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Learning to Fail: Using a Growth Mindset in the K-12 Classroom

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LEARNING TO FAIL: USING A GROWTH MINDSET IN THE K-12 CLASSROOM

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LEARNING TO FAIL

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Abstract

As more and more research is being conducted on learning, the education system is forced to change with it. The approach to creating the right space and culture, lesson planning, instructional methods, and ultimate goal for learning all need a closer look. It is not enough to simply allow students to make mistakes in the classroom. That is just the beginning. The climate needs to one in which mistakes are welcomed, and are an expected part of the learning process. The learners need to feel safe to not only make mistakes, but to use them as part of the process to grow. This review follows studies performed in different classroom environments in which students and instructors respond to errors.

Planning failure-based learning gives opportunity for learners to build problem solving skills, critical thinking, and independence - self-regulation skills. It centers around making mistakes, identifying the error, coming up with possible solutions, implementing, and reflecting on the process. The relevant research shows different methods of this, along with critical skills developed and used in the uncomfortable challenge of this learning process.

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CHAPTER I: INTRODUCTION

Learning depends so much on attitude, environment, mindset, and readiness to learn. Students' willingness to learn how to learn will depend on their first learning experiences in elementary school. This means it is on the educator to provide the right atmosphere and model. Is the growth mindset, and encouragement to make mistakes the best setting for instilling a love of learning? If so, what does that look like? This literature review will explore strategies for instructing and developing learners who can problem solve and think critically, take risks and become independent in their learning.

A review of literature related to growth mindset, setting up a positive learning environment, and demonstrating courage and value in making mistakes will provide educators with a new look on instruction, and the first weeks of the school year. The review will focus on growth mindset instruction in regards to not being afraid to fail. In addition, it will look at the effects on student achievement and classroom culture.

In this society with everything at our fingertips, the education world needs to make a shift. Educators need to develop students to be lifelong learners capable of using their resources. In order for individuals to be prepared and successful in this culture, they will need the practice of perseverance.

There are four factors that come into play when studying perfectionism and mistakes: sensitivity to mistakes, contingent self-esteem, compulsiveness, and the need for admiration. The Adaptive/Maladaptive Perfectionism Scale (AMPS) is a questionnaire used to measure these dimensions.

> Children who appear to be at most risk for self-reported emotional and behavioral difficulties, insofar as these are addressed by the PHSCS and other measures of children's emotional well being, seem similar in some ways to adults who may experience comparable difficulties. The AMPS interaction effects for boys, if replicated, require some general rethinking about the role of sensitivity to mistakes and self-esteem in interventions designed to aid self-concept. One potential implication of this study is that improving the self-esteem of boys who are self-critical or worried about making mistakes could improve their self-concept and behavior without requiring them to abandon their sensitivities and performance aspirations (Rice, Kubal, & Preusser, 2004, p. 281).

Rice et al. (2004) look closely at perfectionism with the purpose of examining how students' scores on the AMPS dimensions correlated with self-concept. They define self concept as, "relatively stable set of self-attitudes reflecting both a description and evaluation of one's own behavior and attributes" (Kubal et al., 2004, p. 281). Perhaps the most important finding in this study was that sensitivity to mistakes is related to decreased happiness and satisfaction. In fact, all aspects of self-concept were negatively affected as sensitivity to mistakes increased. Finally, there was evidence to suggest that perfectionism probably affects self-concept differently for girls and boys.

Children with fewer resources have a more difficult time, emotionally, when confronted with negative outcomes such as making mistakes. These resources have to do with culture, poverty, and readiness to learn. However, the emotional culture of the classroom can have a significant effect on such students. Students have shown to be

adaptable, especially at an early age, and respond well to a positive climate (McCaslin, 2016). "Only to the extent that the individual students are a valued part of the network, will they be more likely to feel that mistakes are important opportunities for learning" (Zander et al., 2014, p. 205).

A student with a growth mindset is a learner. Students with fixed mindsets are performers, and have little room for improvement. If educators are meant to develop self-sufficient members of society, they will have to transform fixed mindsets to growth mindsets. Teaching towards a growth mindset requires a change in thinking. Students must come to realize that intelligence is not a fixed level or destination; it can change. This sort of mindset, combined with grit to persevere through challenges, is the recipe for developing students into problem solvers and goal achievers (Hochanadel, & Finamore, 2015).

Making a change in mindsets definitely takes time, but steps can be taken, and results seen along the way. Engineering activities done in the security of the classroom environment are effective in developing that mindset of reflection and improvement (Burton, 2014).

Carol S. Dweck stresses the importance of language with young students in how we respond and encourage them. Emphasizing the process and effort over the product or outcome is key to fostering a growth mindset. This requires a conscious shift for most adults who are used to focusing on the final performance rather than the work and achievement required to reach that point. Fortunately, Dweck reassures us that, "changing people's beliefs - even the simplest beliefs - can have profound effects"

(Dweck, 2009, p. IX). In her book, *Mindset: The New Psychology of Success*, she discusses a workshop for students struggling with motivation and grades because of their fixed mindsets. Through the workshop, students are taught about how the brain works. The human brain can be thought of as a muscle that can grow, change, and become stronger as you use it for learning. While this is an excellent lesson to teach and reinforce to students, it is also applicable to educators, parents, and other adults.

Challenging students in how they think, and their process for learning can be a time intensive and difficult task. "Learning to become an innovator takes time and practice. Filling students with information doesn't teach problem-solving skills. When students are given open-ended challenges to solve, authentic learning takes place. They practice real-world skills such as collaboration, negotiation, and teamwork" (Burton, 2014, p. 85). Zerr and Zerr (2011) made a point to use strategies to teach students to become critical thinkers and problem solvers. Though they applied their techniques to mathematical proofs, one of their goals was to have them be content independent. Using a layered peer review strategy, they found that students were much more likely to revise their work.

> "Taken as a whole, our results suggest that the overall structure of collaborative relations in the classroom as well as students' embeddedness in this structure, can have a decisive impact upon the affective and partly the cognitive dimension of students' handling of mistakes in educational settings. Recognizing the different ways in which these two independent dimensions of handling of mistakes vary

depending on collaborative networks is crucial when considering the design of interventions to facilitate positive learning processes." (Zander, 2014, p. 220)

Peer review strategies give the students more ownership of their learning. In opposition to a passive approach in which the student hands in completed work to the instructor and leaves it in his or her hands, peer reviewing requires the learner to be active. Variations of this strategy can be used across curriculums and content areas to help achieve learning goals. Both the writer of the original work and the reviewer benefit. Beyond meeting the goals related to the specific content, other transferable life skills can be cultivated. These skills include, but are not limited to, critical thinking, evaluating, actively reading, synthesizing, and understanding the purpose for reading. Upon interacting with classmates, students are also learning how to effectively communicate, collaborate, and give meaningful feedback. Peer reviewing provides several opportunities to reconsider and adjust upon original thinking. Students are able to learn from their own mistakes as well as others. If implemented well, this creates a healthy atmosphere for learning and encouraging a growth mindset.

Research has shown the most positive results of this when response sheets are included. These apply to the author and the reviewer. The purpose of this added component is to facilitate and foster higher order thinking. Harper and Henderson (2009) discuss the importance of metacognition, defined as, "an ability to think about one's own thinking and monitor one's current level of understanding is essential for learning" (Harper & Henderson, 2009, p. 583). Questions or elements to guide metacognition

using response sheets should focus on diagnosing errors and mistakes, and providing a general reflection that goes beyond the specific item to explain and display new learning.

There are a few things to consider when incorporating peer review into your classroom. It does require more time to go through the full process. It also is heavily dependent on students' participation and effort. Finally, peer reviewing puts more on the teacher in regards to grading.

Burggraf, Vriesema, and McCaslin (2016) performed a study to address the ways in which students are affected by and deal with making mistakes in the classroom environment. They found that emotions generated in order to cope with the experience were dependent upon the context of whole group, small group, or private atmospheres. Perhaps the most important and encouraging finding was that while students tend to develop characteristic adaptations to classroom expectations and personal performance, those emotions are also malleable and open to intervention.

Research Questions

How does making mistakes and valuing failure affect learning? Accepting errors and failure during the learning experience is key to making growth. Students need to be stretched and challenged in their thinking to the point of failure in order to analyze and reformat incorrect ideas. How does a growth mindset environment affect student achievement and classroom culture? A growth mindset is necessary for failure-based classrooms to work. Without it, learning through making mistakes will be met with resistance. Finally, what strategies are necessary in order to develop problem solvers and independent, critical thinkers? Several models and instructional strategies can aid and

reinforce this development. Certain self-regulation skills and interventions must be used alongside teacher direction to be successful.

CHAPTER II: LITERATURE REVIEW

The literature used in this thesis was gathered with Teacher Reference Center, Primary Search, Academic Search Premier, ERIC, and EBSCO MegaFILE, and narrowed down to view only peer-reviewed journals addressing the research questions and topics. Publications used for this review are from 1989 to 2017, and focused mainly on mathematics and classroom management. Key words used included, "mistakes in learning," "failing to learn," "error-based learning," and "valuing mistakes in the classroom." This chapter is a review of the literature based on the guiding questions.

Making Mistakes to Learn

There are four factors that come into play when studying perfectionism and mistakes: sensitivity to mistakes, contingent self-esteem, compulsiveness, and need for admiration. The Adaptive/Maladaptive Perfectionism Scale (AMPS) is a questionnaire used to measure these dimensions. Young learners showing risk for self-reported emotional and behavioral struggles appear similar to adults with analogous difficulties. The AMPS failed to consider sensitivity to mistakes and self-esteem for that of boys when measuring self-concept. This gives rise to the possibility that if self-critical boys' self-esteem improves, their self-concept and behavior could also improve (Rice, Kubal, & Preusser, 2004).

Children with fewer resources have a more difficult time, emotionally, when confronted with negative outcomes such as making mistakes. These resources have to do with culture, poverty, and readiness to learn. However, the emotional culture of the classroom can have a significant effect on such students. Students have shown to be

adaptable, especially at an early age, and respond well to a positive climate (McCaslin, 2016). "Only to the extent that the individual students are a valued part of the network, will they be more likely to feel that mistakes are important opportunities for learning" (Zander et al., 2014, p. 205).

Growth Mindset and Classroom Culture

Making a change in mindsets definitely takes time, but steps can be taken, and results seen along the way. Engineering activities done in the security of the classroom environment are effective in developing that mindset of reflection and improvement (Burton, 2014).

When students are stuck in a fixed mindset and unwilling to consider a different process for learning, they are trapped in a sense of permanence without even realizing it. Hochanadel and Finamore describe a fixed mindset as an anchor, learned helplessness, giving up, and unable to see change or ability to learn. There is a belief held that "intelligence is simply an inborn trait" (Hochanadel & Finamore, 2015, p. 48). This is a concrete view and belief that people are either intelligent or not. It is so prevalent that students have come to use it as an excuse for poor work or avoidance. "I can't do it. I'm not smart." Until a student is able to change their mindset, no teaching strategy or tool will have a lasting effect on their learning.

In stark opposition to the black and white view of the fixed mindset, Carol Dweck (2010) describes "individuals with a growth mindset believe that they can develop their intelligence over time" (Hochanadel & Finamore, 2015, p. 48). This is key to learning and being challenged. Some of the words used to describe a growth mindset include

perseverance, grit, resilience, and tenacity. As students begin to accept the growth mindset, more and more possibilities open up. They become more willing to try something new, be stretched, and question on their own.

Beyond encouraging students to embrace the growth mindset, it is essential for educators and parents to learn alongside them. Students, especially younger children, observe the patterns, routines, language, and habits of the adults in their lives. They take their cue from them. If the adult is unwilling to change and accept a growth mindset over a fixed belief, it is extremely difficult for the child to adopt such an idea. Educators must have the same expectations of themselves as they do for their students when it comes to the learning process. The focus of the class should be on *how* to learn, not *what* to learn. The result will be setting and achieving long-term goals, and an attitude of lifelong learning.

Carol S. Dweck (2009) is a forerunner when it comes to growth mindset. She admits that it is a difficult, ongoing battle of the mind as it is easy to get sucked back into the old way of thinking. It takes constant practice to evaluate how the mind is processing and interpreting information. Rather than jumping to a conclusion that one is a certain way because of a small instance or piece of information, the growth mindset way of processing evaluates several pieces of evidence over time to draw a reasonable response. Instead of a definitive conclusion, one should analyze evidence to act constructively. How can I improve next time? What can I change moving forward? Self talk is crucial in developing and maintaining a growth mindset. One must challenge their thinking. The contrast involves destination vs. journey, product vs. process, winning vs. improving,

completion vs. effort. Risk is involved in pursuing a change from a fixed to a growth mindset. Is it worth it?

Duckworth, Peterson, Matthews, and Kelly (2007) consider mindset and achievement when they set out to determine the key to success. They acknowledge that IQ plays a part, but there is clearly more to it than that. They discovered a trait they call grit. "We define grit as perseverance and passion for long-term goals" (Duckworth et al., 2007, p. 1087). They argue that, not only is grit important, but it is crucial in high achievement. Six studies were completed to test their theory on grit and the factors that play into it. Education level was considered with the help of two adult samples (N = 1,545 and N = 690). Grade point average was weighed with Ivy League undergraduates (N = 138), retention of two classes from the United States Military Academy, West Point, cadets (N = 1,218 and N = 1,308). Finally, the National Spelling Bee (N = 175) rounded out the six studies.

Table 1: Summary of Major Findings

Sample	Study design	Success measure	% variance in success explained by grit	*r* between grit and IQ
Study 1: Adults aged 25 and older	Cross-sectional	Educational attainment	4.8[a***]	
Study 2: Adults aged 25 and older	Cross-sectional	Educational attainment	4.8[a***]	
Study 3: Ivy League undergraduates	Cross-sectional	Grade point average	6.3[**]	-.20[b*]
Study 4: West Point cadets Class of 2008	Longitudinal (3 months)	Retention	3.9[c***]	-.05[b*]
Study 5: West Point cadets Class of 2010	Longitudinal (3 months)	Retention	1.4[c*]	-.08[b**]
Study 6: National Spelling Bee finalists	Longitudinal (1 month)	Final round	3.8[a,c*]	.02

Note. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.
[a] Controlling for age. [b] IQ measured by SAT score [c] Percentage of variance estimated using Nagelkerke R^2.

The first task to test this theory, is to develop a scale to measure grit. Analyzing and pulling from several different scales measuring perseverance, passion, ambition, and tenacity, they created the Grit Scale.

Table 2: Common Factor Analysis of Grit Scale with Promax Rotation

Factor and Grit Scale item	Promax loading	Item-total *r*
Consistency of Interests		
I often set a goal but later choose to pursue a different one.[a]	.61	.51
New ideas and new projects sometimes distract me from previous ones.[a]	.77	.54
I become interested in new pursuits every few months.[a]	.73	.59
My interests change from year to year.[a]	.69	.51
I have been obsessed with a certain idea or project for a short time but later lost interest.[a]	.66	.44
I have difficulty maintaining my focus on projects that take more than a few months to complete.[a]	.47	.62
Perseverance of Effort		
I have achieved a goal that took years of work.	.65	.62
I have overcome setbacks to conquer an important challenge.	.68	.53
I finish whatever I begin.	.54	.68
Setbacks don't discourage me.	.58	.59
I am a hard worker.	.44	.70
I am diligent.	.64	.82

Note. The last column displays the corrected item-total correlations for each item with its respective factor (i.e., either Consistency of Interests or Perseverance of Work).
[a] Item was reversed scored.

As shown in the figure, the scale measures both consistency of interests and perseverance of effort. The self-reported survey is based on a 5-point scale ranging from 1= not at all like me to 5= very much like me.

According to Duckworth et al. (2007), once the Grit Scale was tested and proved to be a valid measure, the team began hypothesizing and testing individuals with a wide

variety of educational experience, careers, ages, and personalities. Data showed that people with higher levels of education showed more grit, as did older individuals, suggesting that grit increases with age. Those surveyed who had not changed careers displayed more grit than opposing individuals. Finally, grit proved to be a better predictor of success than the Big Five Conscientiousness (conscientiousness, extraversion, neuroticism, agreeableness, and openness to experience) (Goldberg, 1990; John & Srivastava, 1999; McCrae & Costa, 1987; Tupes & Christal, 1992).

Problem Solvers, Critical Thinkers, Independent Learners

Research has shown that middle school students in particular lack learning strategies and self-regulation required to be successful. The problem is not just not knowing the strategies. These students must learn how to utilize them effectively. Clearly and Zimmerman (2004) promote educating middle school students in this area so they become self motivated learners. "There is a large body of research showing that students who have been trained in self-regulation processes during learning such as goal setting, self-monitoring, and self-reflection processes display high levels of motivation and achievement" (Cleary & Zimmerman, 2004, p. 539).

Cleary and Zimmerman (2004) discuss a school model for the middle school called Self-Regulation Empowerment Program. It consists of two major pieces: diagnostic assessment and developing the self-regulated learner. Diagnosing a student includes gathering information on his or her learning styles, motivation, and use of regulation strategies.

Table 3: Assessment Specificity Guide Used During Diagnostic Assessment Component

Level of Specificity	Assessment Question	Assessment Procedures
Class	In which class(es) does the student struggle?	Review report cards, teacher interviews
Grading Criteria	On which grading criteria in that class does the student perform poorly?	Review tests/quizzes/lab reports, teacher interview
Strategy	Which study and self-regulation strategies does the student use to perform well in that class?	Retrospective self-reports, structured interview, study material review
Microanalytic	How does the student select, use, and regulate specific strategies to perform specific tasks within that particular class?	Think alouds, microanalytic assessment procedures

The second aspect of the Self-Regulation Empowerment Program (SREP) is developing the learner based on diagnostic assessments. There are three steps to this procedure. They are laid out in the figure below.

Table 4: Goals and Intervention Procedures Used in Self-Regulated Learner Development Component

Intervention Steps	Goal of Intervention Steps	Interventions
Empowerment	To enhance student perceptions of control over academic performance and learning processes	Self-monitoring forms, graphing procedures
Study/Learning Strategies	To teach the student various study/learning strategies and self-regulation strategies	Cognitive modeling, cognitive coaching, guided practice
Cyclical Feedback Loop	To teach the student how to use forethought, performance control, and self-reflection phase processes in a cyclical manner	Self-regulation graph, cognitive modeling, cognitive coaching

A case study was conducted to test the effectiveness of the program. Researchers followed the progress of a 12-year-old Caucasian girl named Anna. She began her education in a mainstream setting. Upon reviewing her lack of achievement, she was recommended for the SREP for support with word attack skills and weak computational skills. Anna participated in eight 35 minute sessions of one-on-one training in self-regulation cycles. Upon the completion of these sessions, Anna received a score of

90 on her science test. Her success was attributed to the practice of her new study strategies.

While no formal experiments or studies have been conducted on the effectiveness of SREP middle or high schools, information gathered have shown positive results for students and within the school. "Empowering students to become more self-directed learners and helping teachers and parents further develop these skills in their children can significantly increase students' motivation and achievement in school" (Cleary & Zimmerman, 2004, p. 549).

More and more it is becoming clear how important it is for students of all ages to become problem-solvers and critical thinkers. Motivation is highly influential in obtaining these skills. A study was done by Cudney and Ezzell (2017) to test teaching methods and how they affect motivation for undergraduate engineering students. A survey was conducted at the start of the semester to assess student motivation. A second survey was conducted upon the completion of the class. Six teaching methods were used in the class: traditional face-to-face methods, TED-ED videos, Quizlet, Scoop.It, group project, and homework assignments.

Upon the completion of the Quality course, positive results were revealed as they pertain to student motivation. Students reported to be more motivated to learn the content for the value of the content itself, not just for a grade. They also reported feeling more prepared to graduate, indicating the teaching methods increased confidence in the content material. Cudney and Ezzell (2017) acknowledge some limitations to the study. They lacked a control group, and provide some suggestions to improve teaching

instruction. More self-directed learning, challenges, and hands-on activities would improve the methods already used.

Challenging students in how they think, and their process for learning can be a time intensive and difficult task. "Learning to become an innovator takes time and practice. Filling students with information doesn't teach problem-solving skills. When students are given open-ended challenges to solve, authentic learning takes place. They practice real-world skills such as collaboration, negotiation, and teamwork" (Burton, 2014, p. 85) Zerr and Zerr (2011) made a point to use strategies to teach students to become critical thinkers and problem solvers. Though they applied their techniques to mathematical proofs, one of their goals was to have them be content independent. Using a layered peer review strategy, they found that students were much more likely to revise their work.

> Taken as a whole, our results suggest that the overall structure of collaborative relations in the classroom as well as students' embeddedness in this structure, can have a decisive impact upon the affective and partly the cognitive dimension of students' handling of mistakes in educational settings. Recognizing the different ways in which these two independent dimensions of handling of mistakes vary depending on collaborative networks is crucial when considering the design of interventions to facilitate positive learning processes (Zander et al., 2014, p. 220).

More and more educators have found value in adding quiz or test corrections to their class as a learning tool. Charles Henderson of Western Michigan University and Kathleen A. Harper of The Ohio State University and Denison University share their

experiences and results in this area. These professors noticed that their college students paid little to no attention to the graded assessments that were returned to them. They would glance at the grade, never to look at it again. This is not the response instructors hope for when they desire their students to understand and use the material. This has been a pattern in education as we push to teach more and more content, sacrificing time to reteach. Henderson and Harper (2009) set out to change course.

Both physics professors set out to create an assignment that puts learning back on the student. These assignments have been changed and modified through trial and error. Correcting an assessment is an assignment meant to encourage students to go back and review their work. Students must first diagnose the problem, correct the error, and most importantly, reflect on why the mistake was made. Henderson especially found great value in requiring a general statement or analysis of the mistake beyond the specific problem.

Henderson and Harper (2009) receive positive feedback from their students on this method of learning. Students verbalize and highly rate quiz corrections as extremely helpful to their learning. The table below shows results on nationally normed evaluations of physics concepts, comparing Henderson and Harper's quiz correction classes to a university teaching the same class without quiz correction.

Table 5: CSEM scores for pilot quiz correction courses (students who took both pre- and post-CSEM).

	W04 (OSU)	F04 (WMU)	W05 (OSU)	F06 (WMU)	Comparison University Data ("traditional" courses)
	$N = 194$	$N = 46$	$N = 210$	$N = 107$	
CSEM Pre	$33.8 \pm 1.0\%$	$32.0 \pm 1.5\%$	$33.2 \pm 1.2\%$	$28.2 \pm 1.0\%$	$31 \pm 0.3\%$ (national sample[10])
CSEM Post	$71.0 \pm 1.1\%$	$64.2 \pm 2.1\%$	$70.2 \pm 1.1\%$	$61.7 \pm 1.4\%$	$47 \pm 0.5\%$ (national sample[10])
<g>	<g> = 0.56	<g> = 0.46	<g> = 0.55	<g> = 0.47	<g> = 0.23 (national sample[10]) <g> = 0.15 (NCSU[13])

Overall, through classroom and office observation, course evaluations, and exam scores, Henderson and Harper found quiz corrections to benefit both students and the instructor. Students appeared to take more ownership in their learning, resulting in a better conceptual understanding of the content, and improved reflection and monitoring skills. The process allowed the teacher to use time more effectively to guide students, and gauge their understanding. In each of the courses using quiz corrections, the professors noticed a positive difference in the classroom atmosphere, and student relations.

Failing to Learn

Andrew A. Tawfik, Hui Rong, and Ikseon Choi (2015) discuss the rationale behind failure-based learning. They admit that strategies for incorporating this into the classroom with the most success is still being researched. Tawfik et al. (2015) review the importance of experience in learning. They emphasize that both failure and success are necessary in the experiences in order to keep students engaged. The idea behind this method is that students will use their experiences of smaller failures, recoveries, and

successes to reach a solution, and through analogical transfer, apply the new knowledge to a new problem.

Different theories on failing to learn stress the importance of the uncertainty stage in the internal processing cycle, which likely leads to failure. From here, the student can begin the inquiry process of questioning, brainstorming possible causes for the collapse, hypothesize, and justify their reasoning with evidence. Piaget's theory of cognitive development follows this train of thought. He emphasizes the importance micro-failures to "disrupt current cognitive equilibration and lead to disequilibrium, re-equilibration, and finally a reestablished state of equilibrium" (Tawfik et al., 2015, p. 977). Other theories that support this line of thinking include the VanLehn (1988) impasse-driven learning theory, Kapur's (2008) productive failure, the failure-driven memory in case-based reasoning (Schmidt & Rikers 2007), and negative knowledge in workplace learning (Garmeier et al., 2008, 2010).

Table 6: Comparison of failure theories and cognitive processes

Overall process of failure	Piaget's cognitive disequilibrium	Impasse-driven learning	Productive failure	Failure-driven memory	Negative knowledge
Contexts where theory is developed	<----------	K-12 education	---------->	Experiential/workplace learning	
Experienced failure	Disequilibrium	Impasse	Failure	Failure	Failure
Challenge existing mental model	Challenge to existing schema	Challenge to existing cognitive system	Challenge to existing mental model	Script deviation	Challenge to existing mental model
Inquiry into causality breakdown/solution generation	Inquiry to reestablish equilibrium	Inquiry to resolve impasse	Generation of solution; Consolidation of Solutions	Additional indices generated to describe failure experience	Inquiry to use knowledge of experience for future problem-solving
Expanded mental model	Accommodation /equilibrium	Restructured cognitive system; New subprocedure generated that describes sequence of actions needed to resolve impasse	Updated mental model; Supporting analogical transfer	Updated scripts; Allow for future retrieval of experiences	Updated mental models; Increased certainty of action; Increased efficiency of action; Reflection

(Tawfik et al., 2015, p. 978)

Each of these theories describe a learning process that cycles through problem solving. Defining the problem is essential for the learner so that it is clear if and when an impasse or failure occurs. The following step is just as important to the process. One must be willing to challenge their existing mental model and consider something new. These initial steps propel the failure-based problem-solving process forward.

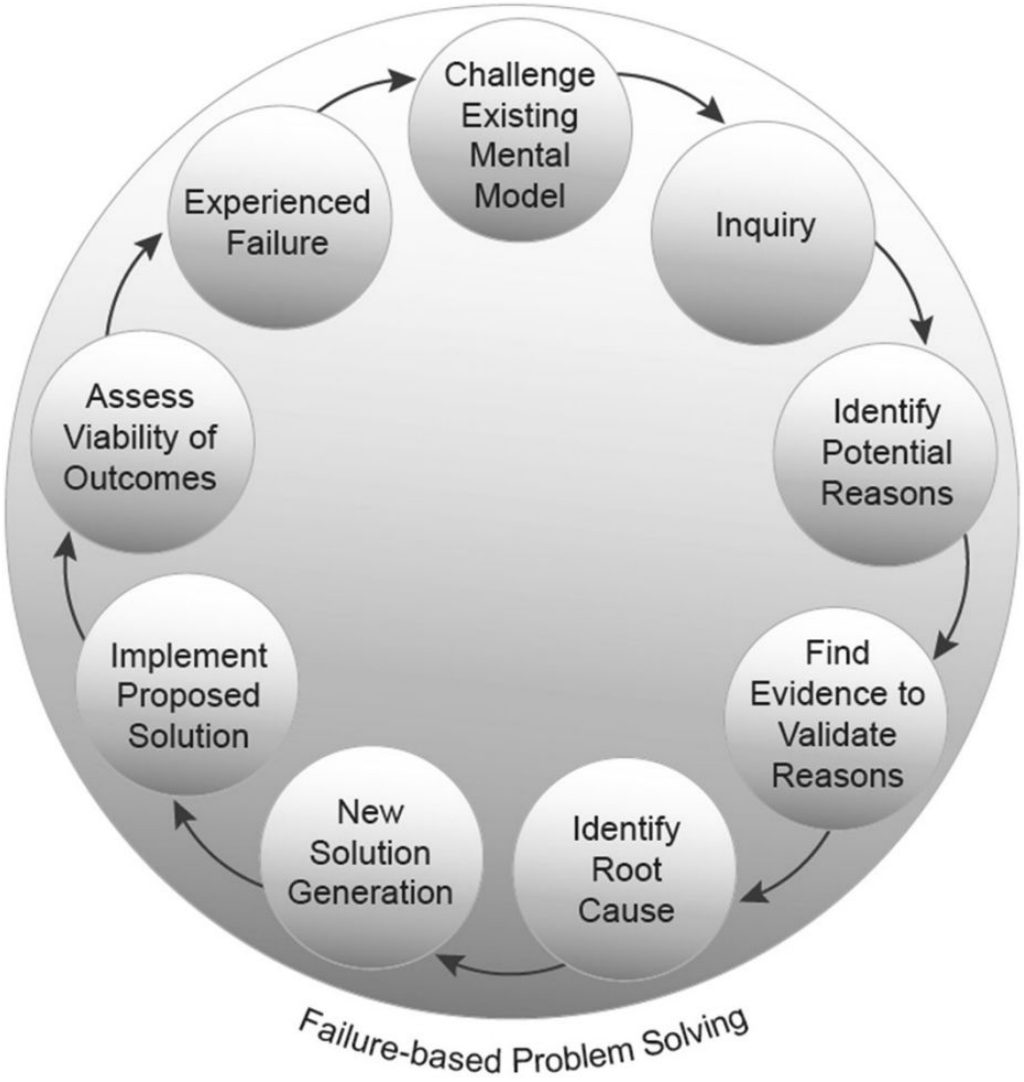


Table 7: Failure-based problem solving

Tawfik et al. (2015) suggest a model of failure to be used in a learning environment. Their design is comprised of four broad guidelines: allow learners to identify failure, design learning environments to intentionally encounter failure, support inquiry into failure for analogical transfer, and support solution generation to resolve failures.

In the first guideline, students must agree upon what failure looks like, and how it affects the learning. Without understanding the parameters of failure, students are unable

to identify whether or not they have reached the learning objective. This first step in the design sets the tone. Social discussion, disagreements, and redefining among the group is essential for understanding and learning.

Intentionally designing a learning setting to encounter failure seems counterintuitive. Tawfik et al. (2015) suggest that delaying support for learners, most likely causing them to fail, increases inquiry and leads to deeper learning by rethinking. Students must also be able to recognize micro-failures before getting too far. Providing question prompts allows learners to monitor progress. These questions encourage and reinforce the need to cycle back to the first guideline of defining failure. Another option for this type of design is to require a causal model that will fail. This brings in decision-making skills, and obligates the learner to create a hypothesis for such a scenario, resulting in the activation of problem solving skills.

Tawfik et al. (2015) emphasize that during the third guideline for the learning systems, design, reflection, justification, and introspection are key. Identifying the failure context and the systematic failure is necessary for transferring the learning. This step in the model is designed to prevent oversimplification in learning. While the goal is for students to apply their learning to other scenarios, generalizing and oversimplifying the outcome can result in misconceptions. Learners reflect on and evaluate the variables and conditions. The learning system must be flexible to allow parameters to change and find new results.

The final guideline is to solidify a solution. In order for this to take place, the learner should review micro-failures to address the breakdown. Examining and

considering the source or cause of the failure will ultimately provide clarification to resolve any misconceptions. Implementing time and opportunities to discuss and reexamine failures and solutions within the learning environment only strengthens the overall objective.

Tawfik et al. (2015) acknowledge that further research needs to be done on the subject of failure-based learning. They conclude that more investigation is needed on a number of factors when it comes to failure. The degree of the failure as well as the type and complexity is a huge variable. Also, not enough research has been completed on the timing of introducing failure in order to have the best impact. Finally, so much depends on the learner in regards to their prior knowledge, and their emotions.

Tulis, Steuer, and Dresel (2016) propose a model related to the *learning from errors* phenomenon. They recognize that this is a powerful tool, stating, "Reaching impasses and clarifying errors turned out to have stronger effects on effective learning than when a tutor modelled the correct action (Tulis et al., 2016, p. 14). They acknowledge that errors provide an opportunity to learn, but metacognitive support and motivational processes must be present. Their model takes into consideration the self-regulation process that results from making errors.

Tulis et al. (2016) give credit to the research that has already been completed on this topic. However, theoretical models addressing different perspectives are lacking. These perspectives involve how the individual deals with errors, and include appraisal theory, achievement goal theory, attribution theory, volition theory, and organisational psychology. Individual reactions to this sort of learning process must also be integrated

and taken into account. The figure below gives a visual representation of the Tulis et al. (2016) process model.

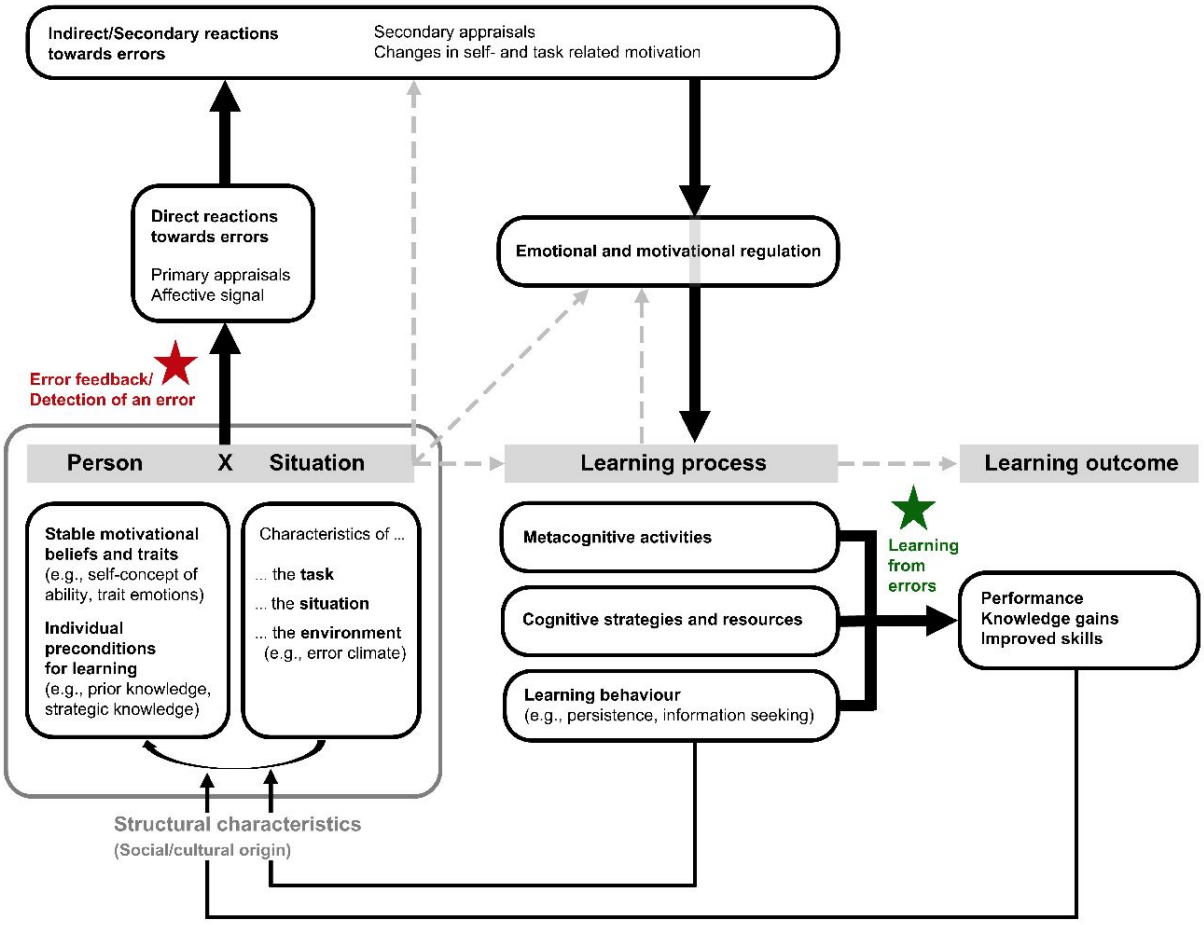


Table 8: Process model of individual reactions to and learning from errors

Immediately following the detection of an error are primary appraisals such as surprise, frustration, anger, boredom. Secondary reactions depend on the type of error that has occurred, along with its degree. From there, emotional and motivational regulation processes are triggered, either positively or negatively. Depending on the characteristics of the task, learning context, and error climate, a variety of responses can occur. The tendency of the individual to over-think the value of the task, utilize social resources, or

employ self talk will encourage them to persist through the obstacle. Concern for well-being by working to avoid a threat to self-worth is also a natural response. Distraction, repression, and rumination are possible negative results during emotional and motivational regulation. This stage becomes the pivotal point for ultimate success or failure of the task.

In the first study that accompanies the model, Tulis et al. (2016) analyzed 614 students identified as "more stable motivational orientations...and emotional/motivational reactions following errors" (p. 20). The researchers tested three components of adaptation to error: cognitive, affective, and behavioral. Results confirmed that students viewed errors as learning opportunities even though they faced setbacks. Students were still able to persist and remain engaged. Researchers also found "domain-specificity" for the cognitive, affective, and behavioral components. Students did not react the same to each domain or subject area tested. This reinforces the notion that so much depends on the individual learner.

The second study (Tulis & Dresel, 2013) looked at motivational changes and strategies. Findings showed a wide variety of strategies used including social resources, proximal goal setting, mastery self-talk, and self consequating among the adaptive strategies. Maladaptive methods included rumination and suppression. An interesting development came out of Study 2 that is worth noting. Data was collected at two separate intervals. In Study 2a, interviews were conducted immediately following the learning session. Students were asked to recall the error process. Study 2b had students

self-report during the learning experience directly following error feedback. Motivation for the task was markedly lower in Study 2b than in that of 2a.

The third and final study by Steuer, Rosentritt-Brunn and Dresel (2013) was comprised of 1,116 sixth and seventh grade students. Through the use of questionnaires, evidence was given for eight different elements of error climate, and their influence on how students deal with errors. This provided confirmation that error climate is paramount to the learning experience.

The model proposed by Tulis et al. (2016) "provides a more complete understanding of the motivational processes following errors" (Tulis et al. 2016, p. 21). It expands current theories of self-regulated learning, analyzes motivational processes, and takes personal, contextual, and situational conditions into account. Suggestions for further and more refined research are provided. It is suggested to "differentiate between strategies learners *tend* to use to regulate their motivation during learning (e.g. assess with questionnaires) and the actual strategy learners use" (Tulis et al. 2016, p. 22).

Classroom Climate

Altermatt and Broady (2009) set out to study how peers contribute to the effect of failure and learning. Two hundred and thirty-two fourth- through sixth-grade students were observed having conversations with friends following some sort of failure in class. Researchers looked for statements made by students with friends involving the task such as off-task talk, negative self-evaluations, seeking help, and giving help. Hypotheses were made that gender, and relative performance of friends would be important variables. This study is related to those that have shown the positive effects of choosing friends who

do well in school and have strong friendship qualities. Altermatt and Broady (2009) wanted to know more about how motivation is influenced, and its long-term effects, as well as if and how peers impact learned helplessness.

The study was conducted in a one-hour laboratory setting in which two friends were put in separate rooms to solve puzzles involving geometric shapes. Fifty-eight focal children were a given friend-success situation in which the focal student was given unsolvable puzzles while his or her friend was given solvable puzzles. Fifty-eight other focal children were given a friend-failure situation where both students received four unsolvable puzzles. Following the task, the friends were encouraged to discuss the task however they wished. They were also told they did not have to discuss it if they choose. Seven minutes of videotaped discussion was allotted before returning to their separate rooms to complete another set of puzzles in which they were successful. The final portion of the procedure involved having both children fill out questionnaires to gain a better understanding of their responses to failure.

Coders evaluated statements by both the focal child and the friend. Statement types ranged from discounting to direct comparison, expectancy to performance, self-evaluative and task. Positive and negative statements were coded as well as off-task statements.

Table 9: Statement Types and Examples

Statement Type	Kappa	Examples
On-task evaluative statements		
Discounting	.86	"It doesn't matter."
Direct comparison statements (failure)	.71	"We both did really bad."

Direct comparison statements (positive)	.80	"That's because I'm better at puzzles (than you)."
Direct comparison statements (negative)	.86	"(Your) one is a lot better than (my) zero."
Expectancy statements (positive)	.61	"I was like, I'm going to do this."
Expectancy statements (negative)	.91	"So, I was like, I'm going to get it wrong anyways."
Help seeking	.81	"How do you do the diamond?"
Help giving	.86	"What you were supposed to do is go back…"
Performance checks	.97	"How many puzzles did you solve?"
Performance statements (positive)	.93	"I got all of them."
Performance statements (negative)	.93	"I got zero out of four."
Other-evaluative statements (positive)	.84	"I thought you would get them all."
Other-evaluative statements (negative)	.78	"You didn't know how to do the diamond?!"
Self-evaluative statements (positive)	.76	"I'm good at puzzles."
Self-evaluative statements (negative)	.82	"I'm really bad at solving puzzles."
Task statements (easy)	.99	"The diamond was the easiest one."
Task statements (difficult)	.95	"The puzzles are too hard."
Task statements (positive)	.93	"Actually, I kind of liked it."
Task statements (negative)	.86	"I hate these kind of puzzles."
On-task nonevaluative statements	.90	"There was one minute for each puzzle right?"
Off-task statements	.95	"I'm still trying to think what I should get for your birthday."

Participants finished 11 Likert-scale statements ranging 1 to 5 for post-failure and post-discussion. Focal students fell into a wide range of adaptive and maladaptive

responses to failure. When considering the gender variable, results showed that girls had more learned helpless responses than boys. Discussions between male friends focused more on directly asking about each other's performance more than female conversations. The time variable also showed a difference. Participants showed more learned helpless reactions post-failure than post-discussion. The Altermatt and Broady (2009) study showed a variation of discussions according to the performance of their friend. Elementary school children participate in social comparison in order to gauge and evaluate their status and direct future behavior. Notable results were discovered in regards to asking for help. Seeking help has proven to be more effective than disengaged coping strategies such as cognitive avoidance. When negative or dismissive statements were made, the friend tended to mirror the emotion, focusing on the negative feelings as opposed to focusing on the problem. So while children benefit from receiving help, friends were far less likely to offer help to each other once a dismissive or negative comment was made.

Altermatt and Broady (2009) recommend future efforts to be made in other environments such as the classroom. This brings in many more factors and conversations. They are interested in how results would be affected by other children who are not friends, but belong to the same classroom environment. The most important information to be gleaned from this study is that children benefit from social support when faced with coping with failure.

Some students, however, avoid asking for help. Ryan, Gheen, and Midgley (1998) examine academic efficacy, teachers' roles, and the goal structure of the

classroom to understand why students avoid seeking help. Because help seeking is so important for self-regulation, it deserves a closer look. Ryan et al. (1998) focused on the cognitive and social pieces of this strategy. They reasoned that students' perceptions play a major role in their thinking, emotions, and behavior. Therefore, classroom climate and teacher affect come into play.

For the experiment, the researchers recruited 516 sixth graders across 63 math classes in three separate school districts. The number of students participating in each class ranged from 4 to 21 with 8 being the average. Data was collected through surveys formatted with a 5-point scale.

Classrooms with a goal structure resulted in a lower level of help avoidance. Classes with relative-ability structures resulted in an atmosphere of competition and a higher level of help avoidance. Academic self-efficacy turned out not to relate to help seeking. It varied across mathematics classes. Finally, there did prove to be a correlation between teacher affect and the likelihood that students would ask for help. When students perceived their teacher to be supportive and caring, they seemed to feel a sense of trust and safety to ask for help. Ultimately, "the social climate of the classroom is important in understanding students' help-seeking behavior. Positive relationships that encompass both academic and social concerns are likely to support students' efforts to seek aid when it is needed" (Ryan et al., 1998, p. 534).

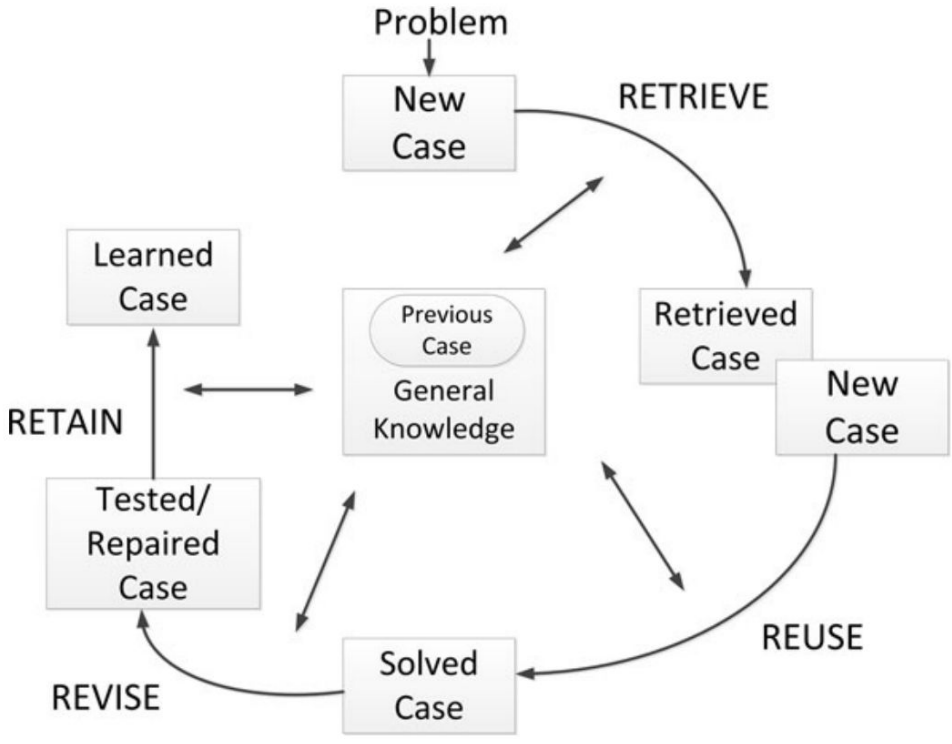
Problem-Solving

Problem solving is yet another strategy and higher order thinking practice that fosters learning and independence. Tawfik and Jonassen (2013) examine successful

cases and failure-based cases in regards to making decisions. Argumentation and causal reasoning or two aspects of problem solving that prove to be difficult for learners to transfer to new tasks. The issue with fostering an environment for problem-solving, is that there is such a huge variety of problems. How do educators prepare students for such a world? Then the question becomes, what form of problems do you present? Presenting successful, well-structured problems provide learners with an example of best practice. However, ill-structured problems give insight to obstacles students did not anticipate, and more closely mirror daily life.

Case-based reasoning refers to complex problems in all kinds of different contexts. Each case or problem is unique and dependent upon an infinite number of possible factors and perspectives. Learning how to solve these problems requires experience and practice with similar encounters. The memory plays an essential role in retrieving information from past experiences to apply to the new case. If it fails, the attempted solution must be revised.

Table 10: The effects of successful versus failure-based cases



The task of educating students on case-based reasoning seems daunting. Case library learning environments, in which there is a database of situations and problems to provide practice, are used in the current study. Tawfik and Jonassen (2013) as, "To what extent does learning performance on an argumentation task outcome differ if the learning experience is based on cases of success or failure" (Tawfik & Jonassen 2013, p. 389)?

Thirty-six undergraduate business students enrolled in a Sales Management course at a Midwestern University participated in the study. During the Fall 2011 semester, students were placed in one of two groups: failure case library, or success case library. For their first task, students were presented with a hiring and selection problem to solve with the use of case library resources. The following week, they were assigned a similar, transfer problem in which they did not have access to the case library environment.

Participants were to construct an argument for the decision on the case, first with the aid of the case library resources, and second with no cases. Both groups were given the same problem. The only difference between the sections was the success or failure cases given. The success condition group referred to five successful cases of hiring and selecting, while the failure condition group referenced five cases for their argument with failed outcomes for hiring and selecting.

Results between the two sections did not show a significant difference in ability to solve problems or construct arguments. That said, the failure condition section performed much higher when asked to give counter arguments because they could use alternative perspectives. Given the overall assessment, the failure case group showed

higher performance in the argumentation task. "Failure-driven memory theory suggests that when a failure occurs, the scripts that resulted from prior experiences are more readily available for revision. A case library that depicts failures thus may have required the student to pause and investigate the 'causal linkages' of the case" (Tawfik & Jonassen 2013, p. 399).

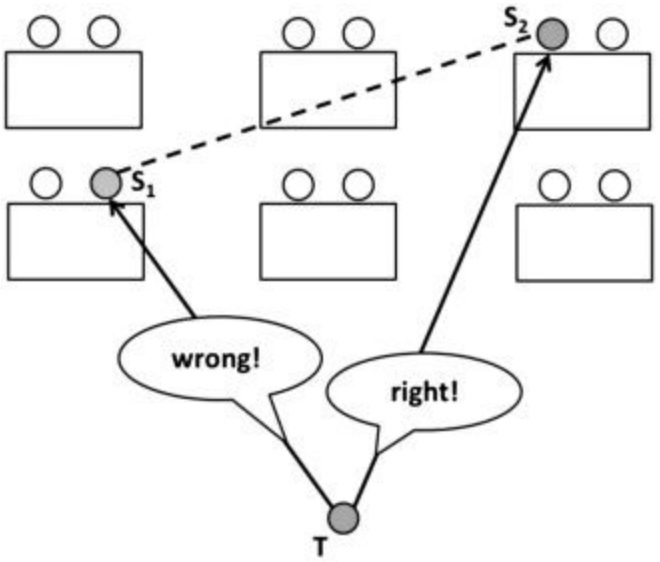
Classroom Management

Tulis (2013) looks into setting a classroom climate to allow mistakes. Setting up an error management in the classroom is very impactful for students. It is not enough to simply allow students to make mistakes and fail. The reactions and consequences to those failures set the tone. This gives rise to student and classroom discussions on misconceptions. Ultimately, with positive error management behavior, students will strengthen their growth mindset to be driven to learn from their mistakes and press on. Tulis (2013) acknowledges that little research has been conducted on interactions between the teacher and students involving mistakes in the classroom. She sets out to gain more information with three studies.

Study 1 set out to understand behavior management in the everyday classroom, and find possible differences between subjects. This was done through classroom observation and coding system. The coding system was comprised of five maladaptive teacher responses to mistakes, five adaptive responses, and one neutral. This study was performed in German "Gymnasium" schools where the highest teaching level and academic expectations are held. Sixteen math classes, 17 German class, and 15

economics classes were observed across the grades 5-12. The bulk of the observations were during class work and instruction.

More adaptive responses were recorded than maladaptive responses, however, only a few responses were recorded in which the teacher encouraged and stressed the importance of making mistakes in order to learn. There was a notable difference in the number of maladaptive responses in math classes than the other two domains. The "Bermuda triangle of error correction" was observed most frequently in mathematics classes. This is when the instructor calls on a student, and that student gives an incorrect response. A second student is called on immediately following this event to correct the mistake. Student 1 has been denied the opportunity to rethink, much less correct his or her error. Oser and Spychiger (2005) coined this phrase, and it is identified, in this study, as a maladaptive behavior response.



T = teacher, S1 = student 1, S2 = student 2

Table 11: Bermuda triangle of error correction (Oser & Spychiger, 2005).

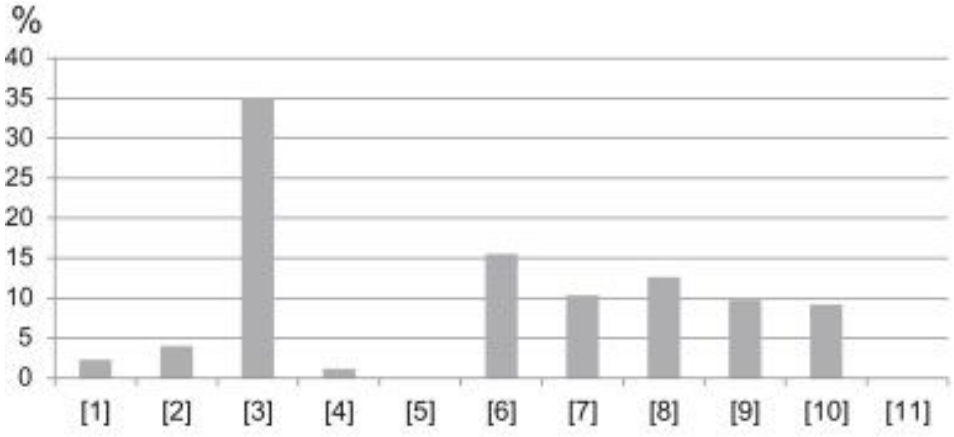
The second study looks specifically at nine different economics lessons taught by three different teachers. Questionnaires were administered to gain student perspectives

on the error climate in the class, and their teacher's responses toward errors. This study was done in Bavarian schools in grades 7 and 10. The questionnaires completed by students indicated positive and negative reactions across five categories in regards to the perceived classroom error climate. The following dimensions of climate being measured on the questionnaire were error communication, covering up errors, error tolerance by the teacher, error strain/fear of mistakes, and rule clarity, and students' own attitudes towards errors.

In general, results showed a higher frequency of adaptive responses than maladaptive responses. One exception to this finding was that of the "Bermuda triangle of error correction." This would be a maladaptive response as students are unable to reflect on mistakes in order to change their thinking. Study 2 also showed differences among teachers. Students in the same class tended to report similar responses on their mutual teacher and class.

The final study set out to analyze the impact of error management on students. Mathematics was the focus for Study 3 as Study 1 showed the highest number of maladaptive responses in mathematics classes.

Table 12: Domain specific responses to students' mistakes (%).



Notes. Category numbers are explained in Table 1.
Maladaptive responses: categories [1] – [5], [3] = Bermuda triangle of error correction.
Adaptive responses: categories [7] – [11], [6] = Teacher states the correct answer.

Twenty-five fifth grade classrooms in Bavaria were studied. Data was collected at the beginning of the school year, and at the end of the first term. Data was collected in the form of student questionnaires on a 5-point scale from *strongly agree* to *strongly disagree*.

The results of Study 3 showed there is a significant impact on students in how teachers handle mistakes. Positive reactions and classroom management towards errors improve student attitudes and perceptions towards mistakes. Students are much more likely to see these errors as learning opportunities than failures. "These findings, combined with the results of Study 3, highlight the importance of including these aspects of adaptive error management into teaching training...the results of Study 3 indicate that how teachers' deal with mistakes has a substantial influence on students' perception of errors as learning opportunities and, in turn, on students' domain specific emotions" (Tulis, 2013, p. 66). The final discovery to note from these studies is that of the "Bermuda triangle of error correction" phenomenon. While this study found more adaptive than maladaptive responses to errors, this phenomenon was an exception.

Feedback

So how do instructors effectively foster learning from errors? Researchers disagree on when to intervene with feedback. What are the benefits of immediate and delayed feedback? Some argue that delayed feedback fosters cognitive and problem solving skills along with self-regulation. Others defend immediate feedback for its success and efficiency. Mathan and Koedinger (2005) set out to find some answers.

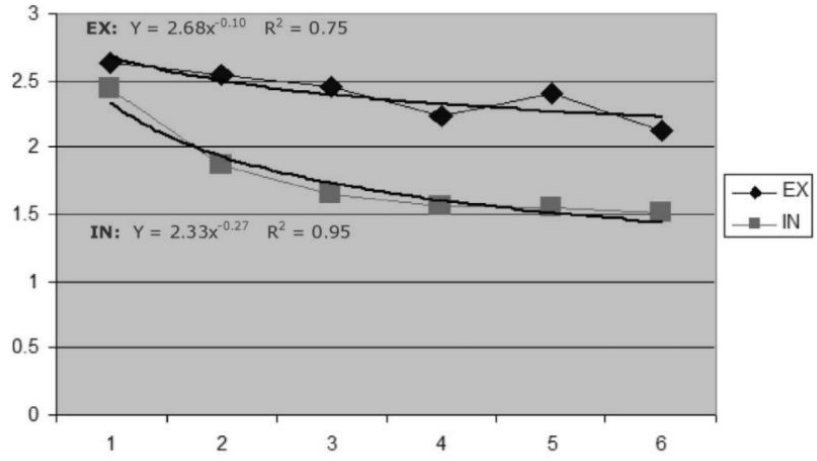
The Spreadsheet Tutor was setup to measure the differences in two models - the expert model and the intelligent novice model. The expert model tutor intervenes immediately when an error is detected. The intelligent novice model tutor also detects errors and provides correction, but delays feedback to allow the learner to use evaluative skills. The intelligent novice model, however, will prevent unproductive floundering.

The Spreadsheet Tutor was designed to teach students how to use cell-referencing concepts for programming. Participants were gathered from a temporary employment agency. Each participant was familiar with general computer knowledge, but was considered a beginner in spreadsheet knowledge. Three separate days were necessary to complete the experiment. Each day included an instructional session and procedural practice. Pretests and posttests were administered. Participants were randomly assigned either the intelligent novice tutor, or the expert tutor for their course.

Eight days after Day 2, students were again given a pretest and posttest, instruction, and practice. The tests contained problem solving components as well as conceptual understanding components. The researchers also gathered data on when differences in the learning process began between the two groups.

The results showed that students who were assigned the intelligent novice model significantly outperformed the students trained with the expert model. The problem solving, conceptual understanding, transfer, and retention tests all showed higher scores for intelligent novice tutor participants. The following figure shows the number of attempts it took to write a formula correctly (y-axis) over time, or number of opportunities (x-axis).

Table 13: Comparison of learning curves associated with expert and intelligent novice versions of the spreadsheet tutor



This study shows that delayed feedback allowed students to learn at a faster rate, and retain and understand information better than students training with immediate feedback. Although, it should be noted that Corbett and Anderson (2001) make a good point that any and all delayed feedback is not necessarily effective. "Inappropriately designed delayed feedback can contribute to unproductive floundering and frustration...it may be necessary to provide direct feedback and support for [detecting, correcting, and learning from errors] skills" (Mathan & Koedinger 2005, p. 264-265).

Errors from the Student Perspective

Lannin, Barger, and Townsend (2007, p. 43) examined the Salvador Dali quote, "Mistakes are almost always of a sacred nature. Never try to correct them. On the contrary: rationalize them, understand them thoroughly. After that, it will be possible for you to sublimate them." Lannin et al. (2007) explore different views on mistakes in a learning setting. The behaviorist view seeks to eliminate errors through reinforcement, changing habits. The repair theory applies previous knowledge to new scenarios. Then

there is the reasoning that students should own their errors in order to gain a deeper understanding. Upon examining different viewpoints on dealing with errors, the researchers as, "(a) To what extent do students perceive generality of the errors they identify? And (b) How do students' perceptions of their errors affect their views of a particular concept?" (Lannin et al., 2007, p. 45).

"The view of errors as 'sites for learning' is essential to the classroom that builds on student sense-making. 'Making mistakes is a natural part of the (problem solving) process; it even may be essential sometimes'... 'it is time to move beyond simple models of knowledge and learning in which novice misconceptions are replaced by appropriate expert concepts" (Lannin et al., 2007, p. 45). A group of fifth grade students were given an algebra pretest and then grouped according to their ability and use of strategy. This research article focuses on a high-medium pair of students, Lloyd and Dallas. Over a period of four months, and 18 instructional sessions, teachers and observers considered Dallas and Lloyd's reasoning and strategies for solving algebraic problems.

According to a framework for errors in general, there are four levels for students' views: not an error, instance-level errors, problem-level errors, and cross-problem level errors. Lannin et al. (2007) learned from Lloyd and Dallas that one must understand instance-level mistakes in order to make conclusions about how to apply generalization. A critical component to the problem solving process is defining the boundary. The subjects in this study had to define the boundaries for when it is appropriate to apply a concept or strategy, and when it is inappropriate.

The implications for instruction are to have teachers recognize when errors apply to other instances, and encourage students to consider boundaries for applying ideas to other problems. The researchers stress that instructors and students hold fast to Salvador Dali's quote, to not just correct mistakes, but to examine and understand them on a much deeper level.

Rach, Ufer and Heinze (2013) provide a glimpse of the student's attitude towards using errors as learning opportunities. Their goal is threefold: how students respond when their teachers engage in error situations, how students respond to their own errors individually, and instruction that provides the best motivation for learning in regards to error.

Rach et al. (2013) review the theory of negative knowledge, or the ability to recognize and identify boundaries between correct and incorrect responses. The following model shows two responses to error.

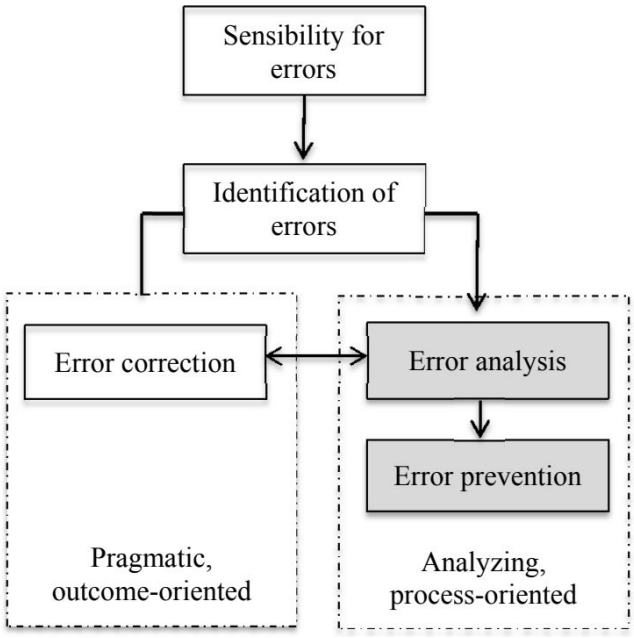


Table 14: Process model for learning in error situations

There is research to support error analysis as more beneficial, however, so much depends on the learner's characteristics. Fear, feedback, and error climate have a significant impact on the individual.

For the experiment, 571 complete data sets were used in the form of pre- and post questionnaires from 6-9th grade students in Germany. Thirty-two mathematics classrooms participated with four of them being the control group, 13 taking part in the error-tolerant culture group, and 15 classes for the error-tolerant culture and strategy instruction. The purpose of the strategy instruction was to expose those students to error analysis and cognitive level support.

Results showed a significantly less fear of error for the two experimental groups, and more affective support than that of the control group. Both experimental groups showed positive responses toward the culture and teacher, as well as reduced fear of errors. No significant difference was found between the error-tolerant culture group and the group with the added strategy instruction.

Findings for this research gives helpful insight into the student's thoughts and emotions surrounding errors in the mathematics classroom. There seemed to be no difference between the intervention groups on an affective or cognitive level. Error-tolerant culture proved to a positive influential change for students on the affective level. The group receiving the additional support in error analysis did not seem to notice this intervention. According to this particular study, there were no effects on the cognitive level with the use of these interventions.

Challenging the Educational System

Clifford (1991) challenges the educator's opinion and assumptions on risk-taking, and urges people to consider theory and be willing to test it to have any hope in advancing the education system. "Risk taking has been defined as a decision situation involving choice among alternatives and characterized by 'a lack of certainty and the prospect of loss or failure" (Clifford, 1991, p. 264). According to earlier research on the topic, people prefer moderate risks. They are more likely to make a more aggressive or uncertain risk in a hypothetical situation, and people are more likely to take a risk when there is group discussion or peer pressure present.

Risk taking theory and research is nothing new to society. Social behavior and economy are just two environments in which studies have shown positive results to risk-taking models, so why not try it in education? Motivation and cognitive effects are the two biggest factors in this topic. Much like Vygotsky's Zone of Proximal Development, there is believed to be a target for student ability and difficulty in the task. "Moderate task difficulty" and "optimal challenge" are two terms used to describe this thinking.

The position of optimal challenge or moderate task difficulty theory is to influence motivation that will lead to cognitive results. It is accepted that the most powerful motivational strategy is providing choice when possible. When the individual is given the option, and freely chooses to take a risk, the biggest benefits are seen. Structuring the classroom and learning tasks toward a risk-taking model becomes the next challenge.

There are two main obstacles with incorporating risk into education: cultural attitude and methodological limitations. There are negative societal attitudes and culture around the idea of taking risks. It is uncomfortable to risk making a mistake or failing altogether. We are wired to avoid those threats and possible rejection and instead search for success.

For this academic risk-taking research, different scales were used for measurement: The School Failure Tolerance scale (SFT; Clifford, 1988) and the Academic Failure Tolerance scale (AFT; Clifford, 1990). The scales assessed attitudes toward mistakes and failure using Likert-scaled items and multiple choice. Academic Risk Taking (ART; Clifford, 1988) and Cognitive Skills Risk Taking (CS-Ris; Clifford, Lan, Chou, & Qi, 1989) were used to measure achievement in risk-taking. Studies were conducted with students in grades three through six to assess the risk-taking behavior and failure tolerance.

Clifford's findings showed positive responses from students who experienced moderate risk, as well as positive academic outcomes. Incentives such as variable payoffs and large payoff increments increased willingness to take a risk. She concluded, based on the data, that the "level of risk taking is a function of expected benefits...and that the application of risk-taking models to education is not only feasible, but promising" (Clifford, 1990, p. 290). Popular opinion on failure and taking risks at the possibility of being wrong, and theory contradict one another.

Theory tells us that errors, cognitive disequilibrium, and failure to reach one's goal are major sources of continued motivation; popular opinion tells us that

> failure wreaks havoc to student motivation and undermines self-esteem…[Psychological theory and educational practice] conflicts are real, they threaten the development of our intellectual resources, and they are but examples of the many conflicts between opinion and theory that obstruct the advancement of both educational practice and educational theory...We must more aggressively challenge popular opinion and long-standing assumptions about education. (Clifford, 1990, p. 290)

Motivation and Attribution Theory

"Attribution theory deals with the question of how individuals make judgments and seek to explain how they consider the causes of their behaviours and those of others. Attributions have the potential to affect beliefs, emotions and behaviour. Therefore, attribution theory has significantly contributed to the studies on motivation" (Baştürk, 2016, p. 365). The following study investigates how students view their role in both successes and failures, and how it affects motivation. The researchers examined dimensions of attributes as internal or external, controllability, and stability. Naturally, effort, engagement, ability, and difficulty fell within the boundaries and were measured.

Baştürk (2016) set up a survey research design in which 28 Turkish student teachers were asked to reflect on an open-ended question regarding the reasons for a student's failure and success in math. Each of the participants wrote a one to two page response. Reflections were analyzed, classified, categorized, and subcategorized. The qualitative data was transferred to quantitative.

Results were organized into four categories to explain causes for failing in math: causal attribution related to students, the nature of mathematics itself, teaching and learning, and family and social environment. Some of the causal attributions from the student included innate mathematical talent, high interest in the subject, and background in math.

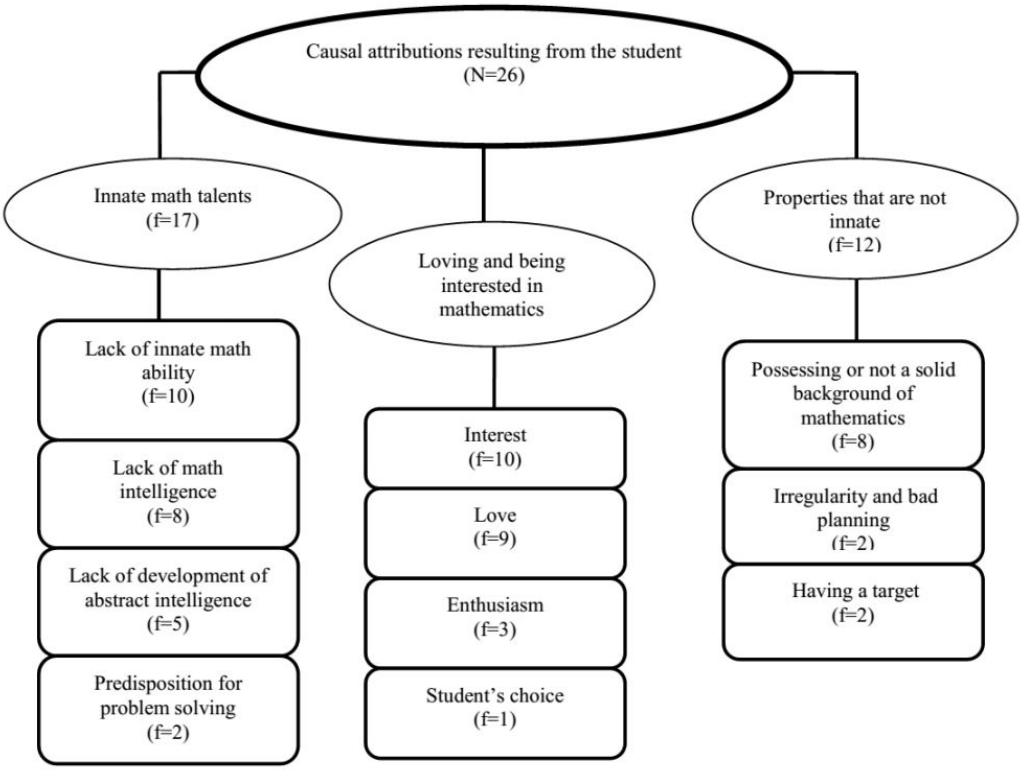


Table 15: Student teachers' causal attribution related to students

This category showed the greatest number of student teacher responses with 26 of the 28 expressing some sort of reasoning to do with the student. The fewest of the participants reasoned that students would experience failure because of the nature of mathematics, including its complexity, cumulative nature, and ignorance in study habits. Only nine of the 28 student teachers expressed such causal attributions.

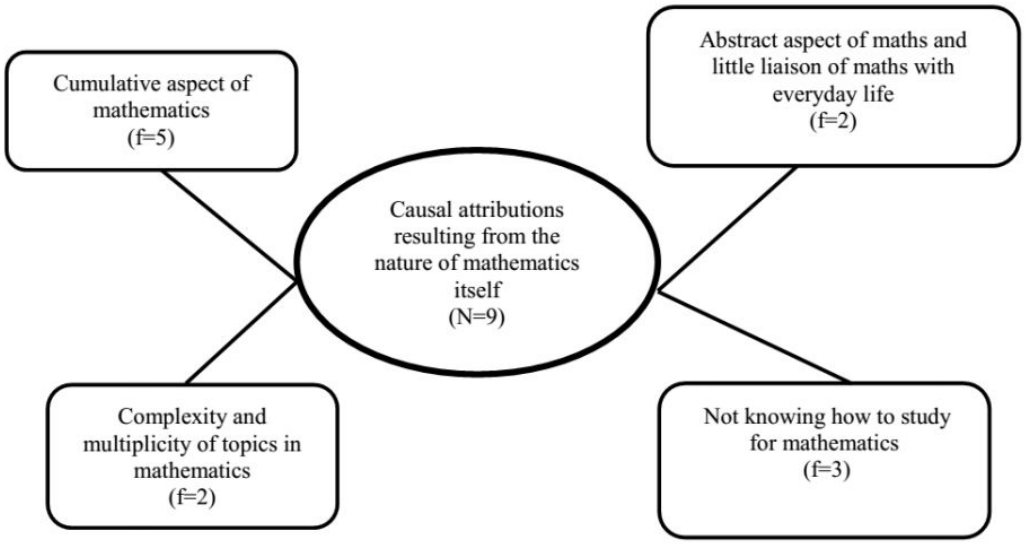


Table 16: Student teachers' causal attributions related to the nature of mathematics itself

Most of the teachers attributed failings to the teaching and learning of the subject. The teacher's attitude toward math, method of teaching, and the knowledge of teaching fall

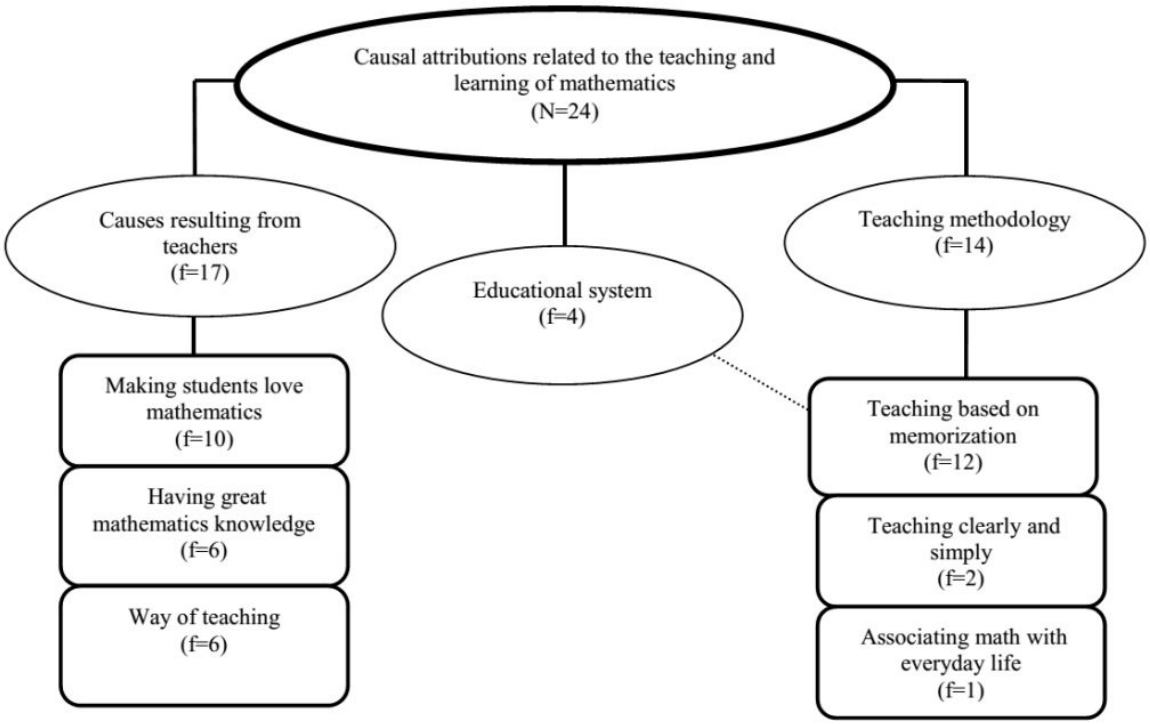


Table 17: Student teachers' causal attributions related to teaching and learning mathematics

into this category.

Student teachers' causal attributions related to teaching and learning of mathematics Finally, causal attributions from family and social environments accounted for 12 of the student teachers' speculations. These ranged anywhere from negative societal environments to economics to family support.

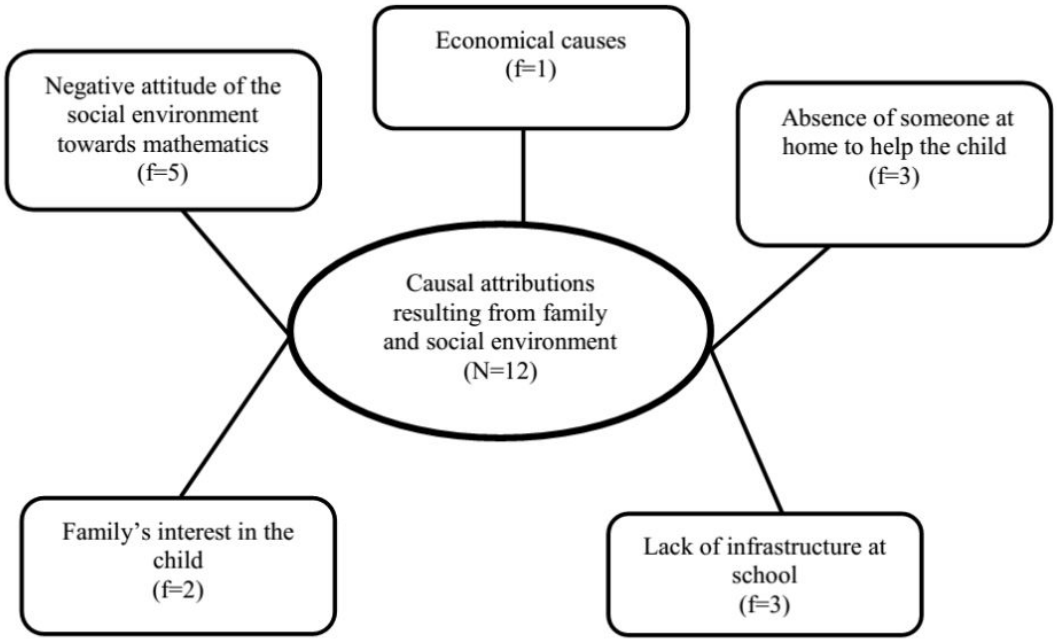


Table 18: Student teachers' causal attributions related to family and social environment

While this study was conducted to gain a better understanding on student causal attributes, light was also shed on how teachers' expectations for the success or failure of students are a causal attribute themselves. It should be remembered that the data gathered from this study was from the student teachers' perspective, not the students themselves. A notable analysis that came from the research was that of the strong belief that innate talent is necessary to succeed in mathematics, which is internal, stable, and uncontrollable. This contradicts Carol Dweck's theory on growth mindset. "The growth

mindset is based on the belief in change" (Dweck, 2008, p. 212). Dweck would argue that innate talent is not stable or fixed. Success in mathematics, or any other subject, goes beyond this. An attitude of effort and growth make all the difference.

Bandalos, Yates, and Thorndike-Christ (1995) look at attributions from the student perspective as they relate to test anxiety. Several attributions were considered at the undergraduate and graduate level, including success and failure, self-concept, self-efficacy, general and subject-specific test anxiety. Variables for the study comprised of gender, class standing (graduate or undergraduate), number of prior math classes, and years since last math course. A total of 338 statistics students from Western Washington University or the University of Nebraska - Lincoln participated, with 193 of them being women, and 145 men. Surveys were conducted during the first 2 weeks of class, and again after an exam. Four attitude scales, one achievement measure, and background items were completed.

To measure math self-concept, a 5-point Likert scale was used to gauge the comfort level with math, and perceived math aptitude. Perceived self-efficacy was measured with a 10-point scale in which students were asked to consider how successful they thought they would be on seven statistic specific skills. In order to understand participants' attitudes towards success and failure, the students responded to a success situation and a failure situation. Responses were categorized into ability, effort, and external attributes. Finally, test anxiety data was gathered through the use of the Test Anxiety Inventory containing 20 items with a 4-point Likert format. The inventory

measured the dimensions of worry as a cognitive component, emotionality as a physiological reaction.

The final model shows paths and measurements based on the resulting data. The only notable difference between genders was found with general test anxiety - worry. Men reported having higher levels of anxiety - worry than women. Participants who attributed failure to low ability had higher anxiety emotionally and cognitively. Students who attributed failure to external causes, however had higher achievement scores. Contrary to the hypothesis, those attributing success to effort as opposed to ability had higher anxiety and were more worrisome with statistics. That said, success attributed to external causes showed higher general test anxiety and lower math self-concept.

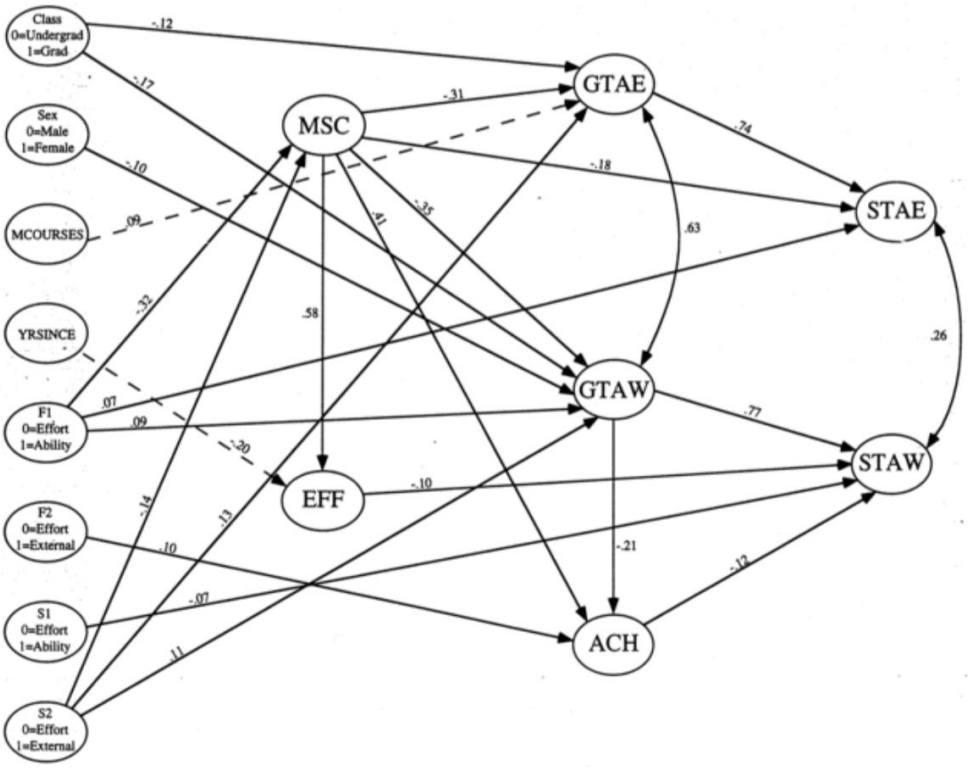


Figure 2. Final model showing standardized path coefficients. Dashed lines represent the two paths added post hoc. ACH = achievement; EFF = perceived self-efficacy; F1 = dummy variable for failure attributions coded 1 = ability and 0 = effort; F2 = dummy variable for failure attributions coded 1 = external and 0 = effort; Grad = graduate; GTAE = general test anxiety–emotionality; GTAW =equals; general test anxiety–worry; MCOURSES = number of prior math courses; MSC = math self-concept; S1 = dummy variable for success attributions coded 1 = ability and 0 = effort; S2 = dummy

Table 19: Final model showing standardized path coefficients

One final noteworthy observation that came out of this study was how much stress students put on math competence or lack of ability to explain success or failure.

Mathematical self-efficacy, mistakes, and mathematical anxiety were studied in relationship in Turkey. The purpose of the study was to analyze possible relationships between self-efficacy, handling mistakes, and anxiety in mathematics. The second part of the investigation was to evaluate whether or not self-efficacy and the handling of mistakes could serve as a predictor for anxiety. Aksu, Ozkaya, Gedik, and Konyahoglu (2016) gathered a group of 323 seventh grade students ages 12-14 for their research. 166 of them were girls and 157 were boys. The tools used to collect data were three different scales or surveys. The Self-efficacy Scale contained four times on a seven point Likert scale to show academic self-efficacy. The Mistake-handling Questionnaire consisted of 9

variable for success attributions coded 1 = external and 0 = effort; STAE = statistics test anxiety–emotionality; STAW = statistics test anxiety–worry; Undergrad = undergraduate; YRSINCE = number of years since one's last math course

items on a four-point Likert scale. Finally, the Mathematical Anxiety Scale included 13 positive and 7 negative items with five-step evaluations on a Likert scale.

The results showed compelling, positive relationships between self-efficacy, mistake-handling, and anxiety in math. Interestingly, the higher mathematical self-efficacy students showed, the higher their anxiety was in the subject. A positive relationship was also found in mistake-handling and anxiety. Mathematical self-efficacy and mistake-handling can effectively be used to predict mathematical anxiety. While the data seems counterintuitive, the experts provide a possible explanation. "The increase in awareness level of an individual towards mistakes enables him/her to realize that there

are so many things that s/he does not know and this, with a high degree of probability, will lead to increase in anxiety level" (Aksu et al., 2016, p. 69).

Motivation can be hard to come by when school becomes stressful. Skinner, Pitzer, and Steele (2016) address coping strategies and student engagement to aid in persistence and learning. Coping in the academic setting is especially essential in the transition from elementary school to middle school. Such coping strategies as help-seeking from teachers, parents, and peers, and emotional support are adaptive. Maladaptive coping strategies come in the form of avoiding help, hiding problems, blaming others, and dwelling on setbacks and stressors.

Skinner et al. (2016) ask the research question, "do students' engagement and disaffection in the classroom predict their profiles of academic coping, and does coping in turn contribute to subsequent persistence (or giving up) on challenging tasks, which then feeds forward into learning and back into ongoing engagement and disaffection" (Skinner et al., 2016, p. 2103). 880 students in late elementary and early middle school were the participants in which a variety of data through questionnaires was collected at two times during the school year from students and teachers. Student grades were also used as data. The following model was used to show motivation or lack thereof.

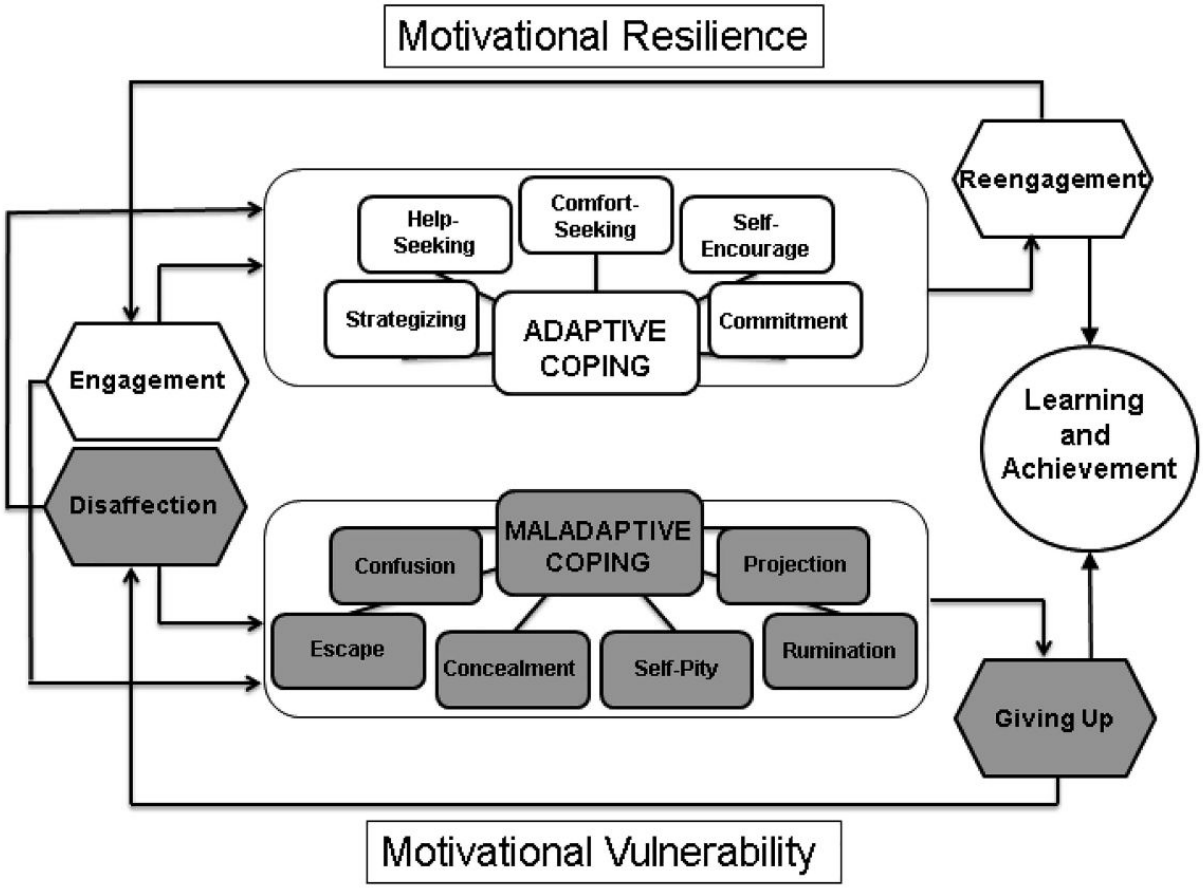


Table 20: A model of motivational resilience in which ongoing engagement acts as an energetic resource allowing students to cope in more adaptive ways, leading to re-engagement with the challenging material and greater subsequent achievement

Specifically, researchers were looking at coping in the form of momentum and persistence in the face of academic problems. Skinner et al. (2016) found that motivation and coping go hand in hand. The results "support the notion that it might be useful to consider engagement, coping, persistence, and achievement as parts of interconnected patterns of motivational resilience and vulnerability" (Skinner et al., 2016, 2113). Those

students showing high achievement also showed using a range of adaptive coping strategies to cope with setbacks, challenges, and stress.

Self Regulation

The key to becoming a lifelong learner is self-regulation. It takes strong motivation and effort to get to a point where these skills become a regular practice. Not only does the student need to learn and practice the skills, but he or she must also overcome individual obstacles of distractions, defeats, procrastination, and anxiety. The self-regulated learner is actively engaged, sets goals, believes they are capable in overcoming challenges, exhausts resources, and values learning.

In research done by Iwamoto, Hargis, Bordner, and Chandler, 2017), undergraduate students were surveyed to measure their self-regulation skills. The general outline or cycle of self-regulation is forethought, setting goals and planning, performance, monitoring progress and behavior, and self-reflection as an assessment and a way to consider making improvements. Iwamoto et al. (2017) used the 44-tiem Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & De Groot, 1990). Subscales of the questionnaire include self-efficacy, intrinsic value, test anxiety, cognitive strategy use, and self-regulation. A total of 161 north Pacific undergraduate students dispersed across the four years completed the questionnaire. The 68% female and 32% male multidisciplinary participants voluntarily completed the Google Form MSLQ.

Findings revealed that these students had a high sense of self-efficacy resulting in a lower level of anxiety. Results suggested, however, that the students were overconfident. Due to this high sense of ability, data showed low scores in the use of

cognitive strategies and self-regulation skill use. These results remained true of freshman students to seniors, suggesting that learning habits do not change during undergraduate school. The alarmingly low level of self-regulation indicates that college students do not know how to adequately study and use these strategies. Perhaps teachers are assuming too much. "The vast majority of students want to do well in the class, but their preparation does not support their aspirations. In response, we as educators cannot assume our students know how to learn at the university level. We must coach our students so their behaviors (i.e., self-regulation skills) align with their academic goals" (Iwamoto et al., 2017, p. 2).

Seeking help is an essential strategy for self-regulation and learning. Other self-regulatory skills are performed independently. Help seeking, however requires social interaction. Richard Newman (2002) explores how important this skill is for the learning process. "Help seeking can avert possible failure, maintain engagement, lead to task success, and increase the likelihood of long-term mastery and autonomous learning" (Newman, 2002, p. 132). Adaptive help seeking requires cognitive competencies, social competencies, personal and contextual motivational resources. Newman (2002) examines the help seeking skill as it pertains to a self-system theory. Students have three needs that coincide with self-regulated learning. These are relatedness or involvement, autonomy, and competence.

Both teachers and peers can have a significant impact on these three areas regarding help seeking. In relating to students through time, energy, attentiveness, and caring, teachers can influence students' focus and affect. When a teacher can establish

trust with a student, it opens up communication and motivation to ask for help. Peers and friendships can also impact the skill. In quality friendships where there is no competition or judgment, friends can be a great resource. Asking this type of friend for help can be very effective for learning. Creating an environment in the classroom that allows for collaboration and social interaction practice can encourage this to take place.

Newman (2002) recommends setting academic goals as a way to build autonomy. Teachers can stress the importance of setting learning goals, and create an atmosphere where this is important. This will send the message that it is okay to ask questions when needed. Performance goals and competition are not helpful in setting this sort of tone. With peers, there can be a sense of comparison in whether or not it is "safe" to ask for help. Classmates can also positively influence each other by showing how to monitor when to ask for help based on the effort you have already put in.

Competence is the last need for self-regulation in seeking help. Newman (2002) says the teacher can encourage questioning during instruction, guided practice, and independent work. Providing quality feedback and just the right amount of assistance gives the student the feeling of competence. The classroom climate should demonstrate that difficulty and uncertainty is natural, and not something to be ashamed of. That, paired with the encouragement for students to speak up and use their voice supports and increase in competence. Finally, peers significantly influence the feeling of competence in a positive or negative way. It is typical for students to feel stupid for asking for help, especially as they get older. In a classroom culture that provides collaborative

opportunities and small group activities, classmates can positively impact one another in their group conversations.

When a student is able to self-regulate, they are aware of when they need help. Metacognition, motivation, and behavior are all incorporated into self regulation. In a study conducted by Ryan and Pintrich (1997), perceptions of competence, achievement goals, and attitudes were examined alongside avoidance of help and adaptive help seeking. They take into account the vulnerability hypothesis that suggests that students who believe they have high cognitive abilities are more likely to ask for help because they do not see it as a threat to their self worth. Ryan and Pintrich (1997) also realize there is a social component in asking for help, and examine students' perceived social competence.

The achievement goals are used to measure motivation for the help seeking skill. Task-focused, extrinsic, and relative ability goals are the three factors. Task-focused goals are believed to positively influence self-regulation strategies and the motivation to seek help. These goals are centered around wanting to understand, and learn for the sake of learning. Extrinsic goals reflect a negotiation of sorts. The motivation to learn comes from the understanding that the student will get some sort of reward in return, or avoid a negative consequence. Relative ability goals view learning as a competition or hierarchy in which the study wishes to show higher ability in relation to others.

The other aspect of this study revolves around attitudes, with the belief that attitude leads to behavior. Ryan and Pintrich (1997) give three variables with attitude: perceived benefits, threat to self worth by peers, and threat to self worth by teachers. The

participants for this research were 102 seventh-graders, and 101 eighth-graders. Considering the age of these students, the three attitude variables are incredibly important. Early adolescents are consumed by weighing threats and benefits as well as self worth and social standing.

The study was conducted with the use of math scores gathered from the California Achievement Test and a variety of questionnaires of a Likert-type scale addressing help-seeking attitudes, perceived social and cognitive competence, and help-seeking strategies in math. As predicted, the results showed that students who viewed themselves with lower cognitive and social competence, were more likely to avoid asking for help due to the threat to self worth by peers. It makes sense that those students with high perceived social competence and relational skills saw little to no threat by peers to their self worth in seeking help. Similarly, students who felt they had high cognitive abilities, were more likely to ask for help.

These results, however, were also found to be conditional on the goals of the students. There is a significant relationship between task-focused goals and help-seeking. Students more extrinsically motivated are more likely to avoid seeking help. Relative ability goals did not show a significant correlation to adaptive help seeking. In the case of adolescents in math class, they "are vulnerable to perceptions of threat, which serve to inhibit seeking help with their academic work when needed, [and are] affected by how they feel about their cognitive and social competence" (Ryan & Pintrich, 1997, p. 339).

A more recent study was done involving motivation and self-regulation in the context of mathematical achievement in the middle school. Cleary and Kitsantas (2017)

gathered information on motivational factors such as self-efficacy, task interest, and school connectedness alongside self-regulated learning (SRL) behaviors. They considered two background variables: socioeconomic status and prior math achievement. Specifically, the researchers wanted to know if the motivational factors and SRL behaviors could predict mathematical achievement.

Cleary and Kitsantas (2017) developed a framework for the social-cognitive study around three components: SRL behaviors, motivational beliefs, and contextual variables. Data was gathered from 331 sixth and seventh grade students in a northeastern middle school to measure their beliefs about their cognitive abilities, interest level in math, and their feeling of support and connectedness to the school. This data was obtained through the use of the Task Interest Inventory containing six items on a 5-point Likert scale about interest and enjoyment in specific content areas. The School Connectedness Scale addressed how connected, supported, and safe students felt on a 5-point Likert scale. Teacher ratings were also obtained through the Self-Regulation Strategy Inventory-Teacher Rating Scale (SRSI-TRS) in which eleven math teachers indicated how often students display motivation and regulation behaviors on a 5-point Likert scale over 13 items. Other data retrieved included student course grades, STAR Math Enterprise scores as a means to assess prior math achievement, and whether or not the student was enrolled in free or reduced-priced lunch to assess SES.

Students' background of prior achievement contributed most to their report card grade. Self-efficacy and SRL behaviors also showed significant positive relationships to grades. Overall results collected showed that both cognitive and social factors play an

important role in predicting mathematical achievement. Self-efficacy, task interest, and school connectedness were all indicative performance. Data gathered from teacher surveys showed "students' regulatory behaviors...served as a direct predictor of their mathematics outcomes but also mediated the effects of how students think and feel about themselves as learners" (Cleary & Kitsantas, 2017, p. 102).

There has been some debate among researchers about the role self-efficacy plays with learning goals and performance-approach goals. Boufard, Bouchard, Goulet, Denoncourt, and Couture (2005) challenge previous beliefs on the impact student goals have on performance.

> A person striving for learning goals in a task is mainly concerned with personal development and the acquisition of new skills and knowledge. Learning processes and effort expenditure are positively valued, and errors are not seen as threatening but act as a spur to perseverance. A person striving for performance goals is mainly concerned with documenting and gaining favour-able judgments or avoiding negative judgments of his or her own ability. Achieving success with low effort and outperforming others are seen as requisite conditions towards feeling and appearing competent. Errors and failures are threatening because they are seen as evidence of incompetence (Boufard et al., 2005, p. 374).

For the study, 140 college students, 85 females and 55 males participated. Half were assigned learning goals, and the other half performance-approach goals. In each of those groups, half were assigned either a high or low self-efficacy condition. Those students assigned the learning goal were presented with an opportunity to improve

vocabulary comprehension. Participants assigned the performance-approach goal were told the situation was a vocabulary assessment. In the high self-efficacy condition, students were praised and highly complimented for their effort and above average performance after three problems. In the low self-efficacy condition, participants were told their responses were incorrect, and that they were performing below average.

Results showed that within the learning goal group, those given the high self-efficacy condition reported being mindful of managing time and energy while being less persistent. They also outperformed the low self-efficacy students who reported being focused on self training and encouragement. There was no significant difference in performance among the performance-approach goal group. Data supported the suggestion that "the degree to which a person is concerned with doing well might sometimes have more effect on task engagement than perceived competence" (Boufard et al., 2005, p. 382). Therefore, it appears important to distinguish personal goals as it affects effort and performance.

CHAPTER III: DISCUSSION AND CONCLUSION

Summary of Literature

The education system is constantly changing, begging teachers, administrators, and students to change with it. The approach to teaching is changing to stay relevant, and better prepare students for success, both now and in the future. Remarkably, educating today is far less about the content of the lesson, but more about the climate, nature, and approach in the classroom (Bouffard et al., 2005; Burton, 2014; Cleary & Zimmerman, 2004; Cudney & Ezzell, 2017; Iwamoto et al., 2017; Lannin et al., 2007; Mathan & Koedinger, 2005; McCaslin et al., 2016; Rach et al., 2013; Rice et al. 2004; Ryan et al., 1998; Skinner et al., 2016; Tawfik & Jonassen, 2013; Tawfik et al., 2015; Tulis, 2013; Tulis et al., 2016; Zander et al., 2014; Zerr & Zerr, 2011). In the dynamic world we live in, learning strategies and the ability to self-regulate are far more valuable.

Creating an environment in which students are free to make mistakes as part of the learning process is essential. Educators build a culture in the classroom, allowing safety in failure (Clifford, 1991; Ryan et al., 1998). Students need constant encouragement and reinforcements to follow mistakes through the learning process to make it valuable (Bouffard et al., 2005; Burton, 2014; Cleary & Zimmerman, 2004; Cudney & Ezzell, 2017; Henderson & Harper, 2009; Iwamoto et al., 2017; Mathan & Koedinger, 2005; McCaslin et al., 2016; Ryan et al., 1998; Skinner et al., 2016; Tulis et al., 2016).

Part of this classroom culture is discovering, identifying, and adjusting one's mindset. Using the aforementioned learning model requires a growth mindset for that of the learners and the instructors. Without it, the fixed mindset student will not take risks, will be unable to accept mistakes or failures, and will ultimately admit defeat (Burton, 2014; Dweck, 2008; Duckworth et al., 2007; Hochanadel & Finamore, 2015). The desire and love for learning is squelched.

Once the climate of the classroom is accepted, and there is an agreement to adjust fixed mindsets, pursuit of lifelong skills and strategies can begin. Critical thinking and problem solving are two major indicators of success. Higher order thinking and learning strategies such as setting goals, monitoring progress, analyzing and self reflection lead to independent, motivated thinkers (Altermatt & Broady, 2009; Bouffard et al., 2005; Burton, 2014; Cleary & Zimmerman, 2004; Iwamoto et al., 2017; McCaslin et al., 2016; Newman, 2002; Rice et al., 2004; Ryan & Pintrich, 1997). Practicing these skills and this process develops resilience for the learner, and the ability to strategize and solve problems (Duckworth et al., 2007; Hochanadel & Finamore, 2015). Each of these skills are applicable in the world outside the school building, and the future.

Professional Application

Do not overlook the importance of setting up a culture ready for learning at the start of the school year, and maintaining and reinforcing it on a daily basis. Students need to feel safe and welcomed into a positive environment for learning to take place. That is the foundation on which the structure of the class will build. From there,

perfectionism and sensitivity to mistakes should be taken down before students will buy into the idea that one must fail in order to learn. Obstacles that stand in the way for students can include culture, poverty, and readiness to learn. These should not be viewed as impassable. Students, especially younger children, are exceptionally adaptable when placed in a safe, trusted atmosphere.

Modeling with personal failures is a great way to demonstrate the safety in making errors, and then learning from them. Instructors should stress the value of the journey and effort of the process, while downplaying the result or product. A growth mindset gives way to resilience, grit, and effort. Teacher feedback is the most important factor in moving fixed mindsets to growth mindsets. To encourage this change in thinking, students need to receive praise and quality feedback for their effort and process, as well as constructive advice for ways to improve. A general statement on the final performance or product, even a positive comment like “good job”, is actually detrimental to the development of a growth mindset. Changing the fixed mindset requires focus and attention on improvement of the process. It is essential to emphasize that intelligence is not innate, but something that is developed over time. Intelligence is also not a destination. There is always room for growth.

It is natural for human beings to avoid failure, therefore it is difficult to convince students that it is necessary for learning, even celebrated. The more students can experience errors and failure followed by acceptance and correction of the error, the easier and more comfortable it becomes. It falls on the teacher to set up such opportunities. Developing engineering activities for the entire class to fail initially is

highly effective. That way, one or a few students are not singled out with potential of experiencing shame. The classroom as a whole wrestles with the uncomfortable emotion together. From there, everyone can work through potential mistakes, try new solutions, and reflect on the process.

The most effective activities for problem-based learning challenges a general misconception accepted by the class. The activity or experience is meant to disrupt this accepted belief or cognitive equilibrium. Taking this misconception through the learning process of the failing to learn model, is uncomfortable as students struggle through the disequilibrium. Eventually arriving back to equilibrium at the correct or accurate concept, however, is more memorable and more likely to prevent this type of mistake again. While distressing to sit in a state of disequilibrium, this emotion and experience is where the act of learning takes place. The challenge and stretching of the brain is key. Learning is not comfortable. Discomfort is unavoidable in true learning.

Ideally, the problem-based learning model acts as a continuous cycle. The initial challenge of thinking leads to inquiry. This questioning step launches the learner into that uncomfortable stretching of the mind. Predictions and posing possible causes for the misconception or failure moves the process further. The next natural step is gaining and providing evidence to support predictions and causes. Correct identification of the core problem leads to the development of a new solution. Implementation and assessment or reflection of the solution reveal either success or another failure, bringing the process full circle.

Limitations of the Research

Evaluating the effects of failure, changing mindsets, and self-regulation skills has its limitations. There are so many factors and variables when dealing with a diverse population that is the education system. It becomes even more difficult when the bulk of the population represented are children. How does one measure the mindset of an individual, especially when he or she lacks certain language and abilities to convey what they are thinking? Most of the literature reviewed in this thesis deal with thoughts, emotions, and changes. These ambiguous areas of the human being are difficult to record and track.

Overall, more studies needs to be conducted in the area of failing to learn. A larger and wider population will give more data to compare with the current research. As the education community is comprised of a wide range of ages, cultural backgrounds, personalities, and resources, the more information that can be gathered on the topic to address the diversity, the greater the understanding.

Right now, there simply is not enough concrete data to prove that making mistakes, allowing errors, and establishing a "failure to learn" model will directly result in higher achievement and success. The limited number of studies cannot lend this correlation as fact. Limitations on this research come down to quantity and time. More research needs to be conducted over longer periods of time. New ideas to measure mindset, self-regulation, and success in terms of mentality and growth towards learning need to sprout to push this subject forward.

Implications for Future Research

Future research should be conducted in the area of self-regulation interventions. This is a promising strategy for growth in theory, and has shown some success. However, the interventions proposed need to be fine tuned and more scripted to be done with fidelity. Researchers will need to measure the success of the interventions with prior performance data, progress monitoring, and post performance data. Once the interventions have proved to be successful, trials should be directed toward multi-age groups of students with necessary adjustments on the interventions to meet the varying needs.

Failure theories need future research completed as well. To show convincing data and results, a lot more populations of students with differing starting points must be considered. More information needs to be gathered about the individual's prior knowledge on the subject, as well as their emotions or mindset going into the study. These divergent starting points need to be tracked throughout the procedure of the failure-based model for learning. The results of each learner would then be analyzed and compared to the group.

The facilitation, degree of failure, as well as the degree and complexity of it will take careful consideration on the part of the researchers designing the study. The workings of the participant's mind both prior to and during the study will need to be controlled or measured throughout. Each learner enters with some sort of cognitive

support in failing, either positive or negative. Monitoring the strategies of these participants will show adaptive coping strategies to failure or maladaptive strategies.

The final implications for future research depend on the role of the educator. These factors would be set, agreed upon, and controlled before the procedure begins. Environments are an important factor to consider, especially with help-seeking studies. Results in a variety of settings give extensive meaning to further practices. Attention to perspectives is challenging, but pivotal in regards to motivation, attribution, and effects of feedback. When measuring motivation and attribution, who is reporting on this? From whose perspective is this? How can the most accurate results be obtained? Most likely, differences will surface between the teacher's perspective, and that of the learner.

Conclusion

The education system is in danger of getting left behind if it passes up the opportunities for changing alongside society. Education has no choice but to adapt in order to stay relevant and make ready future minds. No longer will it be sufficient to continue "the way we have always done it." Even tactics that have shown growth and achievement in the past will soon die away. Most content taught will be out of date and irrelevant beyond graduation. The greatest challenge is overcoming the current cultural attitude around what has been true of education throughout history, as well as the limitations of longstanding methods.

The approach to education cannot be about *what* is being taught; it will be *how* it is being taught. Developing problem solving, independent, critical thinkers will require

providing constant opportunities for practice. The future educator will be responsible for designing and implementing a learning model based around failure. Errors and mistakes are inevitable. Learners need to face those, and learn how to approach them with adaptive coping strategies, self-regulation skills, and a growth mindset.

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