Mathematics is a Social Activity: Using Differentiation to Provide Opportunities for Student Discourse

Stefanie D. Livers, Missouri State University, Springfield, MO
Vidal Olivares, Monroe County Schools, Forsyth, GA

Social learning is one of the foundational principles for effective mathematics teaching (NCTM, 2014), and differentiation is a critical tool in ensuring success for all learners (Heacox, 2018). When social learning is combined with differentiated instruction there is an increase in depth of understanding through the social interaction of critiquing the reasoning of others and the sharing of strategies, models, and solutions.

Differentiation can initially be daunting and overwhelming when added to the stresses of high stakes accountability. Many teachers feel that the tension to prepare students for annual testing prevents them from being creative and differentiating instruction. But when a teacher examines the individual needs of his/her classroom of students, differentiation is the only way to meet the expectations provided in the content standards and practice standards.

As rigorous content standards and the Standards for Mathematical Practice (SMPs; CCSSI, 2010) are explored, it is clear that they cannot be successfully met with an approach that relies on isolation and worksheets (Livers, 2013). Instead tasks have to be meaningful and rich in order to support positive discourse and collaboration, while at the same time addressing the content needs of the students. Students are expected to share, reason, critique, and communicate with peers and the teacher (NCTM, 2014). These interactions are supposed to be for the most part student initiated instead of teacher directed. Differentiated tasks present the opportunity for making mathematics social.

Differentiating to Make Mathematics Social

A mathematics task can be differentiated in several ways; here we focus on the methods that focus on social interactions: tiered assignments, jigsaws, and learning centers/ stations. These types of activities allow for students to share and build upon their varying funds of knowledge established by their diverse backgrounds, experiences, interests, skills, and influenced by their personalities. Through this discourse students share ideas, strategies, struggles, misconceptions that benefit others and leads to a deeper level of understanding. Mathematics is meant to be a socialized experience, so even differentiation methods should support this socialization and not further isolate a learner.

The first step for any differentiation task is to decide which standard needs differentiating (Pierce & Adams, 2005; Voltz, Sims, Nelson, 2010). Here we will use two Missouri Learning Standards for statistics and probability for eighth grade that prepares students for foundational ideas about scatterplots by investigating patterns of association in bivariate data:

MISSOURI LEARNING STATNDARD .8.SP.A.1

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

MISSOURI LEARNING STANDARD .8.SP.A.2

Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit

a straight line, and informally assess the model fit by judging the closeness of the data points to the line.

The next step is to decide whether to tier the task, jigsaw the information, or create learning centers/ stations. Not surprisingly, one standard often requires more than one lesson in order for students to meet proficiency, so over time all three differentiation strategies can be incorporated within a unit of study. In this way, differentiation modifies the content, process, or products depending on the needs of the students (Tomlinson, 2003). The following sections provide examples of specific content differentiation for tiered assignments, jigsaws (also known as expert groups), and learning centers/ stations for these two standards.

Tiered Assignments: Tiering assignments provides several tiers or levels of tasks, questions or products (Tomlinson & Eidson, 2003). These tasks are all based on the same content or standard but allow for varying entry points for students. The tasks vary in their complexity and are assigned to the appropriate students based on assessment data and evidence of students' prior knowledge. Typically, there are at least three tiers. Tier Two is the target proficiency level for the typical grade level task often provided in curriculum materials. These tasks can be found in grade level curriculum materials, like the task we adapted from Dan Meyer (2007), called How Old Am I? found in figure 1. Here students are going to estimate ages of celebrities, then research actual ages (or the teacher can reveal them), then they will use scatterplots to analyze the dataset.

Person	**Estimated Age**	**Actual Age** ***as of 12/31/17**
Taylor Swift		
Ed Sheeran		
Dwayne "The Rock" Johnson		
Gal Gadot		
Chris Hemsworth		
Emma Watson		
Claire McCaskill		
Roy Blunt		
Serena Williams		
Colin Kaepernick		
Zendaya		
Anthony Anderson		

Figure 1. How Old Am I?

Tier One is the task that is scaffolded to reach students that require scaffolding to reach proficiency. Tier Three is the task that is extended to reach students working above proficiency. Below is an example of experiences at each of three tiers that address the majority of the selected eighth grade standard.

Tier One (Scaffolded Level): Discuss a scatterplot of real data. Students will be given a set of tasks to accompany their work to assist in scaffolding the task. This would include finding the mean range, adding the trend line, relationship, etc. These tasks may come in the form of a checklist or a more traditional worksheet. Students in this tier should still work together.

Tier Two (Target): Analyze a scatterplot of real data. Students in this tier would be given a typical grade level task. Their task would not be as leading as tier one. They may

be given criteria for their analysis, but it wouldn't include a leading checklist.

Tier Three (Extension Level): Critique a scatterplot of real data. Students in this tier will be given data to critique relating to causation or correlation. Their data would have them critique datasets like sleeping with shoes on causes headaches, or does ice cream sales cause drowning. Higher levels of thinking are required to make sense of these more complicated data.

Jigsaw/ Expert Groups. This is a group activity where each member becomes an expert in one area of a topic or in one component of the problem. Procedures for designing a jigsaw are found in Figure 2. First, students begin in their "home base" group and are assigned (or decide if they are old enough to do so) roles or topics. Then, they move to another table to work with an expert group where they read or complete a task and discuss how they will present it to others as an "expert." Last, students return to their home base group to teach what they learned in their expert group to the others (Tomlinson & Eidson, 2003).

Procedures for Designing a Jigsaw

- Split lesson/task/ activity into segments (4-6 is ideal)
- Divide class into groups (size between 4-6)
- Designate a leader in each group (student decision or teacher decision)
- Assign each group member on of the parts
- Give time for students to read and understand their part, then move into a sub group/ expert group (the students from each group with the same part, now meet)
- Give time to work and solve work in expert groups
- Students return to original group with the expert group's work and knowledge
- Each member shares their new expertise
- Each bit of the expertise should help in answering the larger task
- Group works to solve new/ larger task together

Figure 2. Procedures for Designing a Jigsaw (adapted from www.jigsaw.org)

Using the same eighth grade standard on statistics and probability, students would meet in their home base groups and each would be assigned the following expert cards: data sets and

coordinate plane, trend line, equations and trend lines, and slope. When they move to their expert groups, they would be given a folder to review and learn about these topics. In the folder could be definitions, examples, and sample scatterplots to identify the terms. When the experts return to their home base group, then together they will be given a data set for something like height and arm span, and they will have to graph the data on a coordinate plan, draw a trend line, write an equation, and analyze the slope of the trend line. Groups will then present to the entire class their data set, work, and analysis. All levels of jigsawing require effective communication and positive discourse to complete all tasks. Students work together to build an area of expertise and then use their expertise to solve a larger task.

Learning centers/ stations. Teachers create different but related tasks for each center/ station that are at differing levels of difficulty to address the content. These tasks can incorporate student interests. This strategy uses a positive learning environment, evidence of students' prior knowledge, and sometimes the results of summative assessment data. Teachers have to be knowledgeable of the complexity of the content as well as common misconceptions and students' errors in order to plan diverse centers/ stations. Students visit the center and complete the tasks as a team or pair. These tasks could be foundational, on target with expectations of the standard or challenging extensions to offer different aspects of the curriculum. Teachers can plan the stations so students have to visit each center in a specific order or progression or just assign students to specific centers for topics that they need more practice (Tomlinson & Eidson, 2003).

Eighth graders working on the statistic and probability standard about scatterplots may visit stations to examine an assortment of scatterplot concepts. This standard (shared previously) identifies two behaviors for students to perform related to scatter plots. This standard makes sense for students to experience in multiple formats within stations before they construct their own. So as students rotate to various stations, there will examine different scatterplots (To find various scatterplots, Google "scatterplots" and click images.). Using the standard, these will be the characteristics that they analyze: clustering patterns, outliers, positive or negative association, linear association, and nonlinear association. Six other possible learning stations related to the scatterplot standards are provided in the table below.

Table 1

Table of Possible Station Activities

Positive Relationships, Negative Relationships, or Nonlinear Associations	Estimate the values of y & x	Baseball Players – Height and Homeruns
Student groups will be given topics like years and cell phone sales, years and landline sales to determine the relationship of the data sets.	Student groups will choose a graph, draw the trend line, write an equation, and then estimate the values of x and y.	Student groups will be given access to the Internet to examine the relationship between baseball player height and homeruns.
What's the Situation?	Graph It	Frequency Tables

Student groups will choose a scatterplot graph and then speculate what would be the situation for this data.	Student groups will generate a topic, collect data, and then analyze the data.	Student groups will be given a data set for a survey, they will then create frequency tables, and make predictions for larger data set.

Summary

A misconception of differentiated instruction is that it is individualized, isolated instruction (Murray & Jorgensen, 2007; Tomlinson & McTighe, 2006). There are options for differentiated instruction that include menus, bingo boards, individualized projects/ assignments, but we focused on the differentiation options that support social learning to support the development and support of the Standards of Mathematical Practices (SMPs). On the surface, differentiation seems daunting with the additional planning and managing, however, when framed as tiering, jigsawing, or learning stations the process becomes attainable. The teacher has the power to meet the needs of all students by choosing to differentiate as they align specifically to the required standards. Differentiating is a process that respects students' content and social needs while providing the opportunity for meaningful collaboration and communication about mathematics.

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