Slide I [Equations]
Solving algebraic equations represents the focus of the educational need addressed with this project. More specifically, this project targeted the following two algebra standards:

- Understand that adding or subtracting the same number to both sides of an equation creates a new equation that has the same solution (A.FO.06.12)
- Understand that multiplying or dividing both sides of an equation by the same non-zero number creates a new equation that has the same solution (A.FO.06.13)

Slide II [National Library of Virtual Manipulatives]
After time spent both thinking and searching for strategies to teach solving equations, the decision was made to use the National Library of Virtual Manipulatives Algebra Balance Scales applet to address the educational need identified. The free Algebra Balance Scales applet provides students with a linked visual and symbolic representation of the equation which change concurrently once students modeled the equation and begin to solve to determine the value of the variable. As students selected an operation to perform to both sides, the changes are evidenced in both the equation as well as the blocks removed from the respective sides of the scale.

Slide III [Algebra Balance Scales]
Why virtual manipulatives, might be the lingering question. Moyer, Bolyard, and Spikell (2002) described virtual manipulatives as “an interactive, web-based visual representation of a dynamic object that presents opportunities for constructing mathematical knowledge” (p. 373). Research suggests the use of virtual manipulatives increases student understanding of mathematical ideas and concepts. The Algebra Balance Scales applet fits this definition in representation as well as opportunity for students to construct and model mathematical concepts.

Suh and Moyer conducted a study and reported the results (Developing Students' Representational Fluency Using Virtual and Physical Algebra Balances). This study compared student understanding of solving linear equations based on instruction with either physical or virtual manipulatives. The authors commented, “The use of multiple representations and the flexibility to translate among those representational forms facilitates students' learning and has the potential to deepen their understanding” (p. 155). This study demonstrated manipulatives enhanced students understanding and concluded, “Different representations, including those increasingly available through technology, can facilitate the teaching of those fundamental ideas,” (p. 172). This study supports the use of the Algebra Balance Scales virtual manipulative to help increase student understanding of solving equations.

Additional support for using the Algebra Balance Scales applet comes from Suh's dissertation (2005) entitled, Third Graders' Mathematical Achievement and Representation Preference Using Virtual and Physical Manipulatives for Adding Fractions and Balancing Equations, summarized from (Dorward 2002): “The creators of the National Library of Virtual Manipulatives designed the virtual manipulatives in hopes that it would add to some of the benefits of using physical manipulatives in the classroom and eliminate some of the drawbacks such as: classroom management, structuring activities with manipulatives, connecting manipulative use with symbolism, and lack of resources and professional development. The Algebra Balance Scales applet was designed with the intent of fostering connections among representations, both visual and symbolic, encouraging a conceptual understanding of solving equations and promoting transfer of ideas to be applied in a variety of scenarios.

Further research exposed the theory of Dual Coding. According to the Dual Coding Wiki, Dual Coding argues that verbal and visual representations are both processed and stored differently. Suh and Moyer
(2007) referenced (Rieber 1994) and commented, “it is easier to recall information from the visual processing codes than the verbal codes because visual information is accessed using synchronous processing rather than sequential processing,” (p. 158). Algebra Balance Scales provides both verbal and visual representations for students while engaging with the mathematical content. This lends support to using the virtual manipulative to help students learn how to solve equations since it connects the different representations.

Slide IV [Pre-Assessment Survey]
The Algebra Balance Scale virtual manipulative would be used as an intervention for sixth grade students who previously struggled with solving equations. To evaluate the effectiveness of the virtual manipulative, the implementation plan included an initial lab session where students completed a preassessment created using Google Forms to gauge student understanding of equations. Students responded to the following questions in the survey:

- What is an equation?
- What does it mean to solve an equation?
- Which of the following could be included in an equation?
  - Equal sign
  - Variables
  - Numbers
  - Operations (addition, subtraction, multiplication, division)
  - Other
- What does it mean for two expressions to be equal?
- Which of the following are equations
  - $3x+17=8x+2$
  - $4m$
  - $7c-11$
  - $9s+4=31$
  - $3j-9$
  - $106=11y-7$
  - $4+5=9$
  - $6p-8=20$
  - $14r+28$
  - $31=17+14$
- Given the equation $7h+2=30$, what is the first step to solve for h?
- Given the equation $52=5r-7$, what is the first step to solve for r?
- Given the equation $2w-9=22$, what is the second step to solve for w?
- Solve the following equation for p, $6p-13=11$

In addition to completing the survey, a demonstration of how to use the virtual manipulative would be given and in turn students would have the opportunity to experiment with the applet individually. In the second lab session, students were to use the applet to both model and solve the given equations capturing the steps to model and solve the equations using the “print screen” feature and copying the image to Microsoft Paint in order to save it as an image file. Images were compiled by individual student to create a presentation using Prezi for them to review and reflect on the use of the applet. In a third computer lab session, students would then review the captured images and responded to reflection questions using another Google Form. Lastly, students were to participate in discussion with other group members to work out an explanation of how to solve equations and then ultimately produce a
Students were to complete the three lab sessions previously described by the end of this project. Future work with the *Algebra Balance Scales* virtual manipulative includes more opportunities for students to work with the manipulative and reflect. Student created tutorials explaining equations and how to solve them will be the final product which will be completed during the following academic year.

**Slide V [Reflection Survey]**
Student reflection responses were used to identify both student progress and success. Students answered the following questions:

- As you watch the presentation of your images, what do you notice about your scale as the equation is modeled?
- As you solved each equation, does each side of the scale have the same number of blocks? How does this effect the scale?
- What do you notice about the scale when you add, subtract, multiply, or divide?
- What happens to the location of the blocks when you add, subtract, multiply, or divide?
- What do you notice about the equation as you add, subtract, multiply, or divide?
- List the steps you would use to solve the following equation: 4x-8=12
- How would you explain the steps to solve an equation to someone who does not know? Be specific.

The first question helps students use the visual representation to note the equality of both sides of the scale once the equation is modeled correctly. The second question draws attention to the fact that although the sides of the scale do not have the same number of blocks to start with or throughout the solving process, still the scales remain balanced as blocks are added, taken away, multiplied, or divided off the scale. The third and fourth question draw student attention to the fact the scales remain equal even if the number or location of the blocks vary. Student attention is then drawn to the symbolic representation to help foster the connection between manipulating the scale or visual representation and its impact on the equations or symbolic representation. Lastly, both listing steps to solve and explaining how to solve an equation initiate thoughts and reflections necessary for the final product of group discussion leading to the creation of a tutorial explaining how to solve equations. These questions and student responses will be revisited later to evaluate student progress and success.

**Slide VI [Venn Diagram overlapping T, P, C Knowledge Circles]**
As noted earlier, the two standards to be addressed with this project include:

- Understand that adding or subtracting the same number to both sides of an equation creates a new equation that has the same solution (A.FO.06.12)
- Understand that multiplying or dividing both sides of an equation by the same non-zero number creates a new equation that has the same solution (A.FO.06.13)

**Technological Pedagogical Knowledge**
The selected technology, *Algebra Balance Scales* virtual manipulative, supports the teaching methods and strategies intended for the intervention. The applet scaffolds solving equations, models steps to solve an equation sequentially both symbolically and visually, and provided immediate feedback both verbally and visually to student responses. The applet offered students the opportunity to compare the created model and the given equation before proceeding to solving. Additionally, the virtual manipulative allowed for connections and observations to be made regarding how changes effect all representations of the equation, an advantage over using a physical manipulative to investigate solving
Technological Content Knowledge

“Meaning does not reside in tools; it is constructed by students as they use tools.” Herbert and Colleagues (1997) quoted by Suh in Third Graders' Mathematics Achievement and Representation Preference Using Virtual and Physical Manipulatives for Adding Fractions and Balancing Equations. The Algebra Balance Scales applet helps make the content accessible by providing linked, multiple representations. The visual representation of the scale and blocks helps address student misconceptions regarding coefficients. The picture links to the symbolic representation by clarifying what coefficients actually mean. “One,” is a common response from students when given an equation such as $3x+7=13$ and asked how many “$x$'s” are on the left side. The manipulative helps address this misconception by providing verbal and visual feedback during the modeling phase. Students have the opportunity to recall prior information, or experience for the first time, that multiplication is repeated addition. Simultaneous manipulation of the scale and symbolic representation contribute greatly to the applet's support of the content and increased accessibility to students. The manipulative prompts students to work between both the visual and symbolic representation. As one representation is changed, students evidence how the change effected the other representation supports the learning objectives. Students watch as blocks are added, taken away, multiplied, or divided and the scale remains balanced. The differences in the two images demonstrate the linked representations previously described. The applet provides students an image of the intended learning goals.

Pedagogical Content Knowledge

The instructional strategies used for this intervention activity support the content much like the selected technology supports both content and pedagogy. Students ability to solve equations depends largely on a developed understanding of the symbolic representation. The misconception regarding coefficients discussed previously relates to the essential understanding of symbolic representations. Scaffolding supports the content by ensuring students have appropriately modeled the given equation. The scaffolding continues after the modeling phase also. This links to the importance and understanding of order of operations. Immediate feedback then continues the support of the content. Students proceed through the scaffold to solve the equation with appropriate mathematical moves; however, the feedback redirects students with a little hint to reconsider and manipulate the equation differently. Both symbolic and visual representations of equations further support the content's accessibility to students. As noted previously, verbal and visual feedback helps connect and develop an understanding of what manipulating an equation actually does to the equation. Again, the visual feedback contributes and supports the learning objectives by showing a balanced scale emphasizing the equality of both sides of the equation. Scaffolding, providing feedback and multiple representations, along with student manipulation of the applet all assist in making the content more accessible to students.

Slide VII [Series of Images to solve]

Although working with the selected students previously during the unit on equations and noting their struggles, the surprises began with student responses to the initial survey students completed before working with the manipulative. Student responses demonstrated incorrect, non-mathematical understandings of equations. Some responses require further questioning to determine the student's level of understanding. This suggests another educational need for students pertaining to developing an understanding of equations. The analysis of student responses prompted revisions to the initial implementation plan which will be described next. Most students correctly identified a couple of the listed equations, yet did not categorize others as equations eliciting the question of if students know what equations are and moreover how the Algebra Balance Scales manipulative could be used to support and develop student definitions of equations. I anticipated incorrect responses to questions
about first steps to solve equations as that misunderstanding was the educational issue to be addressed by using the *Algebra Balance Scales*.

In addition to surprises, some unexpected difficulties arose during implementation. As an academic interventionist, students on my case load must be scheduled out of another class limited to either an elective, lunch, or during Channel 1 News and reading time in the morning. Difficulties arose finding time in a computer lab for students to work. The second lab opportunity included internet connection difficulties. It was decided at that point for the duration of the implementation as well as for future use of the intervention, an alternative needed to be thought through so the time was not wasted and students could still make progress toward understanding how to solve equations in the midst of internet complications.

During the implementation of the intervention, one thing that went well was students taking screenshots while working with the manipulative. I demonstrated how to use the “print screen” feature for students and paste the image in Microsoft Paint. Images were then saved for future use. Students did an excellent job remembering to both take and save the images. In some instances, students received feedback form the applet offering hints and suggestions to try something different to solve the equation. This provided opportunity to dialogue with students to hear more of their thought processes and ask questions prompting students to think. This too generated an idea of how to modify the activity for future use which will be discussed in the remaining minutes.

Despite internet complications leaving most student work saved to the network and inaccessible outside of school, one student's images had been uploaded to Flickr before the difficulties. The series of images represents one example of solving a problem using the *Algebra Balance Scales* and the images to review and discuss. Here the student correctly modeled the equation by placing the blocks on the scale. Visually, the student made both sides of the scale equivalent since the scale is balanced. Although possible to balance the scale by modeling a different equation, the applet does not allow students to proceed without correctly constructing the given equation. The student attempted to solve the equation by subtracting seven from both sides. The prompting below the scale in the red indicated adding seven was incorrect. Next, the student took away an “x” from the right side of the equation since there was at least one on both sides to subtract. After that, although not captured as an image, the student took away the unit block on both sides. Lastly, each side was divided by three to create three equal groups of unit blocks and determine the value of each individual “x” block.

**Slide VIII [Comparison Chart]**

The implementation of the *Algebra Balance Scale* virtual manipulative intervention experienced revisions prior to the onset of the implementation. Some of these revisions coupled with time constraints induced both by the end of the school year and the absences of students selected to participate elicited further alterations to the implementation plan. The chart shown highlights the original implementation plan juxtaposed with the actual implementation plan. As evidenced from the chart, in brief the implementation did not go as planned. Responses from the preassessment described above altered the course of implementation. Additionally, the intention had been for students to solve real-world context-based problems while developing a deeper understanding of solving equations. Despite spending time with the applet's “Create” feature, a limitation was discovered when students were provided the problems and asked to use the virtual manipulative to solve: the applet only allowed for one digit coefficients. None of the problems created for the task could be entered into the applet to solve. The initial plan also included student responses to journal prompts, whole group discussion, and the creation of a video tutorial explaining how to solve equations. Students did respond to reflection questions during the third lab activity but no discussion with other group members occurred due to time
restrictions. Lastly, the video tutorials were not yet created either due to the conclusion after viewing responses to reflection questions that students needed more time than was available. Regardless of the proposed or actual implementation plan, deviations from the plan occurred along the way and revisions were made throughout the process.

Slide IX [Student Reflection Responses]
Since the implementation experienced revisions, so did the indicators of success. Students did not produce the video tutorials, thus using those to evaluate their explanations was not possible. The reflection and discussion involved students viewing the images captured working with the Algebra Balance Scales and responding to questions presented using Google Forms. Reflecting on identifying the level of success led to the conclusion success did not depend on the creation of the tutorial. The actual implementation plan merely changed the presentation of the evidence. Instead of listening to students explanations of solving equations, to look for evidence of success student reflection responses were considered with the educational need in mind:

- Understand that adding or subtracting the same number to both sides of an equation creates a new equation that has the same solution.
- Understand that multiplying or dividing both sides of an equation by the same non-zero number creates a new equation that has the same solution.

Two students reflection responses will be used to note success and progress. Students observations

Slide X [VoiceThread, Google Forms, Blog]
Given the opportunity to consider a similar project of this type, the first step after identifying an educational need would be to gather and analyze information regarding student prior knowledge necessary to address the identified educational need. In the case of the Algebra Balance Scales virtual manipulative intervention, the educational need identified, although relevant, provided insight as to why students struggled with solving equations. Student responses and explanations demonstrated an insufficient understanding of equations. Students needed to develop a conceptual understanding of equations, the necessary previous knowledge, before moving on to the standards identified for this project. Assessing student understanding of prior knowledge essential for approaching the educational need provides opportunities to refine the educational need to better meet students where they are at and perhaps provide insight as to how to approach the subsequent educational need.

Future approaches to similar projects will allow for more implementation time and considerations for the circumstances which made it difficult to arrange meeting time with students. Creating a greater implementation window offers not only more time for students to work with the manipulative itself to see if that fosters a deeper understanding and progress toward the educational need, but also more time for students to reflect. This too would provide time to discuss and question students regarding their reflections and thoughts on the activity to better gauge their level of understanding.

Although not a novel thought, one lesson reaffirmed during this project is the need as an educator to try an activity before asking students to complete the task. Although I spent time working with the virtual manipulative applet and its features, I did not try solving the real-world scenarios using the create feature of the Algebra Balance Scales. Trying the activity would have helped combat the troubleshooting on the fly when I realized with several students at computers that the virtual manipulative could not be used to solve the equations I had created. A second lesson, again reaffirmed throughout the project, is to ask for feedback. Posting the activity and having colleagues respond with questions and thoughts helped shape the actual implementation. Responses prompted ideas not considered and in turn resulted in revised or clarified plans.
The Algebra Balance Scales virtual manipulative provides great opportunity for impacting student understanding of solving equations. I would consider its use in the future to help students develop connections between verbal and visual representations. In the future, I would again assess students before working with the applet. In this instance, student responses indicated another educational need: developing an understanding of equations. Aspects of the implementation plan such as modeling the manipulative and offering students time to individually experiment with the applet would remain. Using Google Form to create surveys also provided significant benefits. Students navigated to the form from a link on the class wiki page. Also, the results were compiled in one place accessible from anywhere with an internet connection. Additionally, Google Forms provided user-friendly options for viewing and representing the data collected. Reflecting on the actual implementation plan, I would still have students complete an activity using context based questions for students to solve; however, the questions need modification to work with the manipulative. Lastly, students would still reflect and discuss their experiences. Students would narrate explanations to their screen images captured step by step using VoiceThread. Additionally, using VoiceThread allows the exchange of dialogue between teacher and student to review for a better understanding of student progress. To facilitate the group discussion, students would post responses to prompts and comment to each other using a blog. Groups could use the blog to discuss ideas and concepts prior to creating the tutorial. The timeline also requires modification. Working with the manipulative over the course of a marking period or semester provides students more time and opportunities to impact their understanding of solving equations. The tutorial then serves as a summative assessment to evaluate student understanding and progress.

Thank you for listening!