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**Grit and Mathematics**

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## **Grit and Mathematics**

**Gheorghita Faitar**

### **Abstract**

The study analyzes the circumstances of success in a first year Learning Mathematics Skill-Mathematics 101 sequence for students involved with the experience of becoming professionals in health sciences occupations at a NY college level. The Upper-NY state institution specializes in fields such as pharmacy, physical therapy, occupational therapy, nursing, biology, dietetics, and health analytics. The study describes through a case study descriptive method the student development in becoming prepared for the introductory Calculus after the classes had been taken. The case studies analysis explains the importance of grit and determination for the students involved in the study. The involved students in spite of them have all the odds to fail the learning skills-MAT 101 course sequence; they managed to surpass the physical or learning challenging obstacles and succeeded at having passing/high grades for the courses taken.

**Keywords:** Grit, Health Professions, LSK/MAT, Non-Traditional Student.

## **Introduction**

Starting with the famous motto, ‘when little is expected, little is achieved’ of the renowned perennialist / essentialist philosopher and educator, Robert M. Hutchins (1899-1977), (Ornstein and Levine, 2006) we re-iterate in today’s complex society the dire need for core subjects of classical education, such as, reading, writing and comprehension, logic, mathematics, natural sciences, philosophy (and technology, added by the neo-essentialists) that have to be rigorously presented and developed in today’s schools. These core subjects ought to be implemented in a curriculum that addresses encompassing concerns, and searches for the best instructional methods leading to the most efficient learners, thinkers, ‘worker bees’, and last but not least, leaders in today’s world. The need for well-prepared future citizens is a paramount demand in today’s complex, inter-connected, globalized world.

Based on the educational philosophies of the neo-essentialist and postmodernist trends, teachers are thoroughly responsible for the product of today’s schools, the well-educated members of contemporary society.

Recently I was looking at some of the most recent developments of cognitive psychology and to my wonder I found an interesting topic explored by Daniel T. Willingham regarding grit as a fundamental educational quality. He thoroughly explained the definition of this overlooked learning attribute and inquired in an understanding of the ways it can be applied to building fundamental knowledge throughout the learning years in school. In his opening statement he rightfully asked the question regarding the applicability of this highly emphasized term that not only has been present everywhere in the last decade, but also caught teachers and educators’ attention for successful learning outcomes. It seems as if it would be possible to make it present in any learner’s endeavor, ‘grit’ could provide the necessary preparation and qualification for as many STEM specialists as needed in every domain of the 21<sup>st</sup> engineering technology domain or STEM career orientations.

## **Literature Review**

Why the rush to define and apply the newest cognitive discovery element, you might ask. To this question, the specialists and scholars’ answers would be first related to the national results at the international educational assessments. In *Trends International Mathematics Science Study* (TIMSS) and PIRLS, the European equivalent of TIMSS, results gather in competitions at assessments of mathematics, science, and technology indicators prove that US students at different learning levels (elementary and middle school) still manifest lower accomplishment rates than their international counterparts (Faitar and Faitar, 2013). The same results were also emphasized by the triennial program for International Students Assessment (PISA) in 2016, released by the American Educator Society in December 8<sup>th</sup>, 2016. The American students’ results at the international competition when compared with the 70 other countries remain in

the middle of the ranking. They are just about average in science and reading and below average in mathematics <https://www.aft.org/our-news/periodicals/american-educator>, retrieved 29<sup>th</sup> of June, 2017.

In addition, according to the Commission on Professionals in Science and Technology, in 2007, at the bachelor's level, the percentage of degrees received by women in biology totalized 62.5 whereas in math and statistics, the degrees were at 45.9 percent. At the master's level, women earned the majority of degrees in 2004 in fields including the biological sciences, psychology, and the social sciences. The math and statistics domains were totalizing 45.4 percentage degrees for women. According to the NSF's 2008 (National Science Foundation) report, women earned less than a third of the PhDs in computer science, earth science, atmospheric, and ocean sciences, mathematics and statistics, physical sciences, and engineering (Rosser and Taylor, 2009, p. 8).

Along the same lines, there is proven fact that the most influential role in choosing a career in any student's life besides parents is represented by the teachers and counselors throughout their school time. The 'feminine' versus 'masculine' career identification might still play a role in students' preferences in life (Moritz Rudasill and Callahan, 2010).

Frequency of the feed-back, input and in-class interactions between student and teacher may also constitute a reason for understanding and enabling learners to work in the complex conceptual work of Mathematics. Girls and boys equally benefit from teacher's undivided attention in a classroom, especially when boys and girls are equally called to answer theoretical or applicative questions (Sadker and Zittleman, 2010). As scholarly studies explain, both girls and boys benefit from the teachers' attention to their progress, even when boys are known for being inclined toward having a mathematical-logical and spatial intelligence and girls better intra, inter-personal social intelligences (Banks and McGee Banks, 2011; Gurian et al., 2001).

Is it a 'masculine' versus 'feminine' career orientations or it is about the direction in life given by the family values and cultural habitat that will impact careers later on in an individual's life? The later question is prevalent when understanding the significant success students of Asian descent have in highly-sought after STEM careers of today's market. Their perseverance in hard-core theoretical and applied sciences is already unanimously recognized. In an article released in 2016, the author talks about the importance of filial piety and academic motivation in succeeding in these STEM careers. A self-determination theory intertwined with the filial piety characterizes overcoming academic obstacles and excelling in an international higher education institution founded in South Korea (Tam, 2016).

As it can be seen, it is important to have a straightforward orientation toward gaining a STEM degree and also quintessential to surpass obstacles in school preparation in fundamental core knowledge essential for STEM. As Mathematics, Biology and Chemistry are highly emphasized subjects of required core curriculum for STEM degrees, it is daunting to analyze

persistence and attrition in school. Therefore the work of the cognitive science becomes inseparable from the profound understanding of developments and success in school.

Previous studies also emphasized the idea that the female students are able to perform at a higher level than their male counterparts as the female learners are the students who better follow the guiding lines of the in-class instruction offered by their teacher. The study was exerted in a pre-test, post-test formatting procedure where the students have been tested with a written classical pencil-and-paper format testing inquiry (Faitar, 2016). In the aforementioned study, the first-year undergraduates who took MAT 101 were tested after in-depth post-test explanations of the quiz's most difficult concepts. Under these circumstances all of the students who performed well at the next test using teacher's in-class highlighted explanations and concepts were female.

In addition, previous applied studies emphasized that teachers are seemingly also recognized as defining factors in implementing reform in the critical skills formation in a classroom. They are the force of progress through inquiry in the learning process. "According to the National Science Education Standards (NSES) inquiry is a multifaceted activity that involves making observations, posing questions, and examining resources of information" (Cripe and Lovelace-Cameron, 2008, p. 202).

By looking at the international assessment test results in sciences and mathematics (TIMSS and PIRLS) through the lenses of a comparative analysis, major guiding lines could be formulated. The practice within the natural sciences and math lessons involving the "right" sequence of instruction, an appropriate practice of the teacher feedback, an efficient seating-practice, in an environment free of the ability tracking procedures is highly effective (Cummings and Altbach, 1997). The afore-mentioned practices strengthen by a systematic student effort combined with a sustained effort of preparing the most specialized teachers could lead to the most beneficial results in any American classroom.

An inquisitive study in the nature and impact of non-cognitive factors explains that these factors not only affect students, but also can impact teachers' effectiveness. Grit and life satisfaction were significant effects in predicting success (Duckworth and Quinn, 2009).

Alongside these lines of inquiry into the significance of teacher's influence in a classroom, as the forces of progress, another study conducted in 2003 spoke about existent classroom control, self-regulations strategies and academic achievement in Mathematics in a sample of sixth grade students (Eshel and Kohavi, 2003). The afore-mentioned study hypothesized that students' achievement would be contingent on the combined effects of teacher and student control. The two-dimensional model proposed by the Israel's researchers explained that the perceived classroom control is determined by two coordinates: the relative degree of both structure and direction maintained by the teacher (teacher control) and by the opportunities for self-directed learning exerted by the students.

In 2007, Angela Duckworth et al. published a highly referenced article that analyzes grit in conduit of learning and implications for a positive outcome in any education. She is also known for spending more than 12 years studying the effect of grit on achievement. She mentioned that self-control and grit might be the keys to a better life when in balance with talent and IQ (Duckworth, 2014). She had an outstanding study on the effect of non-cognitive factors on achievement. She was in agreement with Hanford (2013) when defined grit as the tendency to sustain interest and sticking with things over long term until you master them.

The new research in education prevails considering grit as an important aspect to improve school performance. Pappano in a 2013 research says that the researchers have some really good inquiry and results into showing the correlation between grit and student success, but with a less qualitative/quantitative understanding into what it takes to increase the level of grit.

According to Dweck (2015), the secret to raising smart kids is to not telling them that they are. She proves that thirty year in the research process demonstrated the secret of making kids of all ages learn and overcome obstacles in their knowledge acquiring process is to determine them to focus on the process of learning, not on the intelligence, smartness, giftedness qualities that may be attributed to them at some points in their lives. People in power, teachers, parents, counselors consider it is important praising children's innate abilities. Nonetheless, this reinforced mind-set led to prevention of fulfilling potentials in athletes, students, or even relationships of people found on the edge of failing in their marriages. As Carol Dweck specifies "parents and teachers can engender a growth mind-set in children by praising them for their persistence or strategies (rather than for their intelligence), by telling success stories that emphasize hard work and love of learning, and by teaching them about the brain as a learning machine" (January 1, 2015). As a psychology graduate student at Yale University in the 60's, she started to investigate human motivation and perseverance in the face of adversities in everyday life. She was adamant in finding an answer to the idea that some people, students gave up under difficult circumstances while others succeeded regardless of their initial abilities, talents, or basic knowledge in a certain subject. She concluded that a lack of effort has to be emphasized in any student, at any stage, in a faltering learning process in order for the progress to be attained. She started with a group of elementary and middle school students who had to be taught reasoning skills and abilities in mathematics endeavors. If their mistakes would be explained as being connected to a lack of effort instead of being due to a lower ability or talent, they all will learn to stay focused and willing to solve further problems better in the face of adversities. The researcher also explains her views on intelligence. Based on her theory, there are two classes of learners, helpless and mastery-oriented ones. These two classes hold two different theories of intelligence. The 'helpless' one believes that intelligence is a fixed trait (i.e. a fixed amount), whereas the 'mastery-oriented' ones think that intelligence is controllable and could be improved

through hard work. The ‘helpless’ learners identified in the research as with ‘fixed -mind set’ avoid challenges because challenges mean mistakes that make them look less smart. In contrast, the mastery-oriented class of learners with a ‘growth-mind set’ knows that encountered challenges are energizing and promoters of brain growth and a continuously rewarding scholarly success.

A study published in 2018 by the researchers of Bahrain Teachers College attempts to find if relationships exist between grit, and math and science achievement, between attitude toward mathematics and achievement. The study proved the existence of a positive correlation with math and science achievement (Masooma and Moosa, 2018).

Paul Tough also discusses grit in his New York Times best seller, 2012 book, *How Children Succeed: Grit, Curiosity, and the Hidden Power of Character*. It is assumed that grit combines elements of effective schools with components of a strong character. It is about the gritty kids who do better in school? Or is it about environment that determines children to persevere and perform at their best potential despite all of the unforeseen events?! It is still not well understood if grit is different from motivation, and if it can be taught. Tough also explains that non-cognitive skills might be more preponderant in determining success in a student’s life. Also the researcher mentioned that students who succeed usually are better equipped to overcome their life stress and insecurities.

A recent study relates to Rojas (2015) endeavor that analyzed the outcomes of learning in two sample groups of undergraduate students. In the process, she used a Grit Scale survey to explore the relationship between creativity, perseverance, motivation, and achievement. She discovered that grit had a correlated two-factor structure reflecting interest and effort.

”Being gritty means being deeply committed to a long-term goal and following through on that commitment by pursuing it over the course of the years” (Willingham, 2016, p. 29). The author continues with his straight-to-the point examples. The fact that grit means measuring someone’s willingness to continue in spite of following a ‘bumpy’ road, is portrayed by the talented musicians who diligently practice, and by the competitors in a spelling bee competition who continue studying even when it seems they know all the words. All grittier students as mentioned in the article by Willingham were able to give reasons that transcended personal success (p. 29). They were the ones who meant they want to continue their work in spite of the strenuous work because that implied something grander than their initial goal of a chosen career.

## **Methodology**

The study emphasizes qualitative descriptive analysis on special case studies in the process of understanding attrition and excellence in the LSK/MAT 101 study ensued at the undergraduate level in a college focusing



on the health professions. The LSK/MAT 101 sequence is required in the first year for all the undergraduate degrees.

The present study is focused on understanding grit at the freshmen level in a higher education institution, college, specialized mostly in acquiring a degree in health sciences professions. The Upper-NY state institution specializes in fields such as pharmacy, physical therapy, occupational therapy, nursing, biology, dietetics, environmental sciences and health analytics. The study rests on the analysis of three different case studies implying success in Mathematics for three different students taking introductory level Mathematics as first year undergraduates at the college level twice in their professional training.

As an in-depth procedure for the analysis, the instructor also approaches the study by focusing on the possibility of the existence of a direct correlation between the control exerted by the teacher in a class for the quintessential mathematical concepts and self-directed learning exerted by students when accounting for their performances.

### **Findings/Results**

This study highlights the attrition based on a learning mathematics skill, LSK, Mathematics 101 course sequence, both required for the first year of preparation in health science domains. The inquiry methods rely on formal methods of assessment in Mat 101 classes and in informal discussions with the students during office hours in all three studied cases.

The analysis is quintessential in understanding grit and determination for the students involved in the process of learning, knowing they cannot accede to the next level in their quest for a major unless they successfully complete this LSK/MAT 101 sequence.

The case study analysis was deemed appropriate in presenting the findings. The situation of three undergraduate students, one in the preparatory Learning skill (LSK) course, later in the MAT 101 class, and the other two students' situations involved in MAT 101 served as a basis for the case study analysis developed.

The description of their academic progress is understood along the LSK/MAT 101 sequence for the first student. The student was initiated in the fundamentals of learning skills in mathematics for the first eight weeks of the semester. She started with a very low performance level the first time. At the end of the LSK course when she took the final exam in introduction to basic Mathematics skill she wasn't deemed prepared to continue to the next level with the MAT 101 class. At the end of her session she seemed truly unhappy, vexed by her inability to be present for the next college level Mathematics class planned by her in the quest for a health related major. During summer orientation, she was recommended for a second trial of the LSK initiatory Mathematics in the spring semester. During fall, she took the second opportunity to re-take the preparatory Math course. This time she was 100% involved in the material and homework exercises required for the completion.

She finished first in her class at the introductory level LSK, and also in the following MAT 101-introduction to Calculus, the college-level course that people take as a requirement for their professional degree. Moreover, she was involved in a regional Mathematics contest for her age-level, where she conquered the second place for the whole NY state region.

A second case involved a student having a certain learning disability with seizures and depression whilst on-site. Dealing with serious medical issues she could not finish the MAT 101 class the first time. In the following semester she re-took the class again with me as instructor. She certainly had periods of absence, or non-involvement with the taught material during seminar sessions. Nonetheless, she had the stamina to continue preparing for the midterms and final exam with steady work in homework requirements and review tests, asking for extra help when needed. She considered herself well trained to finish what she has started in her professional aspirations. She ended with 80% accomplishment rate well ahead of many of her classmates.

A last case is represented by a non-traditional student, age 30 plus who adamantly aspired to become a nurse by the end of the college preparation. She was having unanticipated familiar problems at home, with a 5-year old to take care of, and highly motivated to finish the MAT 101 class before she ends her freshman year. The first time when she took the class, everything seemed guided by miscommunications and mishaps. At the end of her class, student mentioned she 'let her instructor down' by not following her guiding lines and recommendations. The second time when she came in, a more present, rigorous, planned ahead attitude transpired. She was coming to extra-help hours, both at the learning center and the office hours available as per syllabus. Once, or twice, she mentioned that she'll be at class time with her daughter, and asked for instructor's permission. She ended up being in class with her daughter taking notes and trying to understand the covered material while performing her duties as a mother as well. Therefore, in the end, the time of being present and active in class, and the extra-help offered through seminars in preparation for the mid-term exams, and finals counted enormously. She ended the course with a 72% accomplishment rate. The non-traditional, mature student proves herself to be at par with the learning expectations by her attitude, determination, and conscientiously approach to completing all the ascribed assignments in preparation for finishing the class requirements.

In the process of acknowledging their accomplishments, the instructor also aimed for direction and guidance necessary in any controlled learning environment. The initiative was at first part of the teacher-controlled course dynamic. As a procedure, the students were included in the pre-test, post-test performance testing. They took the test, got their marks and feedback from the professor, and after the instructor worked in class the key answer form for the test, they were re-tested in a second session on some of the "trickier", and concept-charged type of questions. These questions were separately solved and highly emphasized when teacher presented the answer key to the class after the test. In these later attempts of understanding how students react to a teacher's guiding initiative, the controlled effort was exhibited more by the student

subjects in their endeavors. These students understood the goal and motives that charged the instructor's emphasis on certain main subjects in the key solutions presented in class. As mentioned in the previous study, the female students were always able to show better preparation and able to make the necessary strides to finish their assignments and exams on time, with good results.

## **Discussion**

In the above mentioned case study presentation it is important to acknowledge that two of the students were regular students, while one was a non-traditional, mature student, with a more complex personal life devoted to raising a family. Nonetheless, in all three cases, the grit and determination to finish the work dedicated to be promoted to the next level mathematics was compelling. All of them, second time around, devoted significantly more work hours and seminar time to understand the core mathematical definitions, concepts and the applications involved in the regular quizzes and exams required during the semester.

As instructor aimed to specify, the rigors of producing results in a conducive, learning environment are prone to the changes and transformations that might be applied in a self-directed environment. Better emphasis on what a self-directed environment is, as well as on what the duties and responsibilities of any student are in this regulatory environment has to be addressed.

Under this guide, the definition of a self-directed environment would have to be addressed not only in conjunction to learning in basic Mathematics, but also in any high-level thinking and producing knowledge of a higher education habitat.

As it is mentioned, the study emphasizes the grit and aspiration in all three described cases. Interestingly, all of these worth investigating cases were present with the female students. As it was portrayed in the research method/question under analysis, previous studies (Faitar, 2016) explained girls are usually the ones able to better perform in following guiding lines of instruction encompassed in the process. This might be one more reason to delegate the need to succeed to the fact that all girls, female students are bound to surpass difficult obstacles during their learning experiences as a way to prove that they are determined in their professional and familial goal aspirations.

Other explanations for the students' success in the LSK/MAT 101 course sequence could be connected to the Carol Dweck's, 2015 study emphasizing the need to always develop a positive constructive 'growth-mind set' in learners. This mind frame totally opposed to the 'fixed mind-set' of learners is responsible for progress within any difficult learning processes. The 'growth-mind set' that Dweck mentions in her study of learners' psychology has to be developed in any student regardless of their innate abilities. Students who develop it are able to surpass challenges in any science domain, including Math. As a conclusion, maybe, we as teachers, educators, and parents, can

mostly aim, as Carol Dweck mentions, for building more on learning strategies, effort and persistence. As a practical approach to creating a growth-mind set, with adaptive and workable qualities, Dweck and her research team of psychologists proposed an interactive program entitled ‘Brainology’ (Dweck, 2015). The program described by her with its five modules teaches learners about brain’s compartments and the continuous connections formed or strengthen while students are engaged in learning. The program is important because it teaches virtual students about the endless possibilities that a human brain has in developing new and re-enforcing old connections when a person is eager to confront difficult work or learning-related situations.

Therefore, in the present-study of the afore-mentioned situations, it was quintessential that students related to the most challenging situations. Due to the fact of understanding of the previously encountered setbacks, they certainly decided to include persistence and determination in all of their work in order to solve the pressing in class, or homework related mathematical challenging situations.

The determination to succeed was the guiding factor in all analyzed situations. The determination to succeed was evident in all of the cases in which the students undertook the negative experience of the past and transformed it to a new file in their personal life. They managed to continuously develop strategies to better understand the material, inputting more effort, time, sustained search for solutions to the most difficult mathematical problems that teacher emphasized throughout the course work. It was important that the students understood their misconceptions and mistakes of the past and re-took the class interested in the remedial work needed for improving their performance. The effort input into organizing material and performing well in all of the requirements, and the continuous dialogue with the instructor were promoters of growth and success in all taken quizzes, the two mid-terms and a final exam, all serving as stepping stones in the process of learning the material.

## **Conclusions**

The involved students in spite of them having all the odds to fail the learning skills-MAT 101 sequence, they managed to surpass the physical or learning challenging obstacles and succeeded at having passing/high grades for the courses taken.

Certainly, as teachers and educators, it is imperative to work on building learning abilities, critical thinking skills and perseverance in our students, especially when dealing with core mathematical, scientific knowledge so much in demand for the most rewarding STEM career orientations. It rests with us to be able to connect students’ interests in certain domains with their capabilities to surpass challenges, difficulties, faltering views encountered in the process. The growth-mind set might be the one encompassing grit and determination in all venues of scholarly affirmation.

The study will depict a better understanding of the challenging student situations if applied longitudinally for the extra-sensitive cases in which students with compelling obstacles are graduated from the mathematical sequence described to the next level mathematics needed for their main core preparation toward the aspired degree. In addition, the inquiry into grit/determination necessary especially for the first year undergraduate students will benefit if in conjunction with the same understanding for the other core natural sciences endeavors. It will be beneficial to analyze these very same students in the context of them finishing other undergraduate/ graduate classes applied to a degree obtained in the STEM disciplines.

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