their errors in a positive way, they will gain deeper understanding, including after summative assessments. Henderson and Harper (2009) indicate that allowing corrections creates a more positive atmosphere and gives students a chance to be continually learning and practicing concepts, even after tests are over. Traditionally, a large summative assessment such as a unit exam has been deemed the end of the learning for that unit. However, Wormeli (2011) argues the need for multiple chances on all forms of learning as it correctly models how things are done in adult life. He indicates that even tests taken for medical or law school admissions can be retaken for full credit. If students can continually work through their errors, they will understand better, and will see higher achievement. This framework causes students to examine more in-depth their mistakes and correct them in a more meaningful way than simply re-taking a test or doing basic test corrections.

Masters (2014) argues that this continual measurement of growth is essential for proper and accurate assessment. He points out that this ongoing process raises expectations, as all students can continue to engage. If a student is more advanced, they can continue their trajectory and take learning to the next level. Conversely, a struggling student can see success in meeting smaller targets. Masters (2014) points out that reporting should be based on progress. It does not define their set knowledge, as that is bound to change. Ongoing practice of growth mindset in teaching and assessment pedagogy will enforce those ideas in student learning more regularly and thus fills the gap indicated previously by Anderson et al. (2018).

Suggested Task Design

Review of Tenets

The task design below is based around the tenets of growth mindset theory described above. Table 1 presents a summary for easy reference.

Table 1

Summary of the five tenets of Growth Mindset

Tenet	*Summary*	*Key References*
1) Neuroscience	Brain areas for noticing, attention, and mastery work are active in growth mindset students.	Myers et al. (2016) Schroder et al. (2017)
2) Error Culture	It is important not to ignore errors but examine them fully.	Heinze (2005) Tulis (2013)
3) Behavioural Traits	Growth mindset causes more productive goal setting and effort in schoolwork.	Brown (2009) DeBacker et al. (2018)
4) Motivation	Growth mindset fosters intrinsic motivation, which is better for learning.	Dweck & Legget (1988) Haimovitz et al. (2011)
5) Academic Achievement	Academic achievement goes up, students believe they can improve.	Blackwell et al. (2007) Yeager et al. (2019)
	This is contested, claims of non-statistical significance are made.	Sisk et al. (2018)

Theoretical Framework

Yerushalmi and Polingher (2006) provide a theoretical framework for this task. They outline the relevance of focusing on errors and finding ways to correct errors as a foundation for creating a positive error climate in a physics classroom. They suggest two models for having students work with errors. The first is to have a teacher-created task with common errors associated with different questions that students work through and explain. The other task is to have a similar assignment but with actual student errors embedded. In both cases, students had to convince the teacher that they understood the errors and how to fix them. More often than not, however, the students were satisfied with simply replacing an incorrect answer with a correct one. The authors argue the need for teaching argumentative skills, or having the students learn how to better explain the incorrect logic and the new correct logic. This is supported by Wormeli (2011) who indicates a need for comparison between original work and the new corrected work.

Classroom Application

As previously discussed, growth mindset interventions are often inaccessible to educators. This section therefore provides a four question framework to be used in classroom activities when analyzing errors. This stems from the need to create a more error positive classroom (tenet 2) rooted in growth mindset tenets. This invites discussion about errors, where they came from and ways to proceed moving forward in a positive way. Its use so far has been primarily in a math and science context, but could be utilized across subject areas to invite exploration and growth.

Question 1 – What is the specific learning outcome in the incorrect work? By understanding the specific outcome, a student can focus more directly on the error (tenet 2). In addition, specific learning outcomes provide an opportunity to acknowledge the process to a correct answer and allow for focused effort (tenet 4, tenet 2). A student might get 80% on an assignment. Instead of studying everything in an attempt to improve, they need to study the 20% that they struggled to understand properly. The act of revising in this way can have effects on motivation as students who achieve poorly can feel like they do not understand anything (tenet 4). This can look different depending on the age group, but it should be addressed by the teacher giving feedback (tenet 2). As students know what the end goal is, they can understand the process to get there more effectively (tenet 2).

Question 2 – Why was this attempt at understanding incorrect? This addresses the idea of error noticing (tenet 1). It is also part of the process in deconstruction of errors (tenet 2). It is important to not just acknowledge that the attempt was incorrect, but to know why. Students should be allowed to say something like: “I just guessed” or “I

didn't study, so I tried my best" because it creates self-awareness. Students realize that not all errors come from a lack of ability, it could be a lack of preparation. Preparation is something that can be controlled through self-regulation (tenet 3). This also helps to clarify which point of the thought process had a breakdown (tenet 3). A student could get something mostly correct, but just have one small flaw in understanding, and correcting the process would address that.

Question 3 – What is the correct understanding and why? This is where the positive error environment and culture comes in (tenet 2). Feedback can be utilized to form correct understandings (tenet 2) and show the correct answer in a low stake environment. This question would require students to argue their point (see theoretical framework).

Question 4 – What is another way to solve this problem/remember this concept? This involves creative thinking (tenet 2) as opposed to just fact recall and memorization. This question allows students to focus on process (tenet 3) and create something new to help them deepen understanding. This creative process has been heralded by Willis (2006), as a way to form more and stronger neural connections, thus promoting mastery. An example of this in math could be solving an equation in two different ways. In science, one could write an explanation and then come up with an original diagram, cartoon, or poem that represents the information.

Closing Thoughts

Growth mindset, as a psychological concept, makes many promises to educators. Is simply having a growth mindset sufficient, however? This paper has outlined one way that growth mindset could be implemented in a classroom to promote continual learning. Despite criticism of growth mindset, new and emerging data is suggesting that a well-developed and thoroughly tested growth mindset intervention can yield meaningful results. To continually practice growth mindset in teaching practice as suggested above will amplify these results (Yeager et al., 2019). By implementing an error correction activity by using the framework suggested above, it gives students the opportunity to improve their academic standing. Improvement in this area motivates students to pursue further learning and greater improvement. In these early stages, the motivation has characteristics of intrinsic and extrinsic (reward) motivation, but through continual practice, students can see success and become more intrinsically motivated.

Students disengage from work when they continually struggle and do not see success in their academic work (Rhew et al., 2018). By helping to change student's views of their errors, and motivate them to learn from their opportunities, students can engage more fully and see more success. Here are additional suggestions that have been made for how to support this type of thinking in the classroom:

1) All students should engage in rigorous tasks (Sun, 2018). By giving everyone opportunity at the tasks, it sends the message that all are capable.
2) Encourage the multidimensionality of getting an answer (Sun, 2018). When students look for multiple and creative ways to solve a problem, they are creating stronger neural networks (Willis, 2006) which in turn develops a more mastery-based learning experience.
3) Be aware of your own mindset as an educator (Seaton, 2018). If as an educator your actions are sending messages that some students are better or smarter, then students will pick up on these right away. By giving everyone the time they need and the opportunity to complete tasks, they will see that they can have "productive struggle" (Alberta Education, 2016) and develop mastery.
4) Emphasize that the work will always be unfinished. Although I never directly said to students that they weren't done learning, I indicated in tasks that it was important to persist until an acceptable level of understanding was achieved. By pushing the idea of persistence and continual learning, students will continue to engage in learning activities and develop intrinsic motivation to seek out further understanding (Clark & Sousa, 2018).

Here I re-emphasize that the way that students look at errors is critical. It is important that students see their errors as a process, not a result. Growth mindset encourages this. Even on large summative assessments, learning can still happen, even if the teacher is moving on to new content. The conversation needs to change so that students don't view larger summative assessments as final and definitive definitions of what they know. The correction activity shows the idea that assessments are snapshots of what students know, and that they can improve in areas that they fell short.

Students can know more tomorrow, next week, and next month. They feel safe in a classroom that has a positive error culture and demonstrate improvement in academic achievement. By providing authentic opportunities such as these, students engage, are motivated, and take control of their own learning. I encourage continued discussion from scholars and practitioners in this area of growth mindset, particularly in a Canadian context, to help drive pedagogical change at all levels.

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ABOUT THE AUTHOR

Zachary Patterson is a doctoral student at the University of Calgary and a curriculum Learning Leader in the Calgary Board of Education. He obtained his Master of Education degree in Interdisciplinary Educational Research with a specific focus in neuroscience and school psychology. This article is based on his capstone project. Now in his doctoral work, he is looking at curriculum studies, specifically how to improve the teaching of scientific literacy as a way to improve public health outcomes.