High School: Algebra
Solving Linear Systems of Equations

This learning progression is for a 9th grade Algebra 1 classroom. The progression is supported by the textbook, "Algebra 1: Applications, Equations, Graphs," by Larson, Boswell, Kanold, and Stiff. The portion of the textbook that this progression follows is chapter 7, sections 1-3. This is found on pages 398-417. This progression has two main Common Core State Standard that it focuses on, which 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. The progression has three main lessons, which have focuses on solving systems of linear equations by graphing, substitution, and linear combination.

These lessons will be a mix of direct instruction, discussions, guided instruction, individual work, group work, and homework. Through out the progression, students will make sense of problems and persevere in solving them (MP1), reason abstractly and quantitatively (MP2), and practice attention to precision (MP6). Students will practice these actions through out each lesson.

Student voice and guided instruction will be the main atmosphere of each lesson. This gives students a chance to explain their reasoning and discuss the concepts with their peers. The students will often be working in groups. This helps the students who are struggling to be assisted by their peers, and it helps the students who are excelling to be able to go one step further by teaching the information. It is also a way to give the students who learn better from discussion or are too shy to speak out in full-class discussions, the opportunity to maximize their learning.

Systems of Equations

By using the book as a guide, students should know how to graph and manipulate equations with two variables. This will allow them to learn and understand each strategy for solving systems of equations.

The first segment will focus on solving linear systems by graphing. On this day, I will have students begin by graphing a linear equation by any method of their choice. This will give them practice for review as well as get them used to the idea that they have a choice in how they graph each equation. The next portion will be a rich math task where I will get the students engaged in the content by having them vote on a soccer team that they believe will be less expensive after fifteen practices. There are two teams in the system and each scenario is a linear model. I will then explain to the students the steps in solving a system of linear equations by graphing. For the example problem, I will use guided instruction by asking the students what I should do for each step and how to do each step. It is important that students understand what the intersection of the lines means. This will insure that they can make

sense of a problem and persevere in solving (MP1). They must also understand how to check their answers, which will be proven when a volunteer student explains to the class how to do so. Use the benchmark to the right to determine student understanding (BM1).

Once students seem to have a strong understanding of this concept, it is time for the assessment portion. To assess students in this section, I will have them work in 8 groups of 3, where each group is assigned to a question number on a work sheet projected on the overhead. The reason for having students work in groups is to allow them to discuss their ideas, give students who are struggling an opportunity to have the material explained in a different way, and allow the more advanced students to have a high ceiling of being able to teach the material. During this time I will be walking around the room to answer questions and assess student understanding. At the end of class, to review and promote student-centered learning, a group will be chosen by a number drawn, to present their problem and how they solved their problem, to the class. I will make sure to prompt the students to cover certain information through my questions and comments during their presentation.

The middle segment focuses on students solving systems by substitution. Students should now know how to solve for x and y variables through the method of substituting in a number, but will now be focusing on substituting equation portions with variables, to solve for a specific solution.

The segment will start with three student volunteers who can work together to answer questions that lead into this lesson. I will begin by giving each student their own whiteboard and marker, and asking them to write the equation $3x+2y=8$, and ask them what y would equal if x was 2? I will then ask these students, what if x was equal to 2y, then what would the equation look like? This will allow students to begin the process of reasoning abstractly and quantitatively (MP2) through out the lesson by understanding the relationship of x and y. I will then do a set of myself doing and explaining a problem of this form. I will ask for a student volunteer to complete the next example problem, and allow students to work individually on the last practice problem to allow formative assessment (BM2). After students do an individual problem, I will choose a "my favorite no" problem to go over with the class. For the remaining class time, students will be able to complete a work sheet where they will do four problems where they will demonstrate solving a system both graphically and then checking their answer with substitution.

Specifically in this lesson, students will be focusing on what substitution is, how x and y relate to each other, and how substitution can be used with more than just a single number. Students will be focused on first isolating a variable, plugging the equation on the other side, in for that variable on the second equation, simplifying until they have a variable equal to a number, and then plugging that number back into either equation to solve for the second variable.

The last portion of instruction in the learning progression is focused on solving system of equations by linear combination. This will teach students that replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions CCSS.MATH.CONTENT.HSA.REI.C.5.

The segment will begin with me asking students if they believe the equation x+4=y is equivalent to -2x-8=-2y? I will have the students vote on if they believe the equations are equivalent. This will lead into a class discussion about manipulation of equations. I will then do one example problem of solving linear combinations, but only once the class comes to a general conclusion that the equations are equivalent. I will do a problem similar where the students will lead me in solving the system.

In these problems, students must focus on attention to precision in their manipulation of the problems (MP6). They must realize that in order to combine the equations, one of the variables must have the same coefficient of the variable that corresponds in the other equation, but with the opposite sign. It is important for students to understand these problems because it is how they can relate the math they are learning to their environment. However, in doing this it is easy to make a mistake on keeping the rest of the equation equivalent after the manipulation.

MP6- Attention to precision

There are two assessment portions of this segment. The first is having students do a whiteboard activity. This activity will be focused solely on solving by linear combination (BM 3). Each student will have his or her own white board, marker, and eraser, but be encouraged to work with their table partner to solve the system properly. This will give students the opportunity to discuss what steps in solving are important and create strategies for how to solve problems with this method. I chose to have discussion heavily involved in this assessment to ease the stress that students usually have when completing word problems. The second portion is a take home and to be done as individual work. For this portion students will have five problems, which they will be expected to solve using each different strategy and show their work. This will hopefully

BM3- Solve the system by linear combination: (E1) 2x+3y=6 (E2) x+2y=4

prove to the student that each method gives them the same answer, and will also allow them to check their own work.

In conclusion, this learning progression builds on the three different methods for solving systems of linear equations: graphing, substitution, and linear combinations. Students know basic manipulation of equations, but can now apply it to solving systems of equations.