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Math 499E

Learning Progression

**Introduction**

This learning progression plan is designed for high school Algebra students. The class consists of twenty five freshmen and sophomores students at Ellensburg High School. The resource for this class is the math textbook *Intermediate Algebra Functions and Authentic Applications Third Edition* by Jay Lehmann. For this particular unit the sections in the book that will be used are 3.1-3.3. The students in this class vary from freshmen students that have been placed in Algebra and sophomores students that have had to re-take the class. Like in most classes, students’ learning levels are different therefore the teacher has to create lessons that will be beneficial for all students.

The central focus of this unit plan is systems of linear equations. It is aligned with the Common Core State Standards Math domain High School Algebra, the cluster is HAS-REI, Reasoning with Equations and Inequalities. The standards for this unit are CCSS.Math.Content.HSA.REI.C.5 Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions, and CCSS.Math.Content.HSA.REI.C.6 Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

This learning progression was designed to fulfill the learning needs of the students in this class by providing a diverse learning environment. Throughout these lessons, students will be able to participate in whole-class discussion, individual, and group work. Although most students like working in groups, providing individual work time will make the students accountable for their own learning. The first lesson will be aligned to one CCSS, while the second and third lessons will be aligned to the same CCSS. In the first lesson, students will first learn how to solve systems of linear equations with graphs. Starting this unit by learning how to solve systems of linear equations by graphing is a great way for students to see what exactly a solution means and one way a solution can be obtained. In the second lesson, students will be introduced to the substitution method to solve a system of linear equations with equations that have two variables. After working with graphing equations in the previous lesson, the next step would be to work with equations and think analytically on how to solve for an ordered pair solution. In the third lesson, students will be introduced to the elimination method to solve systems of linear equations involving equations that have two variables. This method will be introduced after the substitution method because this method is a little more complex. Also it is presented in that order in the textbook. The purpose of this learning progression is for students to understand and be able to solve systems of linear equations using various techniques such as the substitution method, elimination method, and graphing.

**Lesson 1**

The Common Core State Standard for lesson 2 is:

CCSS.Math.Content.HSA.REI.C.6: Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

The concept of this first lesson is for students to be able to understand and be able to solve systems of linear equations by graphing. Students will be introduced to order pair solutions and how the ordered pair, if correct, should satisfy both equations and make them true. After giving examples on the board the teacher will give students time to work out problems on their own on graph paper. While working on problems that vary in difficulty, students are going to encounter different scenarios that will allow them to learn about systems with one solution, inconsistent systems, and dependent systems. As a class we will discuss how specific graphs of systems of linear equations can display very important information about a particular system.

Learning Target: I can solve systems of linear equations by graphing the linear equations and distinguishing the point where the two lines intersect. I also know that there are some systems of linear equations that will never intersect and some that are the same line. The learning target will be reached through activity 1 and activity 2 in this lesson.

Activity 1: The teacher will introduce systems of linear equations and demonstrate how a system that has one solution is found. This will give students a basis of how to solve a system of linear equations by graphing. The teacher will show an example of manipulating an equation so that it is in “y=” form and much easier to graph. Then students will be given the opportunity to practice and solve systems of linear equations on their own or with help of classmates if needed. Working in pairs will help students that may struggle to correctly graph the equations. During this time, students will also be working on problems that were not presented by the teacher. Problems that have scenarios of inconsistent and dependent systems will hopefully get students to critically think of what their graphs represent and how it describes the systems. The mathematical practice being used is using appropriate tools strategically, which is CCSS.Math.Practice.MP5. The tool students are using is graphing in order to solve systems of linear equations. This activity is intended to get students thinking about different scenarios that could occur when solving systems of linear equations.

Activity 2: In this activity, students will reunite as a whole and discuss along with the teacher of the different solutions to the systems of linear equations. This is a time where students can ask questions about their solutions and graphs if they don’t understand what the graphs mean. The teacher will introduce the vocabulary words inconsistent system and dependent system. Hopefully students will recognize that some of the practice problems fell under those two categories and would not have an ordered pair solution. This activity should make some ideas click after the first activity and ultimately help students understand how a graph is a great visual representation of solving systems of linear equations.

Assessment: In this lesson, the teacher while walking around the classroom when students are working individually or with peers on their practice problems will informally assess students. By listening to their discussions and observing their progress on the practice problems, the teacher will get a good idea of how well the students are understanding the concept. Also during activity 2, the teacher will be able to ask the class questions regarding their solutions and what they represent. This can also be used as a time to informally assess students’ procedural fluency when solving systems of linear equations by graphing. A formal assessment will be done via an exit slip at the end of class. The students will be given three problems in which they will have to work out independently. The problems will consist of two questions that will have a solution of an ordered pair while the last question will have an equation that will need to be manipulated and the solution set will be empty meaning the system is inconsistent. This exit slip will serve as a formal assessment in which the teacher can accurately measure what students learned from this lesson and therefor decide what needs to be reviewed first thing in the next lesson.

In the next lesson, students will be introduced to two other methods to solve systems of linear equations. The two methods are substitution and elimination. The main concept of the second lesson is for students to be able to understand and be able to apply the substitution and eliminations methods to solve systems of linear equations.

**Lesson 2**

The Common Core State Standard for lesson 1 is:

CCSS.Math.Content.HSA.REI.C.5: Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

In this second lesson students will be able to apply the substitution and elimination methods to solve systems of linear equations. Students will be given systems of linear equations and directed to use a specific method to find the solution for each system.

Learning Target: I can use the substitution method and elimination method to solve systems of linear equations.

Activity 1: The teacher will first present the method of substitution to the class with an example on the board. The example will have one of the linear equations in “x=” form making it easy to substitute that equation into the other. After obtaining the values for “x” and “y,” the teacher will demonstrate that the ordered pair (x,y) is the solution to the system and can be checked by plugging in the “x” and “y” values in each equation and making them true. Next, students will have two problems to practice the substitution method on a separate piece of paper. Students will work individually on the two problems that the teacher puts on the board.

Activity 2: After students find the solutions to the two systems of linear equations on the board, the teacher will present the elimination method. An example will be presented on the board with the teacher demonstrating that one of the equations needs to be manipulated to eliminate one of the variables when adding it the other equation. The teacher will also explain that in some cases manipulating both equations might be necessary in order to eliminate one of the variables and find the solution to the system. Students will also get to see that the ordered pair solution will satisfy both original equations. The teacher at this point will give students two more problems to practice individually. In this case the systems will be solved using the elimination method. The mathematical practice being exercised in this activity is CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them. When using the elimination method students must make sense of what variable is easier to eliminate and correctly manipulate the equation in order to be successful using the elimination method.

Assessment: For this lesson, the teacher will use the students’ work on the four practice problems to assess how much was achieved in this lesson. Students worked independently on these problems so the teacher can have a good idea of the areas students are struggling with. This information will allow the teacher accurately assess areas of concern that may need to be addressed in the next lesson.

The next lesson will be a continuation of lesson number two. In lesson 3 students will explore the substitution and elimination methods more in depth. They had learned in lesson 1 that some systems of linear equations were going to be inconsistent meaning a solution set that is empty and some systems would be dependent system and would have an infinite number of solutions, so now in lesson 3 students will explore how those solutions come about using the new methods they learned in lesson 2.

**Lesson 3**

The Common Core State Standard for lesson 3 is:

CCSS.Math.Content.HSA.REI.C.5: Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

For this third lesson students will continue to work with the substitution and elimination methods to solve systems of linear equations. Group work will play a role in this lesson to help students critically think and analyze when a certain method is more convenient than the other. In the previous lesson students were prompted to use a specific method to solve certain systems of linear equations. This lesson will enable students to make their own decisions of using the method they prefer to solve the systems of linear equations.

Learning Target: I will be able to apply the substitution and elimination methods to solve systems of linear equations and be able to explain the reasoning behind the method I chose.

Activity 1: Students will have problems from section 3.2 of their textbook assigned to do individually at the beginning of class. These problems will consist of systems of linear equations that have one ordered pair solutions, solution sets that are empty, and infinite number of solutions. The teacher as well as the textbook will not specify which method to use when trying to solve specific systems. When working on these problems, student will be asked to think about why they are choosing a certain method to solve the system.

Activity 2: After completing the problems assigned at the beginning of class, students will be in groups of three where they will compare answers. While comparing answers students will also share the method they used and their reason for choosing that method for the particular problem. At this time students will be exercising the mathematical practice CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others. By listening to one another explain their thoughts and ideas regarding the method they chose and the solution they found to the system, students can critique their peer’s thought process. This activity will elicit mathematical reasoning by the dialogue that will be used among students to back up their thought process when solving the systems of liner equations individually. If there are discrepancies in methods being used students will reason with one another about what method was most efficient and convenient.

Assessment: In this lesson, formal and informal assessments will be used. The formal assessment will be the problems assigned from the book in which the students will do individually. This is a great way for the teacher to see the thought process of each student when deciding what method to choose when solving a particular system. An informal assessment will be practiced while students are working in groups comparing answers and discussing the methods they chose to use. The teacher will walk around the class and observe the students comparing answers and listen to their reasoning. At this time, the teacher can also listen to students critique other students’ thought process when deciding to use a different method. This formal and informal assessment will give the teacher an accurate picture of the students’ understanding of solving systems of linear equations.

**Conclusion**

Through the completion of this learning progression students will be able to solve systems of linear equations using three different methods graphing, substitution, and elimination. Students have learned how graphs of inconsistent and dependent systems look as well as graphs of systems that have one solution. After getting a visual understanding of systems of linear equations, students were able to solve systems using two other methods. Choosing the method plays a big role in making students critically think of what their goal is when solving systems of linear equations. By completing this learning progression students have acquired new mathematical ideas when regarding systems of linear equations in which they can connect to more complex real-life problems in future units.