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HOW THE PEER LEADER CAN HELP STUDENTS PERSEVERE THROUGH INTERMEDIATE ALGEBRA & GEOMETRY (MAT 1175)

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Andrew Hacker, in a 2012 Op-Ed piece in the *New York Times*, suggested that the main impediment to graduation, in particular for students in the City University of New York (CUNY) system, is freshman math: "The City University of New York, where I have taught since 1971, found that 57 percent of its students didn't pass its mandated algebra course." Many students at New York City College of Technology ("City Tech"), a campus of CUNY, have had to take a developmental or remedial math course before they enroll in the first credit-bearing math course. Although remedial courses are meant to provide students with foundational concepts to prepare them for college-level math courses, sitting in remedial math may feel like having to go through High School math all over again. I know first-hand the struggles and sense of success in moving from remedial to credit-bearing courses, because I too was in this situation in my first year in college. Yet now I am a Mathematics Education major, and in the Spring 2014 semester, I led my own math workshop with six students. Since I had once failed and now succeeded, I wondered about perseverance and what strategies are used by students to persevere or not in math.

Peer-led workshops were instituted in the first credit-bearing course, College Algebra & Geometry (MAT1175) in Fall 2006 at City Tech. The Peer-Led Team Learning program engages students to work collaboratively with the guidance of a trained Peer Leader. Students are more active in their learning, and positive changes are seen in their attitudes. This type of learning environment has profound effects in students' pass rates and perseverance. Participation in these workshops has showed an increase in pass rates and persistence rates in foundational STEM courses. The pass rates of classes with a PLTL component have been on the average 10%-15% higher than the overall college pass rates for those courses. In their first semester of service, Peer Leaders are trained to facilitate workshops, using learning theories and teaching strategies that actively support cooperative team learning and group discussion.

Have you ever considered yourself either a "Math / Science" or "English / History" kind of person? Do you feel your mind is engaged to only be good at certain subjects, and you are pre-determined not to have interest and perform poorly in others? If so, then Carol Dweck's work is instructive: She has found that this type of belief leads to behavior that is categorized as part of the "fixed" mindset. Dweck (2006) proposes that there are two approaches to learning, characterized as "fixed mindset" and "growth mindset." In the former, intelligence is considered "fixed" and cannot expand, leading to behaviors that do not support learning. Some of these behaviors include arriving to class late, sleeping during class, cheating on exams, withdrawing from the class, answering questions before the teacher finishes asking,

and disrupting other students in the classroom, procrastination, and not asking questions. "Growth mindset," on the other hand, suggests that intelligence is malleable; everyone is capable of learning, leading to "growth" behaviors, e.g., asking for extra work, assisting other students, studying harder, persisting, and bouncing back after a bad grade.

Observations

Some students in my MAT 1175 workshop demonstrated their "fixed" mindset, through inconsistency with studying, not practicing the material at home, and often only relying on mental processes in solving problems, and these remembered shortcuts may have gaps.

"Steven" has had mediocre grades (65's or lower on his exams), only studies for exams but not for quizzes, usually arrives a half hour to an hour late to the lecture portion of the class, and in workshop computes mentally without writing steps. These behaviors affect his performance on exams as he rushes to complete one. These behaviors suggest that he is in a fixed mindset. Yet he also shows effort, working his way to the growth mindset. During workshop he likes discussing the modules with his classmates, he does a good job at struggling through problems in working his way towards a solution, and he does not lock himself out or give up no matter how challenging a problem might be. These are key indicators that he is working towards reaching the growth mindset.

Here is an example of Steven's train of thought on a problem he worked on. I will illustrate the way Steven solved the problem on the left, and the correct method to the right in Table 1.

Table 1. Problem: Subtracting Binomials

Problem: Subtract (9x-3y) - (4x+8y)

Steven's Solution (Explanation by talking)	Correct Solution
1. Changed the value of (4x) into (-4x)	1. Change the value of (4x) into (-4x)
2. Changed the value of (+8y) into (-8y)	2. Change the value of (+8y) into (-8y)
3. Subtracted like terms (-4x) by (9x) = 5x	3. Subtract (4x) from (9x) = 5x
4. Added like terms (-3y) with (-8y) since both had same sign = +11y	4. Combine (-3y) and (-8y) = -11y
5. Result (5x+11y) **(Incorrect solution)**	Result: (5x-11y) (**Correct solution**)

In this problem, Steven confused rules between multiplying binomials and their change of sign and rules with adding/subtracting binomials. He did not write anything or show work in finding the solution, but instead relied on remembering steps. Remembering steps is the process by which a sequence of steps is carried out, but forgetting to complete something along the way. For example, Steven was familiar with how to add and subtract integer numbers, which is something he can do mentally. However, in problems like these, one has to take note of the changes in sign that occur. This is one thing he did not do, which led to his error. Since both signs were the same, Steven added 8 and 3 together but was not then aware of leaving the sign as negative. Steven explained his process aloud to me, and I wrote out an alternative way to solve the problem while I discussed the problem with him.

For example, another way Steven could have solved this problem was to write down -3 and then add another -8, to find out how much altogether? The correct solution to this would be -11. He could have thought about doing this by imagining a number line and jumping back 3 spaces, since the problem states -3, from that -3, then going 8 spaces further back which gives a result of -11. When I explained this to Steven, he understood better how to combine same sign numbers, and was aware of mistakes he was making. By showing Steven an alternative way of solving the problem, I was also modeling the importance to writing out steps and avoiding mental shortcuts, and explicitly stated that using these methods would help him.

Roberto previously took the class and failed, and counter intuitively felt that this time he had to make less effort to score high grades on his exams. Roberto boasted about not doing homework and not studying for exams. However, he made many simple errors by not checking his work, tried to show off by rushing to be the first one to complete problems in the weekly module (problem set), and tried to leave the workshop early, disengaging from working with classmates during workshop, did not like being corrected, and would not write out each step in a problem (trying to solve the problem in his head). Table 2 presents Roberto's verbal explanation on a math problem he attempted to solve.

Table 2. Solving systems of linear equations

Question: x+3y=8y, 5x-9=3x+y

Roberto's solution	Correct solution
1. Solved the 2nd equation for "y"	1. Solve the 2nd equation for "y"
2. Moved 3x to the left side of the equation	2. Move the 3x to the left side of the equation
3. Subtracted 3x from 5x	3. Subtract 3x from 5x
4. Solved the 1st equation for "x"	4. Plug in your 2nd equation "y=2x-9", into the first equation to solve for "x"
5. Moved 3y to the right side of the equation	5. Multiply 3 by "y" or 3 * 2x-9. Then multiply 8 by "y" or 8 * 2x-9
6. Subtracted 3y from 8y	6. After multiplying you get "x+6x-27=16x-72"
7. Result: y=2x-9, x=5y (Incorrect solution)	7. Combine like terms, "x+6x" = 7x
	8. Now, add 27 to both sides to keep the equation balanced. -27 + 27 = 0 and -72 + 27 = -45
	9. Subtract 16x from both sides. 16x – 16x =0 and 7x – 16x = -9.
	10. Divide -9 from both sides of the equation. X=5
	11. Plug the value of "x" back into the second equation, since we solved using the first equation.
	12. y=1, x=5 (**Correct solution)**

As noted in Table 2, there are many more steps to solving this problem than Roberto presented. He forgot the rules when it came to solving systems of linear equations. He did not remember the rules associated with this, therefore chose to solve for each variable, but did not complete the problem. The three forms to solving systems of linear equations are solving by elimination, solving graphically, and solving by substitution, which is the route Roberto went. The solution presented on the right in Table 2 also solves by substitution, and other methods could have been used.

Roberto did the initial step in this type of problem, which is to solve for a variable. In the second equation he chose to solve for "y". Rather then plug the equation for "y" into the first equation he then tried solving for "x" separately in that first equation. His tendency to rush led him to leave the problem unfinished. Rather than be left with a solution, he was left with two separate equations and refused to revise his work. An issue for Roberto was his rushing to get to the end instead of taking his time and checking over his work. He wanted to be the first one done as usual, which contributed to his not reviewing his work and mixing up concepts. Worse, Roberto may have been trying to conceal his lack of knowledge about the process to solving this type of problem by substitution; this might lead to not being cautious in checking his work. These are all behaviors that come from a "fixed" mindset. In a fixed mindset, one tends to find shortcuts, one does not check over work due to confidence in believing what one worked out by hand or mentally was correct.

Kelly is a sophomore. She took a few years off after high school before coming back to college and being placed in MAT 1175. Kelly struggled throughout the semester, due to not having taken a Math course for several years. One thing that impressed me while seeing her work was that she never gave up and even when she answered a problem incorrectly, she would go through each step and struggle through it until she arrived at the correct answer. Table 3 provides an example of one of the problems Kelly was working on. Although Kelly did not understand it originally, she underwent the process of the "growth" mindset. She learned from her setbacks, she accepted the challenge, and she did not give up until she was confident in her ability.

Table 3. Solving radical equations

Question: $\sqrt{(2x+1)}+7=x$

Kelly's solution	Correct Solution
1. Square both sides, to get $2x+1+49=x^2$	1. Subtract 7 from itself, and from the x on the other side of equation. $=x-7$
2. Combine like terms. Add 1 and 49. $2x+50=x^2$	2. Square both sides (To get rid of radical or square root). $2x+1=x^2-14x+49$
3. Subtract x^2 from itself and from the left side of equation.	3. Subtract 1 from itself, and from 49. $2x=x^2-14x+48$
4. Divide 50 by 2, and by itself	4. Bring $x^2-14x+48$ to left side of equation, and combine like terms. $-x^2+16x-48$
5. x=-25 (Incorrect solution)	5. Factor out into two binomials, to get $(-x+12)(x-4)=0$
	6. Using zero property, solve for x. x=12, x=4
	7. x=4 gets rejected

In this problem, Kelly initially made the mistake of squaring both sides, rather than move the "7" over to the opposite side of the equation. Before guiding her through the problem, I asked her to check her answer and walk me through what she was doing. She was able to clearly explain to me why she did what she did in each step, but was unclear at times as to the order of certain steps in the problem. I gave her a few minutes to think about her process in solving this type of problem, and after she composed

herself she answered the problem correctly. Kelly had to do several similar problems, and eventually understood what was going on and where she made her mistakes.

Discussion

Dweck's Mindset theory (2006) relates closely to the students with whom I am working. Roberto is in the fixed mindset because of his belief that in his second semester taking this class there is nothing he can improve on. He failed the class last semester, so there is clearly room for him to improve and grow if he wants to. It is commonplace for freshmen students to fail Algebra (Hacker, 2012). Additionally, Roberto is extrinsically motivated (Ryan & Deci, 2000). *Extrinsic motivation* is being motivated for rewards; in Roberto's case, he enjoys being recognized as the first to finish a problem, getting recognition from peers, although his behavior does not seem to be driven to avoid punishment (getting approval, avoiding punishment, bad grades). Unlike intrinsic motivation where one learns to fulfill one's desires of learning, with extrinsic motivation less emphasis is put on learning and more is put on being rewarded either by seeing oneself as smart to peers, or feeling as if one needs the recognition and acceptance of one's professor for what one has done. *Intrinsic Motivation* is the drive to engage in learning for its own sake, such as working through problems for understanding and mastery of mathematical concepts. Roberto is one of many students who has been rewarded for answering questions first, gets praised by his classmates for high grades on exams, and therefore when he sees others get higher grades than him he is motivated to do better. Roberto strives to improve on each quiz and exam.

Roberto uses what he remembers as shortcuts or tricks to solve problems without writing them out. Teachers often reward students who are the first to respond to a question, and students are viewed by their classmates as looking "smart," rather than being "smart." The unfortunate downside to using mental shortcuts is that one puts less emphasis on using a calculator, or using pencil and paper to do calculations and instead try to compute steps mentally. Mental math is not helpful because one starts leaving out steps in a problem, one is not able to conceptualize and think deeply about a problem, which makes it harder to explain one's conceptual understanding and process in solving a problem. Although this should be viewed negatively, students are often rewarded by being viewed positively for their ability to do *Mental Math*. Consistently doing Mental Math perpetuates bad practice on the part of the students. After a certain point of developing understanding, it is acceptable to use Mental Math; but in the fundamental classes students should not be rewarded and praised for doing this. This maneuver can also be a detriment because the student is relying on their ability to prove that they are smart, rather than being willing to show one's work and write out step-by-step solutions (which has the effect to show that one knows what one is doing). This can potentially lead to the student forgetting how to show a step by step solution to a more advanced problem, or can lead to him/her answering a question incorrectly due to a miscalculation along the way which is caused by having a misconception on how to do the problem. By doing Mental Math, when students answer a question incorrectly they tend to blame it on a miscalculation. Students do not understand the reality that there maybe a gap in knowledge with material they do not understand.

Generally, in the lower level Math classes students should focus on the simple aspects such as repetition through re-doing problems and writing out their solutions, practicing writing out formulas, plugging in values into the formula and going step by step with each formula as practice. Doing this

consistently builds the students' base, and helps in gaining a deeper familiarity with the material. By doing this, it is not rare for a student to come up with alternative methods for solving these types of problems.

While Steven showed signs of being in the growth mindset, he is currently in the fixed mindset. Steven takes his time to settle into workshop, but once his classmates are working and fully focused then he gets on task and gets into working mode. This goes hand in hand with Schunk & Pajares' (2001) theory of model similarity and its effect on students in a peer group. It is important to note that Model Similarity is built on Albert Bandura's (1977) theory on Social Learning. Behavior is learned through the process known as observational learning. Model Similarity is a way in which peers increase each other's self-efficacy. In watching others succeed, work hard and try their best, students who are observing are likely to be motivated to do the same. Conversely, watching others fail can lead others to believe they are not competent enough or will not attempt the activity or task at hand. Peer influence occurs through large groups of friends and classmates. This can be either positive or negative. Despite the troubles Steven may have while in class, he tries to work out the solution as long as he can before asking for help from either his peers or the peer leader. These are the signs of a growth mindset, but he still finds himself engaging in behaviors of someone who is in a fixed mindset. He procrastinates in beginning his modules, often doubts his abilities and he copies work from others. What has helped Steven greatly is sitting alongside students who are of the growth mindset.

Steven's peers are not A or B students, but they are individuals who thrive on perseverance and proving others wrong. Kelly is in the growth mindset (Dweck, 2006; 2008). She had failed multiple exams and was doing poorly in the class. During the mid-semester evaluation the professor advised Kelly to drop the class because of her low grades and the high possibility of her failing the class. Kelly did not quit, she continued to work harder, and she was supported by her group and lent support where she saw fit. When she got a problem wrong on her module, she reviewed it step by step until she realized where the mistake was made. Each time she would receive her test or quiz back, she would work the problems out on another sheet and try to understand her errors. She would identify the mistakes made, write them out using words and then solve the problem correctly. As Saltzman & Coffin (1998) state, "Successful studying for math exams is somewhat different than successful studying in other courses. Mathematics exams typically emphasize skills and concepts, neither of which can be memorized the night before the exam" (p. 7). As a result of all this, a second practice Kelly used repeatedly was thoroughly checking over her work. Kelly realized the importance of this strategy for performance on future exams, homework problems, modules and quizzes. She employed these strategies after realizing that what she had been doing was not working for her. By the end of the semester Kelly got a B in the class after scoring a 94 on her final.

This sort of herculean effort was instrumental to Steven as he sat next to her and saw her struggles and successes throughout the class. Steven saw how Kelly did not quit despite every reason to, and he saw how she stayed committed to continue working hard despite the low grades she was getting. Steven saw the process that Kelly went through in correcting her mistakes, and learning from them in each test or quiz that followed. This effort and hard work by Kelly is an excellent example of the grit a student in the growth mindset generally has. No matter what setbacks one might face, there is always reason to believe that one can continue improving. This correlates to a study by Good, Rattan, & Dweck (2007, cited

in Dweck, 2008) that looked at minority women who were students at Columbia University, and their continued achievement in math. Dweck and colleagues found that the growth mindset helps women believe that they are accepted members in the math community, and who then are confident in pursuing careers in the STEM fields. The fixed mindset, however, contributes to women believing they do not belong, and do not then feel the need to pursue careers in STEM majors.

Conclusions

The Peer Leader can help students create habits of perseverance in part because of the Peer Leader's knowledge of course concepts in higher-level math courses. Encouraging students to make efforts is challenging, no less so in preparing them for the upper level Math courses they will need to take. Some of the struggles are how to get students not only to create study patterns that will work for them, but help them to persevere. Motivation, self-efficacy and perseverance are necessary in order to help students create appropriate study habits: they first have to see that their methods and tactics were not helping them succeed. Helping students to create useful study habits was one of the most difficult tasks as a Peer Leader.

Through the experience of being a Peer Leader, both in practice and while participating in weekly training, I have reinforced my understanding of certain areas of mathematics, and I have learned once again how easy it can be to get discouraged and feel defeated by lower level Math concepts. This last point is critical because when the lower level beginner math concepts are tripping us up, then every math concept to follow will be tougher to understand. The lower level concepts are what give us the foundation to everything else that will be learned thereafter, hence why it is important to stay consistent with studying, attempting to do homework (even when it is tough, it can be done by looking over problems carefully), seeking support from both professors and other peers, and being willing to struggle, persevere, and succeed in the end.

In addition, as a Peer Leader one cannot be shy about trying different strategies in the workshop. It is essential to the growth of our students that we try different pairings and groupings to see the effect we get with different combinations. For me, one strategy that was useful was grouping students of the two mindsets together. This way, students could learn from one another and pick up different techniques that would be useful to each. In closing, I would tell other Peer Leaders to embrace this opportunity. You must be willing to not only help others learn, but you must be open to learning as well.

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