Utilizing Magma Math to Implement Data Driven Differentiated Instruction

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Differentiated Instruction is a pedagogical approach where instruction is modified to optimize learning for individual learners in a diverse classroom (Tomlinson, 2017). Teachers using differentiated instruction implement a variety of strategies to increase student access to a learning objective. Within the literature, there are many models for differentiation, each including different strategies and terminology. One of the most prominent strategies for differentiating instruction across the existing models is tiered assignments (Hall, 2002; Lawrence-Brown, 2004; Pozas et al., 2020; Tomlinson, 2017). Tiered assignments are a set of assignments that target the same learning objective however include variety in their complexity, challenge, learning styles or the interest they appeal to (Heacox, 2012; Pierce & Adams, 2005). The intention is to give all students worthy tasks that challenge them; giving students opportunities to draw on their past experiences, use significant mathematics, and draw connections between mathematical ideas, while ensuring that each student has an appropriate amount of scaffolding and support to be successful (Little et al., 2009). Significant positive effects on student achievement have been found when students experience tiered assignments (Richards & Omdal, 2007; Tieso, 2005). This paper outlines key features of tiered assignments and how Magma Math facilitates data driven differentiation using tiered assignments and formative assessment.

Tiered Assignments

Magma Math facilitates tiered assignments by providing teachers access to a library of assignments that are organized by learning objectives and differentiated into three categories of difficulty. Tomlinson (2017) describes that to develop tiered assignments teachers should first start with the critical knowledge, understandings, and skills and then vary the difficulty of the task to develop the tiers. Little et. al (2009) outline three mechanisms of differentiating tiered assignments: (1) increasing or decreasing the number of facets, (2) altering the level of abstraction, and (3) expanding the problems to adjust the degree to which students are asked to stretch their understanding. These mechanisms are not mutually exclusive; they can be used in combination with one another.

The number of facets in a problem can be increased or decreased by adjusting the number of problems, variables, and/or steps. Facets can also be decreased by adding scaffolding that directs students to focus on fewer facets at a given time. For example, Little et. al (2009) gives two sets of trinomials for students to factor. The first set includes trinomials like $3x^2 + 14x + 8$ and the second set includes trinomials like $6x^2 + 28x + 16$. The second set of trinomials have a composite leading coefficient which adds an additional facet to the problem as students must consider the possible factorizations of 6 in their solution.

Altering the level of abstraction can be accomplished by requiring different levels of reasoning. As an example, Little et. al (2009) provides one prompt where students are asked to factor three expressions that are factorable and a second where not all expressions are factorable. Students then are asked to explain why the expressions cannot be factored in the cases where the expression is not factorable. The second prompt has an increased level of abstraction as students are reasoning about the structure and properties of the expressions.

The final mechanism of differentiating tiered assignments outlined by Little et al. (2009) is expanding problems. This strategy involves moving between foundation skills and transformational applications. For example, solving an equation for x is a foundation skill for grade 8 students in the United States. An example of a transformational application extending this activity is for students to model a situation using an equation to find a real-life solution by solving the equation for a variable.

Magma Math uses a blend of these mechanisms described by Little et al. to categorize problems as easy, medium, or hard (2009). Consider the three problems in Figure 1 from an assignment targeting the learning objective writing linear equations in slope-intercept form. The problem classified as medium difficulty is representative of the learning objective. It captures the critical skill for the learning objective suggested by Tomlinson (2017) as the starting point for building the tiered assignments. To complete this task, students will need to find the slope of the line and the y-intercept, then collate this information into an equation in the form of $y = mx + b$. The problem classified as easy includes additional scaffolding. Here, students are directed to perform the individual steps necessary to find the equation. The scaffolding reduces the number of facets the students must consider at any given time by directing their attention to specific features of the graph in each part (Little et al., 2009). In the problem classified as hard, students must extend what they know about graphs and their equations to decide how to determine whether Stephanie's equation is correct. The problem has added difficulty because the y-intercept is not included in the graph given so students must use reasoning from the information they have to determine whether 2.5 is a reasonable value for the y-intercept.

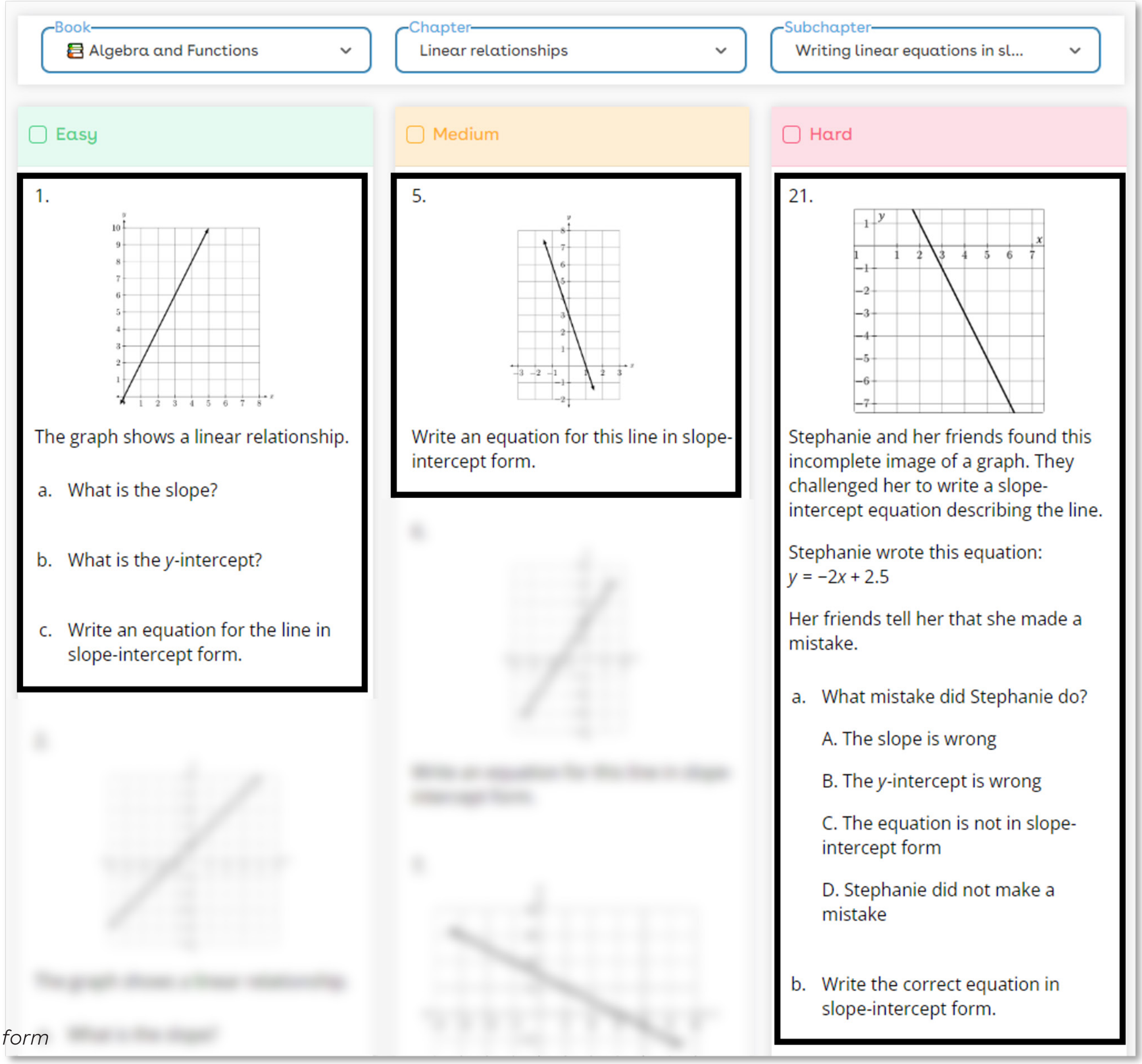


Figure 1: *Example problems for assignment on writing linear equations in slope-intercept form*

Another example of how problems are tiered is shown in Figure 2. In the problem classified as easy, students are given two fractions with shared denominators and a diagram demonstrating the whole and the parts for each fraction in the subtraction problem. Here, the diagram gives a concrete representation for the meaning of the symbolic notation making the problem less difficult (Little et al., 2009). The medium problem features a subtraction problem with two fractions with common denominators, which is the target learning objective. The hard problem features a subtraction problem where students must first conceive of 1 as $^{23}/_{23}$ before they can complete the problem, increasing both the number of facets and the level of abstraction.

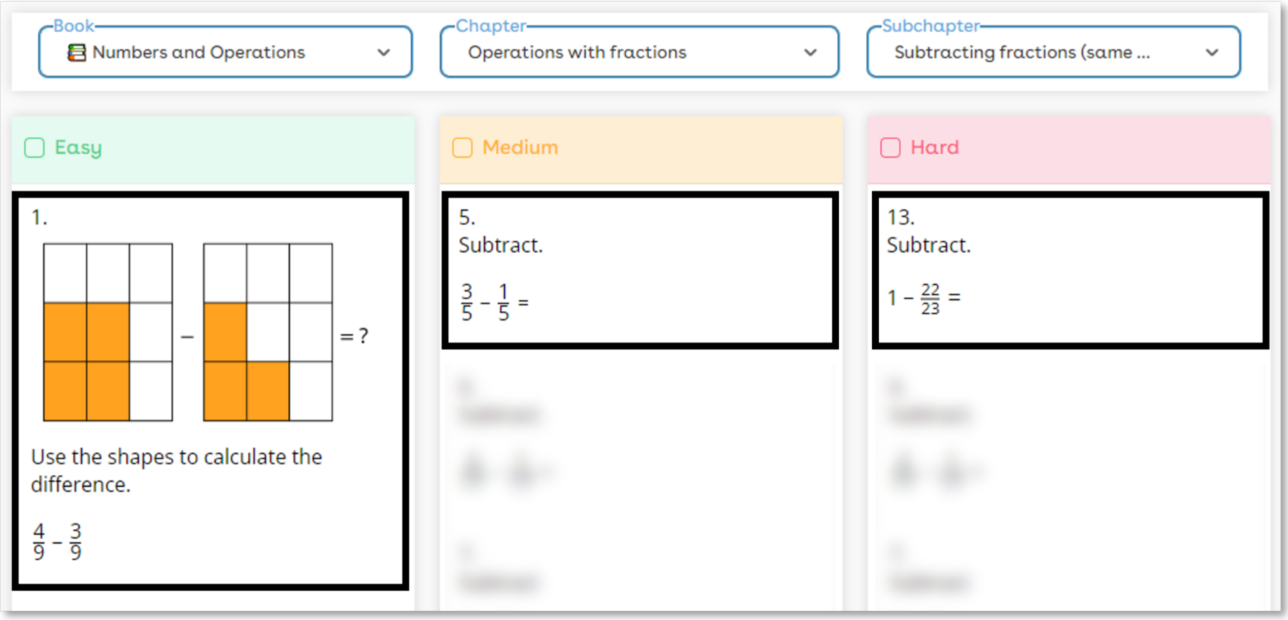


Figure 2: *Example problems from assignment on fractions*

Formative Assessment

Assessment as a teaching tool before, during, and after learning takes place is one of the foundational guidelines for differentiated instruction outlined by Tomlinson (Tomlinson, 1998, 2000, 2001, 2003, 2014, 2017). Regular formative assessment is necessary for tiered assignments to be used effectively. For students to see positive gains teachers need to be able to correctly assess students' understanding before assigning students to a tier (Helmke, 2014; Praetorius et al., 2012; Smit & Humpert, 2012). Tiers differ from fixed ability grouping or tracking in that tiers should be flexible and that a student's performance on prior assignments should inform the teacher of the appropriate tier to assign to the student on the next assignment (Little et al., 2009).

The implementation of data driven differentiated instruction faces some real challenges in the classroom in the form of time limitations and accessibility of data. In a 2020 review of empirical studies, Lavania and Nor found that time constraints was one of the most frequently found barrier to teacher implementation of differentiated instruction. Furthermore, Earl and Katz (2002) found that lack of accessibility to data – or access to data when needed – was commonly cited as reasons teachers did not use data in their pedagogical decision making. On each problem and the learning objectives, Magma Math provides teachers with immediate data on individual and class performance. Data is displayed to teachers in multiple easy-to-interpret graphics giving teachers quick access to data to make pedagogical decisions.

Magma Math assignments are graded immediately upon completion. The Heatmap (see Figure 4) shows teachers an overview of each student's individual performance on the problems assigned to them. Teachers can at a glance note which problems students completed correctly on their first attempt in green, problems completed correctly on additional attempts in yellow (with the number of attempts given in the box), and problems completed incorrectly in red with the number of attempts given.

		1 83%	2 83%	3 50%	4 16%	5 83%	6 83%	7 16%	8 66%
Charlie Magma	5/8	2				1	1		1
Lizzie Magma	5/8			1	1			1	
Daniel Magma	5/8			1	1			1	
Sara Magma	3/8		1		1			1	1
Grace Magma	5/8	1						1	
Terry Magma	6/8				1		2	1	
Demo Teacher Ma...	0/8								

Figure 4: *Heatmap*

To further understand student performance, teachers can click on a problem to access the Solutions Matrix (see Figure 5). Here, teachers can scroll through cards of each student's work, allowing them to quickly note what strategies or representations students use across the classroom. By clicking on a student's individual work, teachers can view the work in full size (see Figure 5 and Figure 6) to better determine the support or extension the individual student needs in relation to the content goal.

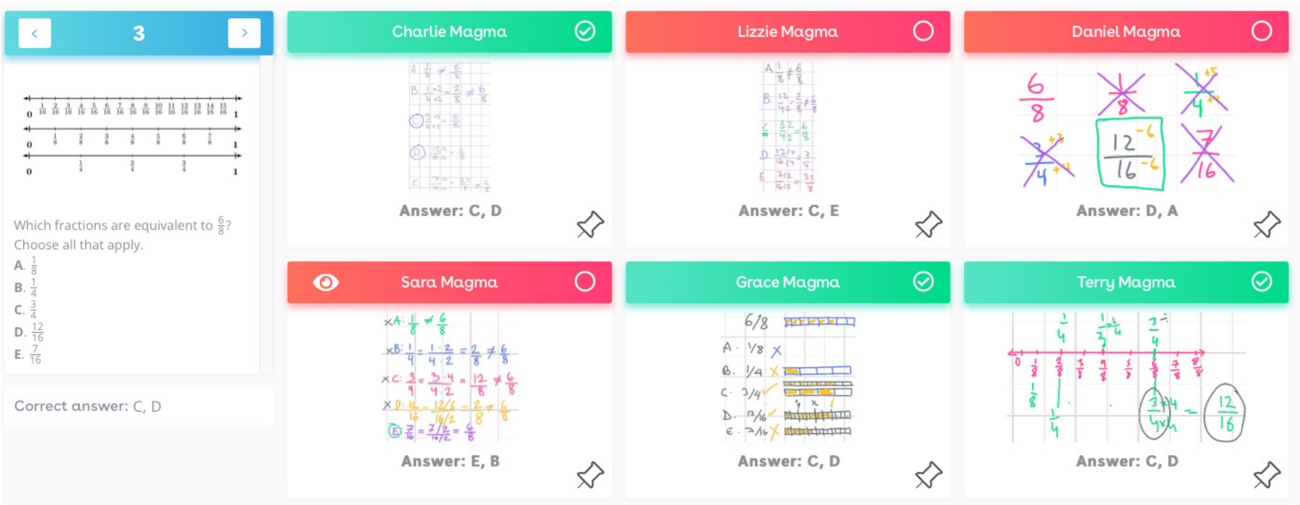
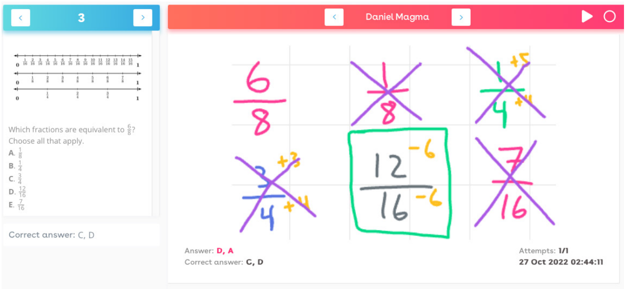


Figure 5: *Solutions Matrix*

For example, as we see in Daniel and Lizzie's work, they both have incorrect answers. However, Daniel's work indicates a fundamental misconception about fraction equivalence while Lizzie's work demonstrates understanding of fraction equivalence, but she made a calculation error. Without their work, these students would be assumed to have the same level of understanding of fractions. Access to the student's work and not just their answer allows teachers to know exactly what conceptions the student has, and plan accordingly.



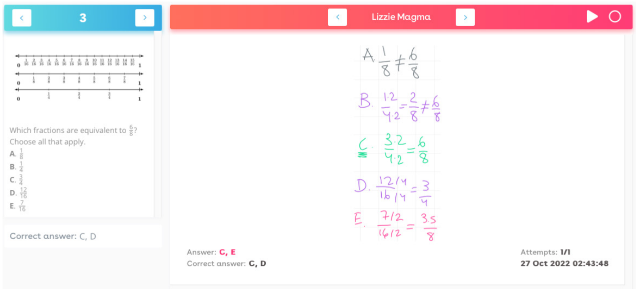


Figure 6: *Daniel Magma's solution*

Figure 7: *Lizzie Magma's solution*

Viewing the Skill Matrix (see Figure 8) and Skill Wheel (see Figure 9), teachers can make decisions based on the classes' performance on specific learning objectives. In the Skill Matrix individual student performance on specific learning objectives is shown using green to indicate proficiency with the skill and red to indicate skills requiring more practice or support.

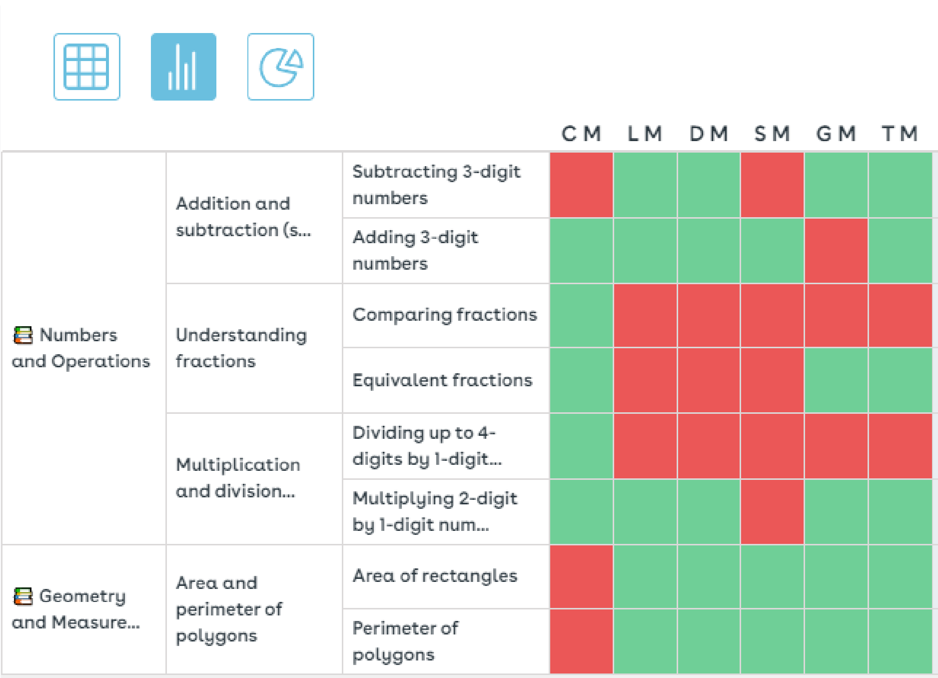
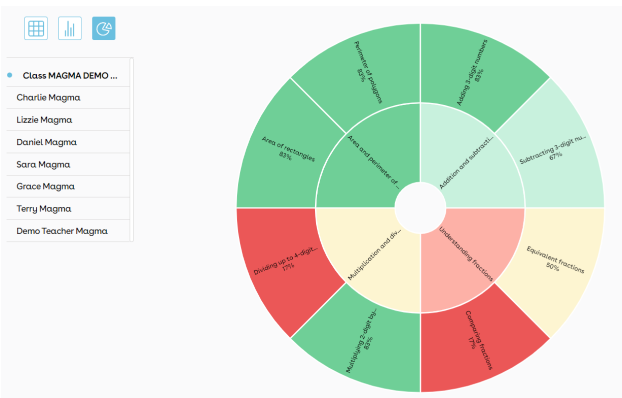


Figure 8: *Skill Matrix*



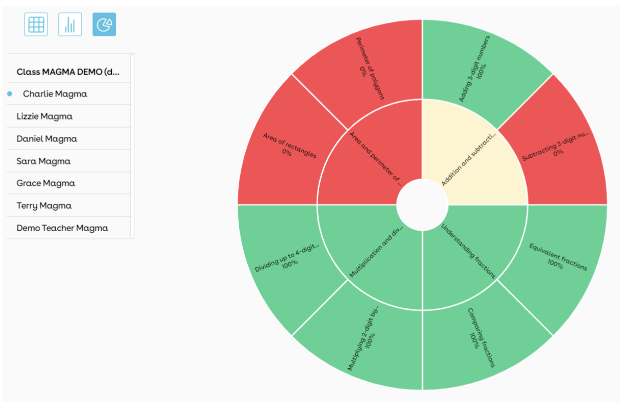


Figure 9: *Skill Wheel showing class performance*

Figure 10: *Skill Wheel showing individual performance*

Conclusion

Magma Math facilitates differentiated instruction through providing a catalog of tiered assignments and a tool for regular formative assessment. Magma Math assignments are grounded in the critical skill or understanding for a particular learning objective as detailed by Tomlinson (2017), and the variation in difficulty is then developed by altering the number of facets a student must attend to, the level of abstraction, and/or whether the problem is a basic application of a given skill or an extension (Little et al. 2019). The tiered assignments create opportunities for students to engage in problems that provide them with the appropriate amount of challenge and support to optimize individual student learning in the classroom (Little et al., 2019; Tomlinson, 2017). Key to the successful application of tiered assignments is regular formative assessment Helmke, 2014; Praetorius, Lipowsky, & Karst, 2012; Smit & Humpert, 2012). To support teachers in utilizing data to make responsive pedagogical decisions, the scope of data considered needs to be broadened beyond just standardized test data to include observations of student performance and student work (Pella, 2012). Using Magma Math, teachers can view class and individual performance on problems and learning objectives, providing teachers with easy-to-interpret data for their pedagogical decision making.

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