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From Performance to Learning: Assessing to Encourage Growth Mindsets

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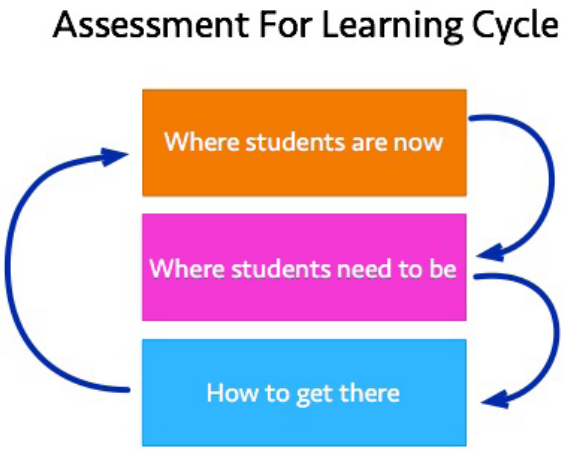
Introduction

Many teachers across the US and the world have embraced the Growth Mindset movement, recognizing that students need to know that there are no limits to students' achievement (Boaler, 2016). But traditional educational practices often get in the way of the good work of teachers, undermining the growth mindset messages they give. Tracking and labelling students is one practice that leads to dangerous fixed mindsets among students (Romero, 2013), another, that will be the focus of this paper, is the ways students are tested and graded, especially in mathematics classrooms. We are fortunate at youcubed to be connected to thousands of innovative and caring teachers who read research and embrace change. In this paper we will share the work of three different high school mathematics departments who have successfully changed their students' focus from one of performing to one of learning. We have chosen to focus on high schools as these are the places in which students often feel tremendous performance pressure, from frequent testing and grading, that causes them to lose their focus on learning and growth and replace it with a focus only on performing. The ideas and examples in this short paper go well beyond high school and are intended to help teachers of any grade level, from kindergarten to college.

Research studies have consistently shown the benefits of a growth mindset culture and the drawbacks of frequent testing and grading (Boaler, 2015; Lemos & Verissimo, 2014; Dweck, 2006). The "Assessment for Learning" (A4L) approach developed in the UK reframes assessment as an opportunity for students to learn 3 things: Where students are now, Where they should be, and How to get there.

The A4L approach highlights opportunities for students to take responsibility for their learning and to be given useful information about ways to progress from teachers' diagnostic comments and student self and peer assessment. Paul Black and Dylan Wiliam, pioneers of the A4L approach, share that the impact of any country moving to an A4L approach would be so great that it would move a country, in international comparisons, from a place in the middle of the pack to a place in the top 3 (Black & Wiliam, 1998a, b Black et al, 2002; Wiliam & Leahy, 2015). This paper will share the ways 3 mathematics departments in the US took A4L ideas and developed them in their schools, to great effect.



Why is it Important to Shift the Focus of Classrooms from Performance to Learning?

Significant evidence points to the importance of students knowing they are on a growth journey and that learning is a process of hard work and takes time (Boaler, 2016; Blackwell et al, 2007; Dweck, 2006). We have found that it is important for teachers to emphasize growth and learning in mathematics, and de-emphasize performance, in order that students stay motivated and encouraged about their learning. A study of 5th grade teachers who took the "How to Learn Math Class" and changed their teaching to emphasize growth mindset messages and approaches showed that the students' achievement significantly increased by the end of the school year, and the students developed significantly improved beliefs about themselves and mathematics, compared to a comparison group of teachers who did not take the course (Anderson, Boaler & Dieckmann, in press). By contrast, in an important study of 1st and 2nd grade students, researchers (Park et al, 2016) found that students with a growth mindset had higher mathematics achievement levels. They also found that the more any teacher focused on classroom performance outcomes the more students developed fixed mindsets over the school year. The focus on classroom performance the researchers refer to can be as simple as words such as – "you need to know this by the end of the year" that orient students towards performance and away from learning. As there is conclusive evidence that fixed mindsets are associated with lower achievement (Blackwell et al, 2007; Dweck, 2006), it seems that any messages or practices teachers give or use that contribute to fixed mindset thinking among students should be addressed. Assessment plays a key role in the messages given to students about their potential, and many classrooms need to realign their assessment approach in order to encourage growth instead of fixed mindsets among students.

Why Move Away from Frequent Grading and Testing to an A4L approach?

The traditional forms of assessing students that have been used across the US for decades were designed in a less enlightened age, when it was believed that grades would motivate students. But grades are a summative measure – they give a record of where someone has reached at the end of a course or unit of work. One of the reasons for the performance culture in the US is the widespread use of grades, not as an end point, but as weekly or more frequent feedback. In other words a summative tool is used to assess formatively. The problem with this is a grade tells you little, other than where you are in relation to others. For this reason grading is categorized in research studies as "ego feedback". If we consider the A4L principles of showing students where they are, where they need to be and how to get there, grades seem wholly inadequate as they do none of these things. Even worse students often view grades not as feedback on where they are in their learning but as a judgement of who they are – which is why students can often be heard describing themselves as an A student, or an F student. Grades are blunt instruments that are not oriented towards growth or learning – and, importantly, give no feedback to learners on what they should do differently. Fortunately there are other assessment methods that are helpful for students, much more nuanced and oriented towards growth.

A few years ago two maths teachers at High Tech High school in Chula Vista, San Diego decided to change their assessment practices and they wrote a letter to parents, communicating their concerns about grading. The full text of the letter is available here (Link 1), it included this important paragraph:

The anxiety students feel with regards to grades is like a dark cloud that hangs over them. No matter what is going on in class, or how much they are enjoying the topic they are learning, there is still this looming pressure to perform in order to receive the highest grade possible. Whether it's higher achieving students or lower achieving students, many students' focus is on performing in order to achieve a certain grade.

The teachers, who are featured in this paper, worked to address the performance culture and the removal of grades was a key part of their work.

Teachers give grades to students because they think they are motivational, but often they serve the opposite purpose. In a short film on youcubed, (Link 2) we hear from a middle school girl, Delia, who shares that the F she gained in her maths class not only stopped her trying in maths but in all of her classes. As she recalls: "When I saw the F on my paper I felt like a nothing. I was failing in that class so I thought I may as well fail in all my other classes too. I didn't even try." This describes the ways in which students interpret low grades and how they can prompt low motivation from that point on (see also Abeles, 2016).

"When I saw the "F" on my paper I felt like a nothing." Delia

In an A4L approach grades are replaced with diagnostic feedback – which is probably the greatest gift teachers can give to students – a teacher's feedback on what students are doing well and what they need to work on, with specific ideas for them to try. Diagnostic feedback takes longer than simple checks and crosses and scores or grades, but it does not need to be given as frequently as its value is long lasting. Ruth Butler (1987, 1988) has performed a number of research studies - followed up by Pulfrey et al (2011) showing that when grades are replaced with diagnostic feedback, students' achievement increases – including both the highest achieving (top 25%) and lowest achieving (lowest 25%) students. The book: "Mathematical Mindsets" details the story of a middle school teacher who shifted her students from a performance to a learning culture by replacing tests with rubrics and diagnostic feedback, which she learned to give at a rate that she could manage, with multiple classes of students to teach.

In the cases that follow we will hear from teachers who have moved to giving students diagnostic comments and have moved to replace grades entirely, or use them only at the end of units, courses or semesters.

Testing

Another way in which a damaging performance culture is cultivated is through frequent testing. Many teachers who have embraced the need for a growth mindset culture are frustrated by testing as they tell students that mistakes and struggle are important for brain growth, and then are forced to grade them down every time they

make a mistake. John Hattie is an Australian researcher who conducts meta-analyses – bringing together different research studies and measuring the impact of the innovation upon learning and achievement (Hattie, et al, 2016). Any factor with an effect size of over 0.4 is regarded as positive and worthwhile for students' learning. In his meta-analysis involving 70,000 studies with 300 million students the 5 highest factors, out of 150, that increased students learning gains significantly were these:

1. Students reporting their own progress (1.44)
2. Piagetian programs (teaching that focuses on students' thinking) (1.28)
3. Response to intervention – (giving assistance to students who need extra help) (1.07)
4. Teacher credibility - students trusting their teacher and believing them to be competent (0.90)
5. Formative Evaluation – teachers using A4L methods (.90)

It seems noteworthy that two aspects of Assessment for Learning, students reporting their own progress and teachers using formative methods (such as diagnostic comments) are among the top five factors and students reporting their own progress has the highest impact of all. Conversely the impact of "teaching test taking" comes in at a lowly 98th place with an impact of 0.27 – well below the 0.4 effect size that makes an educational practice worthwhile.

Another reason for us all to give pause before giving students individual mathematics tests is the possible consequences for gender equity, as results from two different PISA assessments show. In 2012 the PISA team conducted a focused analysis on mathematics, with a special report on gender (PISA, 2017a). Alarmingly they found that girls achieved at significantly lower levels than boys in 38 countries, but when anxiety was factored into the results achievement differences disappeared – the factor that was really making the difference was that girls were more anxious than boys when it came to the testing. Contrast this with the results of a PISA test on collaborative problem solving (PISA, 2017b). Students were tested individually but they interacted with a computer agent, using their ideas to help solve complex problems together. In that collaborative assessment girls outperformed boys in all 51 countries. This incredible achievement for girls was matched by another important result - in the collaborative assessment there were no differences in the achievement between students from advantaged and disadvantaged backgrounds, something that is very unusual in large scale testing. Considering these two PISA results side by side suggests that girls are disadvantaged in individual tests of mathematics as anxiety reduces their capacity to be successful, but they are enabled in tests that involve collaboration, even with a computer agent.

Program for International Student Assessment (PISA) by the Organisation for Economic Co-operation and Development (OECD)

If individual testing of students is unhelpful for learning, and may also be gender inequitable, why do so many mathematics teachers give frequent tests? This is probably because they see some benefit in students' learning and recent brain science gives helpful insights into what that benefit may be.

Elizabeth and Robert Bjork are learning scientists at UCLA who have studied productive learning for decades and they point out something important. They have shown that retrieval of information from the brain is very helpful in

remembering information, in fact every time we retrieve something it changes in the brain, and is more accessible when needed later. Daniel Coyle (2009) has written a fascinating book called "Talent Code: Greatness Isn't Born. It's Grown. Here's How" in which he investigates the ways people achieve at the highest levels, pointing out that "talent" comes from work and not genetics. The particular type of work that Coyle identifies is interesting as he points out the value of being in situations where you test yourself and make mistake after mistake, constantly pushing at the edge of your understanding. Testing could achieve what these different scientists recommend – but not if the test is graded or used to contribute to a grade, as then the focus shifts from learning to performing – and for many students, anxiety. If students tested themselves or peers tested each other, using difficult questions that promoted mistakes, retries and the recall of information, then they would be engaging in what Bjork calls "desirable difficulties" and Coyle refers to as "targeted mistake-focused practice". This type of work is extremely valuable for students but it should not be graded or assessed. Instead the focus of the testing should be on students' improvement and learning.

Different studies suggest that the best type of testing is self-testing, peer testing and collaborative, group testing, and the next decade may be a time when all of these forms of testing are developed and refined by innovative teachers, hopefully replacing the individual, anxiety-provoking testing that plays such a large part in students' lives at this time.

What About Homework?

Many high school students think they are performing all day in school, and when they get home they continue to perform – often until the early hours of the morning. Technology has not been helpful in this regard as now students can check their grades online, and often do so at multiple times of the day, well into the night - so they are constantly feeling that they are performing. Homework adds to the feeling of performance, especially the repetitive questions that students typically take home that have little value and rob children and families of something extremely important - quality home time. Effective practice that stimulates the brain is not the repetition of similar questions over and over again; it is multi-dimensional and involves students representing ideas in many different ways, thinking creatively, and visually, and moving between words, visuals, numbers, and other mathematical forms (for more detail see Boaler, 2016).

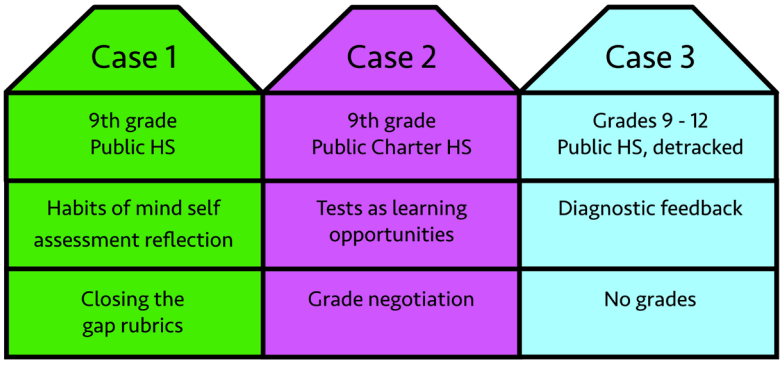
A group of thoughtful middle school teachers with whom we have worked, that appear in the book "Mathematical Mindsets", needed to give homework so they stopped giving practice questions and instead gave important reflection questions. They would choose one or two from a list that included:

- What was the big idea we worked on today?
- What did I learn today?
- What good ideas did I have today?
- What did I struggle with today?
- Where could I use the knowledge I learned today?
- What questions do I have about today's work?
- What new ideas do I have that this lesson made me think about?

Reflection questions are important for students and help move the focus from performance to learning. In this blog post and book Alice Keeler, high school mathematics teacher and thought leader, describes the ways she replaced homework with more thoughtful opportunities for practice. (Link 3)

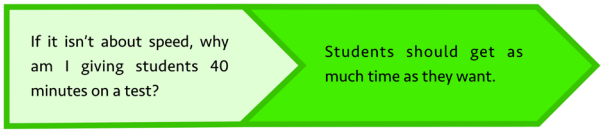
In the three cases of change, that make up the rest of this paper, we will learn about three different high schools – two of them public comprehensive schools, in Chicago and Colorado, and one a public charter school in San Diego. The different cases share teachers at different stages of the journey, and in different situations. Our first case features the work of Laura and Jon, two teachers in a large public high school in the first year of change who are working to reduce grading. Our second case features Gavin and Aurmon who have been developing A4L ideas for a few years and now only use grades summatively, and the third case features an entire mathematics department who have developed A4L practices over twelve years and eliminated grading all together. Each of the cases share what we think are helpful and different practices that others may learn from.

This visual shows grade levels taught and some assessment practices in each case.



Case 1: One Year In: Teachers Grading Less

Laura and Jon are two maths teachers at New Trier High School, Illinois, a large public school with over 4000 students. The 2 teachers read "Mathematical Mindsets" and other youcubed resources and began asking questions of the traditional assessment system in the school. In particular they asked two important questions: 1) "If we really value mistakes how can we be testing students and then saying you are done? Instead we need to say, 'keep making mistakes and we'll see how you grow over time.'" 2) "If it isn't about speed, why am I giving students 40 minutes on a test? Students should get as much time as they want."



In the fall of 2017, Laura and Jon focused on developing assessment practices that give students information about their own learning. As a part of integrating 'students reporting their own progress', which Hattie found to be so powerful, they developed a Habits of Mind Self-Assessment and Reflection for students:

Habits of Mind: Self-Assessment & Reflection

Name: Date: Period:

HoM	Novice	Emerging	Proficient	Advanced
Makes Sense of Problems and Perseveres in solving them. I can make sense of a problem and I will keep at it.	I am generally: • unable to make meaning of the problem. • unable to initiate a solution. • unwilling to take on a challenge.	I make meaning of a problem, however I may: • misinterpret the given information. • not verify reasonableness of solution. • not check answers. • need support to take on a challenge.	I make meaning of a problem by analyzing givens and goals. I make conjectures about the form and meaning of the solution. I monitor progress and change course if necessary. I continually ask "Does this make sense?" I check answers. I persevere to solve challenging problems.	
Reason Visually, Numerically, and Abstractly I can show my thinking in multiple ways.	I represent my thinking in only one way.	I use multiple representations to show my thinking, however I may: • use an invalid representation. • not demonstrate connections. • not use appropriate tools.	I use multiple representations to show my thinking (pictures, diagrams, numbers, words, tables, graphs, expressions, etc.) and am able to demonstrate the connections among them. I understand the meaning of the quantities. I use a variety of tools (including technology) appropriately to explore and understand a problem.	
Create Viable Arguments & Critique the Reasoning of Others I can make conjectures, defend my thinking when faced with a skeptic, and be a skeptic for others.	I generally: • am unable to make my own conjectures. • struggle to make arguments.	I am able to make conjectures, however I may: • be unclear in my presentation. • not confirm the validity. • have difficulty making sense of others' arguments.	I make conjectures and explore the validity of those conjectures. I present my thinking with clarity and purpose in spoken and written forms. I make sense of others' arguments and determine their validity. I ask clarifying questions.	
Think Interdependently & Flexibly We achieve more when we work together and listen to each other's ideas – synergize.	I generally: • struggle to remain engaged and contribute to my group. • judge the ideas of others. • respond to others with rigidity.	I am a mostly productive member of my group, however I may: • have difficulty listening to others. • exclude others. • be unwilling to be flexible in my thinking. • be unwilling to teach/learn from others. • not value mistakes.	I am an engaged, productive member of my group. I share ideas, listen to others, and build ideas collaboratively. I teach others with new ideas and concepts. I am willing to learn from others, shift perspective, consider other options, and generate alternatives. I value mistakes and use failures to motivate and adapt my strategy.	

Reflection: (Do on a separate piece of paper – feel free to type or hand-write)

1. Reflect on one HoM for which you rated yourself "Master" or "Exemplary" (What went well? How do you know? Be as specific as you can.) Didn't rate yourself there yet, that's okay just talk about why not.
2. Reflect on one HoM for which you would like to focus your growth. Why do you want to grow here? What do you think you need to do to achieve your growth?

Please leave me the space on the page to write you some comments.

The teachers have designed the "Habits of Mind Self Assessment and Reflection" to give at the end of terms and they have deliberately left the advanced column blank, so that students can come up with their own ideas for what it means to be advanced.

Another strategy that Laura and Jon have adopted is to allow students to revise tests without penalty. They no longer write points or grades on the tests or 'Gap Check'. Instead they write feedback throughout the Gap Check and include a list of criteria along with their comments on how students are progressing (See Gap Check Rubric below). Students receive this feedback from the Gap Check and if they have areas where they need to do more work they are not penalized in any way. Instead they are given the opportunity to complete a 'Close the Gap' activity where they reflect on their work and complete revisions and extension problems. After students complete the 'Close the Gap' assignment they are given a 'Learning Summary' for the unit that describes how the student is progressing on key ideas from the unit (See example Learning Summary on page 9).

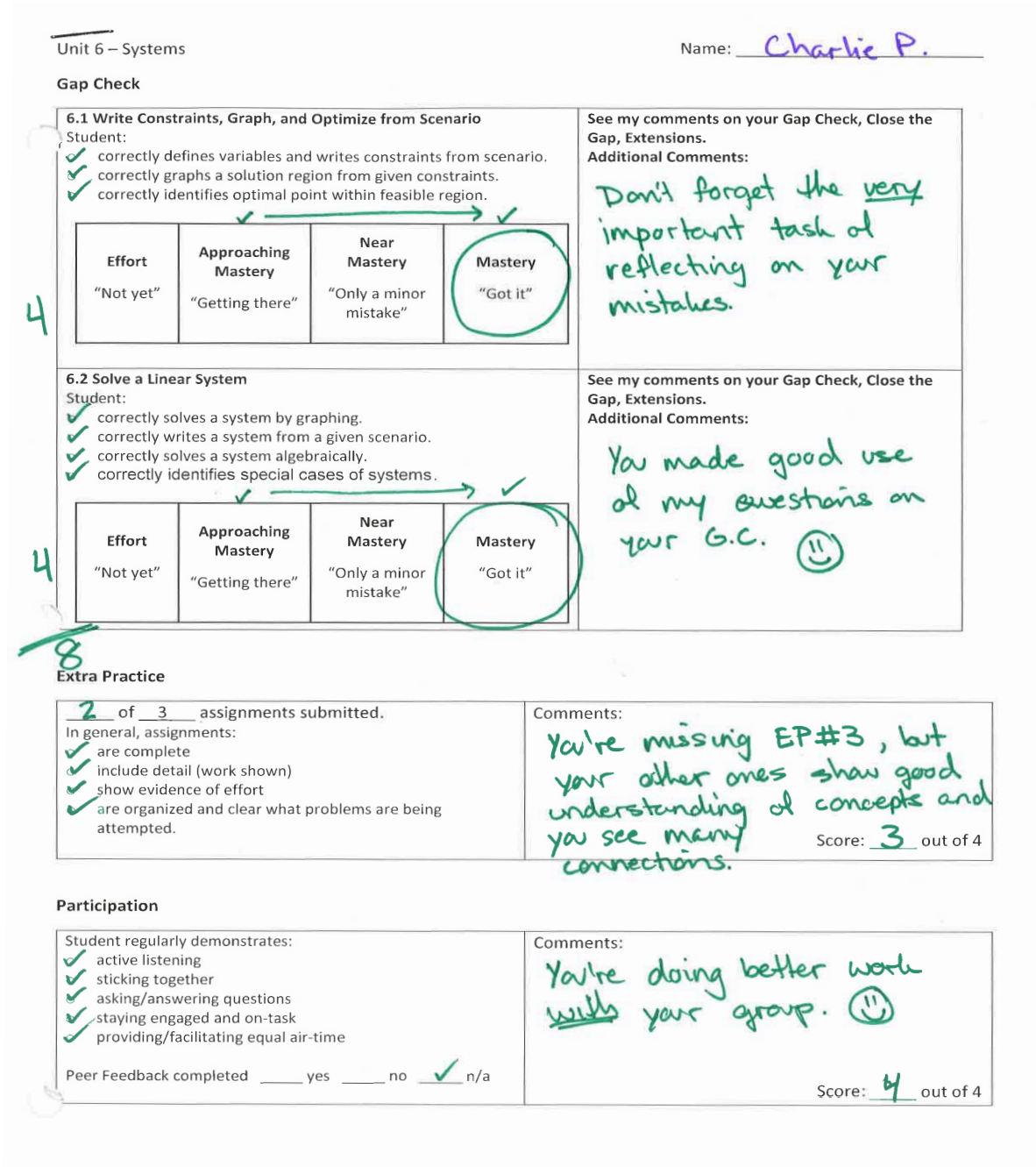
Allowing students to revise tests is the ultimate growth mindset message, communicating to students that you care about learning, not just performance. Some teachers think this is unfair, as students may go away and learn on their own what they need to, to improve their achievement; but we should value such efforts, as they are, at their core about learning.

Below are examples of a Gap Check Rubric and a completed Learning Summary for a student.

Gap Check rubric example:

U5.1 Transformations & Graphs of Absolute Value Student show knowledge of the Absolute Value parent function and: • correctly graphs transformations of absolute value functions. • correctly identifies transformations. • correctly identifies characteristics of transformed function.	Comments:

Learning Summary example:



Unit 6 – Systems

Name: Charlie P.

Gap Check

6.1 Write Constraints, Graph, and Optimize from Scenario

Student:

- ✓ correctly defines variables and writes constraints from scenario.
- ✓ correctly graphs a solution region from given constraints.
- ✓ correctly identifies optimal point within feasible region.

Effort	Approaching Mastery	Near Mastery	Mastery
"Not yet"	"Getting there"	"Only a minor mistake"	"Got it"

4

See my comments on your Gap Check, Close the Gap, Extensions.
Additional Comments:

Don't forget the very important task of reflecting on your mistakes.

6.2 Solve a Linear System

Student:

- ✓ correctly solves a system by graphing.
- ✓ correctly writes a system from a given scenario.
- ✓ correctly solves a system algebraically.
- ✓ correctly identifies special cases of systems.

Effort	Approaching Mastery	Near Mastery	Mastery
"Not yet"	"Getting there"	"Only a minor mistake"	"Got it"

4

8

See my comments on your Gap Check, Close the Gap, Extensions.
Additional Comments:

You made good use of my questions on your G.C. ☺

Extra Practice

2 of 3 assignments submitted.

In general, assignments:

- ✓ are complete
- ✓ include detail (work shown)
- ✓ show evidence of effort
- ✓ are organized and clear what problems are being attempted.

Comments:

You're missing EP#3, but your other ones show good understanding of concepts and you see many connections.

Score: 3 out of 4

Participation

Student regularly demonstrates:

- ✓ active listening
- ✓ sticking together
- ✓ asking/answering questions
- ✓ staying engaged and on-task
- ✓ providing/facilitating equal air-time

Peer Feedback completed _____ yes _____ no ✓ n/a

Comments:

You're doing better work with your group. ☺

Score: 4 out of 4

Jon and Laura's online grade book no longer shows totals or a grade, but scores from the rubrics that go towards the grade decisions they make at the end of the semester. Jon and Laura are only a few months into their journey but they are already seeing a reduction in student stress. Students now know that they can show what they know in a 'Gap Check' and if they make a mistake or do not understand something yet, they have an opportunity to learn it and show their understanding later. Students are being helped to understand that learning is a process and not a performance and teachers and students are celebrating growth and learning together. Laura and Jon are the only 2 teachers from their department of 50, who are making these changes, and they are excited to connect with and learn from other teachers who are employing Assessment for Learning principles.

Case 2: A Few Years Along: Grading Summatively

Gavin and Aurmon started teaching 9th grade mathematics at High Tech High in San Diego six years ago. They began making their classrooms more student-centered in their 2nd year of teaching. As they did this, they realized that their assessment system wasn't aligning with their messages to students about learning from each other, persisting in solving problems, making mistakes, and learning over time. In the summer of 2015, they attended a Youcubed conference and decided to make dramatic changes in the way they assessed students so there was alignment between their approaches to teaching mathematics and the ways they assessed students. They changed to giving students only a pass/no pass with written feedback on their work and opportunities for revision that do not involve assigning points. A pass is based on completion of work including participation in the revision process. In addition to quizzes and tests, students build portfolios throughout the course in which they keep evidence of their work and learning over time. Students develop paper portfolios of their work and digital portfolios where they respond to questions around the big ideas from the unit.

When students receive their tests/quizzes back, questions are marked correct or incorrect with written feedback to help students identify their mistake or to provide a prompt to help get them unstuck. Whether students miss every question or whether they get every question correct, all students are given additional problems. For some students, the questions they are assigned are questions that are scaffolded in a way to provide more access to problems that were seen on the test. By working on these problems, the teachers hope that the students will be able to develop the understanding they need. For some students, the assigned questions are simply extension questions to help challenge their thinking. The reason why all students are assigned additional questions it to help reinforce the idea of growth in their understanding. No matter how well the student did on the test, there should be opportunities for the student to push their thinking and to understand concepts more deeply.

A grade negotiation process between the teacher and the students decides semester and course grades. In preparation for the meeting with the teacher students complete a self-assessment rubric that contains four categories: math content understanding, group participation, class participation, and work ethic, see below:

End of Semester Rubric Name: _____

I think I deserve a _____ because...

Meets the criteria. . .	Quality	Comments
Growth in Content Understanding: I am able to show growth in my understanding of the content through: • Assessments • Classwork • Class discussions • Responding to feedback What's the first thing I do when I get a new problem? • How much do I push myself to try to understand what is happening in class? • What actions do I do to get unstuck? • How often do I challenge myself?	Exceeds I am constantly pushing myself to understand the content. I am excited and eager to not only learn the math but to also understand WHY a solution works. If I don't understand something, I question constantly until I am able to restate it for myself. I've displayed this in class by... Meets I work to understand the math content in class. I want to get the answer correct, but I also try to understand why a solution works the way it does. If I don't understand something, I will ask questions until I feel more comfortable with it. I've displayed this in class by... Approaches Sometimes I work to understand the math we're doing in class. I'm satisfied with just getting an answer correct, I don't always push to understand the "why". If I don't understand something, I sometimes ask questions, but sometimes I don't do anything about it. I'm still learning how to..	
Growth in Group Participation: I am able to show growth by participating in: • Small group work • Group quizzes • Participation quiz How do I typically contribute during group work? • Listening • Sharing an idea • Asking questions/being a skeptic • Restating another student's thinking • Understanding and valuing another student's idea	Exceeds I am a fantastic group member. I regularly share my ideas with my group and constantly value the ideas of my groupmates. I push myself to try to make sense of their ideas and help their learning by asking them to restate my ideas when I share. I also try to restate my group's ideas to show that I value their ideas. I have demonstrated this by... Meets I contribute to my group by sharing ideas and asking questions. When I feel comfortable with my solution, I share what I know. When I don't understand something, I ask one my groupmates to explain it to me and move on. I demonstrated this by... but I know I still need to improve in... Approaches I am typically quiet during group work or prefer to work by myself. I rarely like to share my ideas or speak up to ask my groupmates questions. When I'm confused, I simply tell my groupmates "I get it" or remain quiet. I rarely check in with my group and have often worked ahead of my groupmates. I'm still learning how to...	
Growth in Class Participation: I am able to show growth by participating in: • Class discussions How do I typically contribute during class discussions? • Listening/Making eye contact • Sharing an idea • Asking questions/being a skeptic • Restating another student's thinking • Understanding and valuing another student's idea How often do I raise my hand per week?	Exceeds During class discussions or share outs, I'm eager to stay involved. I often raise my hand to volunteer. I always keep eye contact with the people speaking. I ask questions when I I'm not sure what somebody is saying. I am always confident that I can restate my classmates ideas if I'm ever called on. The area I'm proudest of is... Meets During class discussions or share outs, I like to stay involved. I raise my hand to volunteer. I keep eye contact with the people speaking. I sometimes ask questions out to the class when I hear something I don't understand. I still get nervous whenever we use the playing cards to randomly call on students. I can usually restate my classmates ideas but sometimes I can't and I stay quiet. I am proud that I've gotten better at... but I still want to improve in... Approaches During class discussions I'm still figuring out how to stay involved. I don't raise my hand to volunteer. Sometimes I don't keep eye contact or pay attention when my classmates are sharing. I'm okay with staying quiet at times when I don't understand something. I'm going to get better at this by...	

During the grade negotiation process students present their self-assessment rubric and their portfolios to their teacher as evidence for the grade they believe they should receive. Gavin and Aurmon recall that students usually assign themselves the same grade that the teacher would have assigned or a lower grade. It is very rare that students assign themselves a higher grade than the teacher believes they should receive.

After three years of implementing changes in their assessment system Gavin and Aurmon are very happy with the changes they see in students - they see that students have moved their focus off grades and onto learning. They also report that students are less stressed and have taken more ownership of their own learning process. The teachers continue to refine and develop their practices as they learn more about the most effective assessment methods for their students.

Case 3: Twelve Years Along: No Grading

Twelve years ago Castle View High School opened to accommodate the rapidly growing population of Douglas County, Colorado. The school was opened as a reform-based school; the mathematics department leaders recruited like-minded teachers who were focused on teaching maths in student-centered classrooms. The mathematics department uses the IMP mathematics program (Link 4) to teach a 21st century mathematics focused on collaboration and problem solving. The department has identified eight big ideas in their mathematics courses: four habits of learning (Modeling, Looking for patterns, Risk Taking & Persevering) and four mathematics content ideas (Multiple Representations, Similarity, Experimentation & Analysis, Modeling) that span their courses. Because the mathematics classes meet every day for 90 minutes, the students complete a year-long class in one semester. At the end of IMP 1-5 the courses available are AP Calc A-B, AP Calc B-C, Calc 3, College Algebra, AP Statistics, and Discrete Math.

From the four mathematics content ideas, course teams developed course goals which teachers use to guide their work and provide feedback to students. Importantly the maths department has agreed that students should not be tracked. Every student goes through the same series of maths courses (IMP 1-5) and students do not retake courses. Students start as freshman in either IMP 1 or 2. Teachers do not hold students back from moving onto the next course.

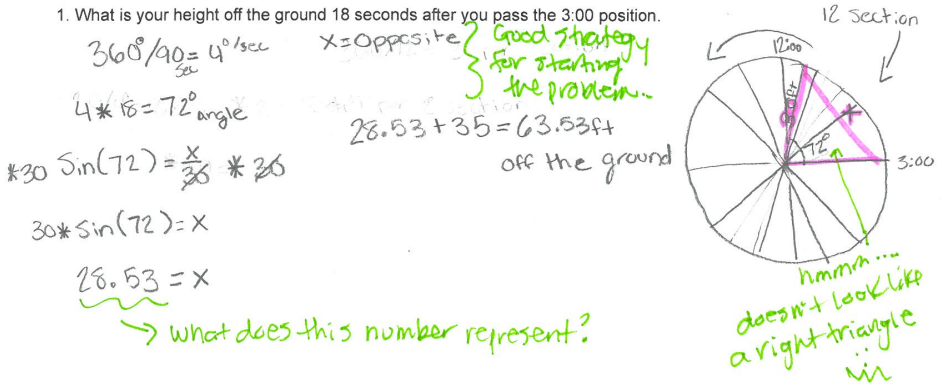
Approximately 4 years ago the teachers were grading assessments using standards-based rubrics but they started to notice that their grades did not reflect what students knew. They felt that their approach to assessment wasn't aligning with the messages about mathematics that they were communicating to their students. They also recognized that grading was creating competition, stress, and fear among students and they wanted to create a "judgment free" environment that did not include grades. Inspired by research, a few of the maths teachers on the team decided to remove grading entirely and they now only give diagnostic feedback on all assignments and assessments, as this example shows:

High Dive – Checkpoint 1 **Name** _____

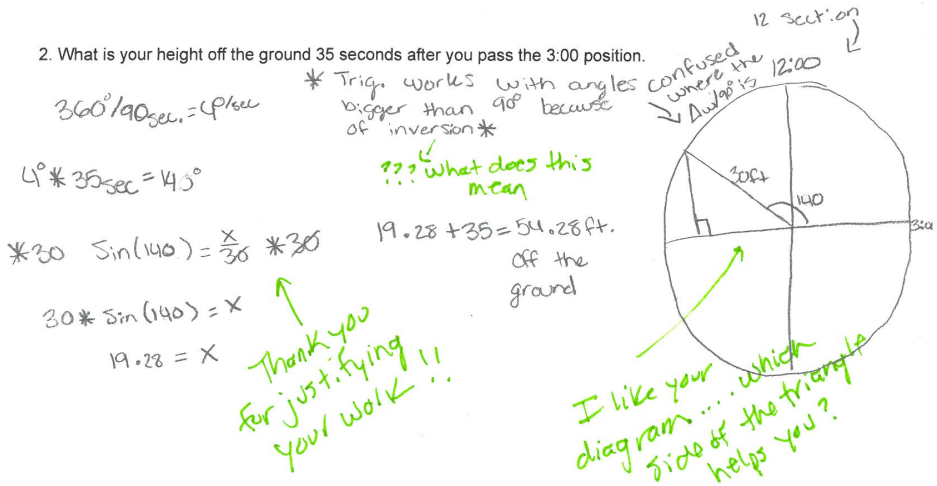
While on a road trip with your family, you stop for lunch in a small town that has a Ferris wheel. This Ferris wheel has a radius of 30 feet, the center of the wheel is 35 feet above the ground, and the wheel completes one full rotation in 90 seconds. (The Ferris wheel still rotates counter clockwise.)

You want to impress your family by telling them how high off the ground you are at certain times. To convince your family of your expertise you justify your solutions by including labeled diagrams and organized work.

1. What is your height off the ground 18 seconds after you pass the 3:00 position.



2. What is your height off the ground 35 seconds after you pass the 3:00 position.



The teachers give personalized feedback, on both areas of strength and areas for growth, based on the course goals and the student's individualized needs. This personalized feedback is what students and families see when they check the online gradebook. When students are not meeting expectations teachers have one-on-one conversations with students to find out more and to encourage them.

Teachers and students know more than ever about students' strengths and areas of growth. And most importantly, the classroom environments have become non-competitive and supportive communities focused on learning rather than performance.

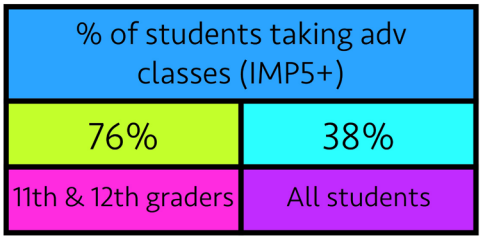
Parents have been positive about the change because the teachers are able to communicate their child's strength and areas

of growth. Sally is one of the mathematics teachers in the department and she described to us her conversations with parents about the change. She says that parents are happy when they know that Sally knows mathematics and knows where their child is at in their mathematics learning. She says that when parents email her, she writes a paragraph sharing what she knows about their child's strengths and areas of growth. Then in a second paragraph she describes how she wants students to focus on the feedback she has given them.

The students are similarly positive about the changes – the following comments come from a survey Kimberly gave to her students to find out how things had changed after grading was removed:

> *"It has allowed me to be relaxed knowing if I ever make a mistake I can come in and learn from it to improve. It allows me to improve in all fields and feel more relaxed in class without so much stress."*

> *"This makes the learning experience much more enjoyable. You are actually able to learn and understand the math not cram the math in your head for a test because you are worried about the grade."*



The five maths teachers who are implementing this approach are finding that students in their classes are less stressed, more engaged, and they work harder to make sense of mathematics. They are also taking more mathematics classes in high school. Students are only required to take three maths classes, but mathematics is now the largest department in the school as students choose to stay with mathematics longer, taking many classes of mathematics. Of the 2143 students at the school last year, an impressive 817 took advanced classes (IMP 5 and above), 38% of the student body. Of the juniors and seniors who are able to take the advanced classes, 76% choose to take them. The high numbers of students choosing to stay with mathematics is perhaps the greatest testament to the change the teachers have made in the school.

Discussion

We are fortunate to be working with innovative teachers that recognize the need to move students from a performance to a learning orientation, encouraging and preserving important growth mindsets. Some people worry that grades are needed for students to get into colleges but at Stanford only 81% of incoming students have a GPA. Other students come from schools that give diagnostic comments and no summative grades or tests. Importantly, if grades are used they should be a summative measure given at the end of courses and ideally negotiated with students using multiple sources of evidence. The following table captures the different ways students may be assessed, showing the ways traditionally used and the ways that we believe encourage a growth mindset.

From Performance to Learning Assessment and Grading Practices

Common US assessment practices	Growth mindset assessment practices
- Frequent individual test taking and grading (weekly quizzes, unit test, mid year exam, final exam) • Problems are multiple choice, procedural, one-dimensional • Each problem scored on a points system • Significant and minor mistakes are weighted the same - Daily homework and homework checks - Daily Exit tickets on procedures from the day - No opportunity for revision on formal assessments	- Journals - Progress check - Anonymous quiz - Participation quiz - Diagnostic feedback (written feedback no grades) - Portfolios and portfolio conferences Individual and group projects and tests • Problems are open, complex, multi-dimensional • Problems can be solved in many ways • Rubric (mastery and standards based) evaluation - Grades represent final understanding or grades are replaced by diagnostic feedback - No time constraints - Opportunities for revision on formal assessments

Many different people and organizations are recognizing the need to move away from a performance orientation based on grades. The Mastery Transcript Consortium (Link 5) is a collective of high schools with a mission to remove grading and instead have assessment be based on transcripts, allowing students to present a range of forms of evidence for their achievement. It was started by a group of private schools and now has hundreds of schools on board. The organization is working with colleges to change their expectations from schools.

A range of colleges is now also moving to replace grading (Link 6), and innovative teachers are courageously creating new classroom cultures oriented around growth and learning. Middle school mathematics teacher Andrew Burnett authored a blog entitled "How to Create a Gradeless Math Classroom in a School that Requires Grades" (Link 7) in which he shares many helpful examples of his "Show me what you can do" assessments and opportunities for self assessments. A facebook group entitled Teachers Going Gradeless (TG2) (link 8) also brings together the teachers who recognize this important cause. The high school teachers featured in this paper are leaders taking steps into a new landscape in which students are encouraged to take responsibility for their own learning, gaining feedback from teachers and others that helps them grow, in a healthy growth mindset culture. They are unusual in taking these steps, but their work is very important and we hope the examples in this paper will help others know about the many different ways assessment can be implemented in classrooms, oriented towards learning and growth. This paper has shared cases from high schools - as the upper grades are where many think students have to have grades. But the ideas are intended for all grade levels K-16. Performance pressure in the years before high school is arguably even

more damaging than such pressure when students are older. Whatever your grade level, country of teaching, or school subject - we hope that these examples are inspiring. The appendix shares other resources and, as always, we welcome feedback and discussion on the ideas we have shared – at #youcubed (Link 9), @joboaler (Link 10) and in our youcubed facebook group (Link 11) . As we work to bring about a mathematics revolution in classrooms, we regard the assessment culture of classrooms as a critical place of change. When we set students free from the crippling idea that they must not fail and can never mess up or make mistakes, and instead celebrate growth and learning, everything changes for them. Students start working with mathematical freedom and teachers feel fully empowered to help them.

Viva La Revolution!

References

Abeles, V. (2016). Beyond measure: Rescuing an overscheduled, overtested, underestimated generation. New York: Simon & Schuster Paperbacks.

Best College Reviews. (n.d.). 10 Colleges without letter grades. Retrieved from https://www.bestcollegereviews.org/colleges-without-letter-grades/

Bjork, E., & Bjork, R. (2009). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In FABBS Foundation & M.A. Gernsbacher (Ed.), Psychology and the Real World (pp. 55-64). New York: Worth Publishers. Retrieved from https://bjorklab.psych.ucla.edu/wp-content/uploads/sites/13/2016/04/EBjork_RBjork_2011.pdf

Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2002). Working inside the black box: Assessment for learning in the classroom. London: Department of Education & Professional Studies, King's College.

Black, P. J., & Wiliam, D. (1998, October). Inside the black box: Raising standards through classroom assessment. Phi Delta Kappan, 139-148.

Blackwell, L., Trzesniewski, K., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. Child Development, 78(1), 246-263.

Boaler, J. (2016). Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages and Innovative Teaching. San Francisco, CA: Josey-Bass.

Boaler, J. (2015, May 7). Memorizers are the lowest achievers and other Common Core math surprises. The Hechinger Report. Retrieved from http://hechingerreport.org/memorizers-are-the-lowest-achievers-and-other-common-core-math-surprises/

Burnett, A. (2018, March 8). How to create a gradeless math classroom in a school that requires grades [Blog post]. Retrieved from https://burnettmath.wordpress.com/2018/03/08/how-to-create-a-gradeless-math-classroom-in-a-school-that-requires-grades/

Butler, R. (1987). Task-involving and ego-involving properties of evaluation: Effects of different feedback conditions on motivational perceptions, interest and performance. Journal of Educational Psychology, 79, 474-482.

Butler, R. (1988). Enhancing and undermining intrinsic motivation: The effects of task-involving and ego-involving evaluation on interest and performance. British Journal of Educational Psychology, 58, 1-14.
Coyle, D. (2009). The talent code: Greatness isn't born. It's Grown. Here's How. New York: Bantam Dell.

Dweck, C. S. (2006). Mindset: The new psychology of success. New York: Ballantine Books.

Hattie, J.; Fisher, D., Frey, N., Gojak, L., Moore, S., & Mellman, W. (2016). Visible learning for mathematics, grades K-12: What works best to optimize student learning. Corwin.

Keeler, A. (2015, July 13). Stop Giving Homework [Blog post]. Retrieved from http://www.alicekeeler.com/2015/07/13/stop-giving-homework/

Lemos, M. S., & Verissimo, L. (2014). The relationships between intrinsic motivation, extrinsic motivation, and achievement, along elementary school. Procedia – Social and Behavioral Sciences, 112, 930-938.

Miller, M., & Keeler, A. (2017). Ditch that homework: Practical strategies to help make homework obsolete. San Diego, CA: Dave Burgess Consulting, Inc.

Organisation for Economic Co-operation and Development (OECD). (2017a). PISA 2015 Results (Volume 1): Excellence and equity in education. A Program for International Student Assessment (PISA) Report. Paris: OECD Publishing

Organisation for Economic Co-operation and Development (OECD). (2017b). PISA 2015 Results (Volume V): Collaborative Problem Solving. A Program for International Student Assessment (PISA) Report. Paris: OECD Publishing

Park, Gunderson, Tsukayama, Levine, and Beilock, Young children's motivational frameworks and math achievement: Relation to teacher-reported instructional practices, but not teacher theory of intelligence. Journal of Educational Psychology, 2016, Vol 108. pp. 300-313

Pulfrey, C., Bucks, C., & Butera, F. (2011). Why grades engender performance-avoidance goals: The mediating role of autonomous motivation. Journal of Educational Psychology, 103(3), 683-700. Retrieved from http://www.researchgate.net/profile/Fabrizio_Butera/publication/232450947_Why_grades_engender_performance-avoidance_goals_The_mediating_role_of_autonomous_motivation/links/02bfe50ed4ebfd0670000000.pdf

Romero, C. (2013). Coping with challenges during middle school: The role of implicit theories of emotion (Doctoral dissertation). Stanford University, Stanford, CA. Retrieved from https://purl.stanford.edu/ft278nx7911

Wiliam, D., & Leahy, S. (2015). Embedding formative assessment: Practical techniques for K-12 classrooms. West Palm Beach, FL: Learning Sciences International

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Appendix

Link 1: https://www.youcubed.org/evidence/aligning-assessment-brain-science/
Link 2: https://www.youcubed.org/resources/why-a-math-revolution/
Link 3: http://www.alicekeeler.com/2015/07/13/stop-giving-homework/
Link 4: https://www.mathimp.org/
Link 5: http://mastery.org/
Link 6: https://www.bestcollegereviews.org/colleges-without-letter-grades/
Link 7: https://burnettmath.wordpress.com/2018/03/08/how-to-create-a-gradeless-math-classroom-in-a-school-that-requires-grades/
Link 8: https://www.facebook.com/groups/277181926058422/
Link 9: https://twitter.com/hashtag/youcubed
Link 10: https://twitter.com/joboaler
Link 11: https://www.facebook.com/groups/youcubed/

Additional Resources

Youcubed assessment advice:
https://www.youcubed.org/resource/assessment-grading/

Mastery consortium:
http://mastery.org

Teachers going gradeless FB page:
https://www.facebook.com/groups/277181926058422/

Hattie Resource:
https://visible-learning.org/john-hattie/

Challenge Success:
http://www.challengesuccess.org/

Alfie Kohn on Homework:
https://www.alfiekohn.org/article/rethinking-homework/