Mathematics

Planning Guide

Grade 9
Single Variable Linear Inequalities

Patterns and Relations
(Variables and Equations)
Specific Outcome 4

This Planning Guide can be accessed online at:
http://www.learnalberta.ca/content/mepg9/html/pg9_singlevariablelinearinequalities/index.html

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Planning Guide: *Grade 9 Single Variable Linear Inequalities*

Strand: Patterns and Relations (Variables and Equations)
Specific Outcome: 4

This *Planning Guide* addresses the following outcome from the program of studies:

Strand: Patterns and Relations (Variables and Equations)	
Specific Outcome:	4. Explain and illustrate strategies to solve single variable linear inequalities with rational coefficients within a problem-solving context.

Curriculum Focus

This sample targets the following changes to the curriculum:

- The previous program of studies focused on solving single variable inequalities algebraically; the revised program of studies invites students to explain and illustrate strategies to solve single variable linear inequalities.
- The processes of problem solving, reasoning and visualization carry over, and communication and connections have been added.

What Is a Planning Guide?

Planning Guides are a tool for teachers to use in designing instruction and assessment that focuses on developing and deepening students' understanding of mathematical concepts. This tool is based on the process outlined in *Understanding by Design* by Grant Wiggins and Jay McTighe.

Planning Steps

The following steps will help you through the Planning Guide:

- **Step 1: Identify Outcomes to Address** (p. 3)
- **Step 2: Determine Evidence of Student Learning** (p. 5)
- **Step 3: Plan for Instruction** (p. 6)
- **Step 4: Assess Student Learning** (p. 17)
- **Step 5: Follow-up on Assessment** (p. 22)

Step 1: Identify Outcomes to Address

Guiding Questions

- What do I want my students to learn?
- What can my students currently understand and do?
- What do I want my students to understand and be able to do based on the Big Ideas and specific outcomes in the program of studies?

Big Ideas

Mathematics is sometimes referred to as the "science of patterns." Exploring patterns and then translating and representing these patterns into words, symbols, expressions, equations and graphs help Grade 9 students better understand the linear functions. Contextualizing functions is an important part of these two outcomes. These Big Ideas are often described as:

- Algebra is a way to represent and explain mathematical relationships and is used to describe and analyze change (Small 2009, p. 7).
- Situations where the quantity on one side of an equation is not always equal to the other side can be represented in a variety of ways.
- Solving an inequality uses many of the same strategies as solving an equation.

Sequence of Outcomes from the Program of Studies

See http://www.education.alberta.ca/teachers/program/math/educator/progstudy.aspx for the complete program of studies.

Grade 7	Grade 8	Grade 9	Grade 10
Variables and Equations	**Variables and Equations**	**Variables and Equations**	**Relations and Functions**
Specific Outcomes	**Specific Outcome**	**Specific Outcome**	**Specific Outcome**
3. Demonstrate an understanding of preservation of equality by: • modelling preservation of equality, concretely, pictorially and symbolically • applying preservation of equality to solve equations. 4. Explain the difference between an expression and an equation. 5. Evaluate an expression, given the value of the variable(s). 6. Model and solve, concretely, pictorially, and symbolically, problems that can be represented by one-step linear equations of the form $x + a = b$, where a and b are integers.	2. Model and solve problems concretely, pictorially and symbolically, using linear equations of the form: • $ax = b$ • $\frac{x}{a} = b$, $a \neq 0$ • $ax + b = c$ • $\frac{x}{a} + b = c$, $a \neq 0$ • $a(x + b) = c$ where a, b and c are integers.	4. Explain and illustrate strategies to solve single variable linear inequalities with rational coefficients within a problem-solving context.	9. Solve problems that involve systems of linear equations in two variables, graphically and algebraically.

Step 2: Determine Evidence of Student Learning

Guiding Questions

- What evidence will I look for to know that learning has occurred?
- What should students demonstrate to show their understanding of the mathematical concepts, skills and Big Ideas?

Using Achievement Indicators

As you begin planning lessons and learning activities, keep in mind ongoing ways to monitor and assess student learning. One starting point for this planning is to consider the achievement indicators listed in *The Alberta K–9 Mathematics Program of Studies with Achievement Indicators*. You may also generate your own indicators and use them to guide your observation of the students.

The following indicators may be used to determine whether or not students have met this specific outcome. Can students:

- translate a given problem into a single variable linear inequality, using the symbols $\geq$, $>$, $<$ or $\leq$?
- determine if a given rational number is a possible solution of a given linear inequality?
- generalize and apply a rule for adding or subtracting a positive or negative number to determine the solution of a given inequality?
- generalize and apply a rule for multiplying or dividing by a positive or negative number to determine the solution of a given inequality?
- solve a given linear inequality algebraically, and explain the process orally or in written form?
- compare and explain the process for solving a given linear equation to the process for solving a given linear inequality?
- graph the solution of a given linear inequality on a number line and understand the differences between an integral solution and a rational solution?
- compare and explain the solution of a given linear equation to the solution of a given linear inequality?
- verify the solution of a given linear inequality, using substitution for multiple elements in the solution?
- solve a given problem involving a single variable linear inequality and graph the solution?

Sample behaviours to look for related to these indicators are suggested for some of the activities listed in **Step 3, Section C: Choosing Learning Activities** (p. 9).

Step 3: Plan for Instruction

Guiding Questions

- What learning opportunities and experiences should I provide to promote learning of the outcomes and permit students to demonstrate their learning?
- What teaching strategies and resources should I use?
- How will I meet the diverse learning needs of my students?

A. Assessing Prior Knowledge and Skills

Although inequalities are not covered in any prior outcomes, students may have been presented with the idea of inequality in a prior grade, so it is important to assess what the students know. Inequalities can be related to skills students used in both Grade 8 and Grade 9 for linear equations. Before introducing new material, consider ways to assess and build on students' knowledge and skills about their understanding of variables, equality and solving equations. You may choose to use indicators from prior outcomes or grades to help determine what students should know or understand. Consider using open-ended questions to more accurately assess what students are able to communicate and do. Students may or may not have familiarity with symbols for inequalities, so assessing what they know will help guide instruction strategies.

Activity 1: Assessing and Building

Separate the class into two groups with students working in pairs in each group or have pairs of students each take turns generating terms.

- Ask students to think of and record as many words as possible on a graphic organizer like the one below that mean *less than* and have the second group do the same for *greater than*. They may think of words such as *less than, more than, greater than, exceeds, at least, over, under, faster* and *slower*.
- Ask them to think of numerical situations that involve these words. Consider providing examples like "my friend's age is younger than 16" or "if you drive faster than 30 kilometres per hour in a school zone, you might get a ticket."
- Have the students translate these English statements into math statements using $<$, $\leq$, $>$ or $\geq$.

Terms that mean *less than*	**Terms that mean *greater than***	**Sentence or situation using the term**	**Math statement using $<$, $\leq$, $>$ or $\geq$.**
younger than		my friend's age is younger than 16	$n < 16$
	faster than	if you drive faster than 30 km/h in a school zone, you might get a ticket	$n > 30$

Students may need some assistance with selecting the direction of the sign and asking them how they decide which sign to use will help assess background knowledge and student thinking. See if they can generate the understanding of the symbol. Some ideas that they might present are:

- the smaller pointed end points toward the smaller number
- the open end faces the larger number
- if the sign includes the equal line, e.g., greater than or equal to, it means that that number is part of the solution.

Students may be more challenged to generate situations where the $\leq$ or $\geq$ signs are used and, if they do, consider presenting situations like those in Activity 2 below to further build some basic understanding.

Activity 2: Understanding the Language and Symbols for Inequalities

Students may have very different levels of understanding and experiences with inequality situations and symbols. Have them translate these statements into mathematics symbols:

1. My grandfather's age is greater than 45 years old.
2. Four or fewer students dropped the course.
3. Mario's golf score was less than 75.
4. My brother is older than my sister who turned 21 this month.
5. The speed on the highway between Edmonton and Calgary is less than or equal to 110 kilometres per hour.
6. Lethbridge is more than 150 km away from most Alberta towns.

Pose the following questions to students:

1. What are the similarities and differences between the situations?
2. How do you know which sign to use?
3. How do you decide what direction the sign goes?

You may want to help them begin the discussion by thinking about the difference between these two scenarios:

Mario's golf score was less than 75.	Mario's golf score was greater than 75.	Could Mario's golf score have been 75? If so, how would you change the wording of the questions?
Four or fewer students dropped the course.	Fewer than four students dropped the course.	How does changing and rearranging the wording change these two questions?

If a student appears to have difficulty with these tasks, consider further individual assessment, such as a structured interview, to determine the students' level of skill and understanding. See **Sample Structured Interview: Assessing Prior Knowledge and Skills** (p. 8).

Sample Structured Interview: Assessing Prior Knowledge and Skills

Directions	Date:	
	Not Quite There	**Ready to Apply**
Read the following to the student: **"A number is less than or equal to –4."** Translate this into a mathematics inequality and explain a situation in real life that models this inequality.	The student is unable to translate the operations into an inequality. The student does not use the correct inequality symbol or reverses the symbol. The student cannot think of a context or identifies the context incorrectly.	The student is able to translate the inequality into $n \leq -4$. The student is able to articulate a context like the temperature was colder than –4°.
Ask the student to talk about the similarities and differences between: • $3x > 6$ • $2x < -6$ • $-3x \leq 6$ • $-2x \geq -6$.	The student is not able to identify the operation on the left as multiplication. The student can use one representation more competently than the other or does not know the difference between the $\leq$ sign and the $<$ sign, or the $\geq$ sign and the $>$ sign.	The student solves the questions correctly with tiles and is able to show the steps. The student is able to translate the pictorial or manipulative steps into symbolic mathematics.
Ask the student to solve each of the following inequalities, talking about and showing his or her steps: • $3x > 6$ • $2x < -6$ • $-3x \leq 6$ • $-2x \geq -6$.	The student is not able to solve some of the situations or cannot solve the inequalities with negative coefficients. The student is unable to show dividing both sides of the equation by a common divisor. The student does not realize that he or she needs to reverse the sign when dividing both sides by a negative value.	The student solves the questions correctly and is able to explain his or her solution using diagrams and words.

B. Choosing Instructional Strategies

Consider the following instructional strategies for teaching patterns:

- Students should be provided with regular opportunities to engage in conversations and discuss open-ended questions to build confidence and competence with mathematics.
- When students are given opportunities to communicate their thinking (either orally or in writing), explain their reasoning and listen to the strategies used by other students, there are more opportunities to deepen their understanding.
- Have students model inequalities using balances (actual or pictorial) or algebra tiles. The concrete materials will help reinforce understanding of the abstract concepts, even if the student is already a capable abstract thinker.
- Provide opportunities for students to represent inequalities in multiple ways, including manipulative, pictorial and numerical. The more flexible they are in moving between these representations, the better their understanding will be.

C. Choosing Learning Activities

The following learning activities are examples of activities that could be used to develop student understanding of the concepts identified in Step 1.

Sample Activities:

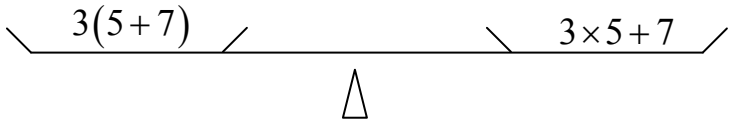
1. **Tilt or Balance** (p. 10)
2. **Understanding Inequalities** (p. 11)
3. **The Effect of Adding and Subtracting on Inequalities** (p. 12)
4. **Solving and Representing Solutions for Inequalities by Addition and Subtraction** (p. 13)
5. **Multiplying and Dividing Inequalities** (p. 14)
6. **Solving Inequalities** (p. 15)
7. **Problem Situations** (p. 16)

Sample Activity 1: Tilt or Balance

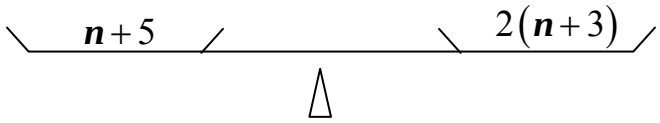
(Van de Walle and Lovin 2006, p. 279)

This activity has students begin to see the similarities and differences between equalities and inequalities.

Draw a two-pan balance like the one below:



- Should this model tilt or balance? Why?
- Can you write a mathematics statement to illustrate the situation?
- How might you make it balance?



- What values of *n* will make this model tilt or balance? Explain?
- Write a mathematics statement to illustrate each situation.
- Explain how an equality is different from an inequality.

This last group of questions should help students see that an inequality can have multiple solutions, while an equality will have a single solution.

Sample Activity 2: Understanding Inequalities

Write the following question down: $\boldsymbol{n \leq 5}$

1. Ask the students to think of more than one way to say this question.

Most would say *n is less than or equal to 5*; however, they also could say *5 is greater than or equal to n.*

Write $\mathbf{n < 5}$ next to $\boldsymbol{n \leq 5}$.

2. Ask the students:

    a. how these questions are similar and how they are different
    b. how they might represent the solutions on a number line.

Students will most likely say that one solution includes the number 5 and one does not. Since the Grade 9 outcomes expect rational values as the solution set, guide students to understand that 4.999 … might be a solution, and that there is a convention for showing when a value is included and when it is not.

3. Draw the four solution sets:

    a. a number line with an open circle on the number 5 with a heavier line going from the circle to the right
    b. a number line with a shaded circle on the number 5 with a heavier line going from the circle to the right
    c. a number line with an open circle on the number 5 with a heavier line going from the circle to the left
    d. a number line with a shaded circle on the number 5 with a heavier line going from the circle to the left.

4. Ask the students the following two questions:

    a. which solutions match the two inequalities $\boldsymbol{n < 5}$ and $\boldsymbol{n \leq 5}$?
    b. what are the expressions for the inequalities that were not matched?

Sample Activity 3: The Effect of Adding and Subtracting on Inequalities

Ask students to hypothesize what happens to an inequality when they add or subtract the same number from both sides of the inequality?

The following exploration should help them discover the differences:

- Begin with the inequality $5 < 10$.
- Ask students to perform the following operations to both sides of the inequality to see what the effect is:

Inequality	Operation	Value of the left side	Value of the right side	< or >
$5 < 10$	+6			
$5 < 10$	–6			
$5 < 10$	–7			
$5 < 10$	+7			

- Explore possibilities like $6 > -4$ or $-8 < -6$ to confirm student findings.
- The conclusion that students should arrive at is that the values of both sides of the equation change in proportion to the operation and number that is being used.

Sample Activity 4: Solving and Representing Solutions for Inequalities by Addition and Subtraction

Students should have strategies for solving one-step equations. Introduce a comparison question and ask students, "How might you solve and verify an inequality that has similar values as an equality ($n + 2 = 5$ and $n + 2 > 5$)?"

Students may propose methods, including:

- guess and check
- subtracting 2 from both sides
- showing their solution using algebra tiles.

Once they agree on the solutions of $n = 3$ and $n > 5$, ask them how they could represent the solution graphically?

It is important to help students understand that the equality is shown by a closed dot on 3 and the inequality is shown by an open dot on 3 with a heavy arrow going to the right.

Have students explore how the following three solutions are similar to and different from $n + 2 > 5$:

- $n + 2 \geq 5$
- $n + 2 < 5$
- $n + 2 \leq 5$.

Students should use steps showing the subtraction of 2 from both sides and then be asked to verify their answers both as a solution set, e.g., $n \geq 3$, as well as graphically.

Sample Activity 5: Multiplying and Dividing Inequalities

There are some differences when students multiply and divide by positive or negative rational numbers.

Ask students to hypothesize what happens to an inequality when we multiply or divide both sides of the inequality by the same number?

The following exploration should help them discover the differences.

- Begin with the inequality $5 < 10$.
- Ask students to perform the following operations to both sides of the inequality to see what the effect is:

Inequality	Operation	Value of the left side	Value of the right side	< or >
$5 < 10$	$\times 2$			
$5 < 10$	$\div 2$			
$5 < 10$	$\times -2$			
$5 < 10$	$\div -2$			

- Explore possibilities like $6 > -4$ or $-8 < -6$ to confirm student findings.
- The conclusion that students should arrive at is that when an inequality is multiplied or divided by a negative value, the comparative value of the two is reversed; therefore, the sign must be reversed.

Sample Activity 6: Solving Inequalities

This activity provides students with an opportunity to explore the impact of negative values as an addend, minuend, factor or divisor on the solution and the direction of the inequality sign. Have them work in pairs with one student completing the A questions and the other completing the B questions, and then have them verify each other's solutions and look for patterns in the exploration.

Student A Solve using algebra tiles. Show all steps.	Student B Solve showing all steps and verify your answer.	How are the solutions to the two inequalities similar and how are they different? [Think of the solution, sign and graph of the solution.]
a. $n + 5 > 7$	b. $n + -5 > 7$	
a. $2n \leq -6$	b. $-2n \leq -6$	
a. $2n + -3 \geq 7$	b. $2n + 3 \geq 7$	
a. $-2n + 3 > -5$	b. $2n + 3 > -5$	
a. $2(n - 3) \geq 6$	b. $-2(n - 3) \geq 6$	
a. $3n + 2 < x - 4$	b. $-3n + 2 < x - 4$	
a. $\frac{n}{4} \geq 2$	b. $\frac{n}{-4} \geq 2$	

You may want to consider adding to these examples to help students find the differences and patterns with the signs.

Sample Activity 7: Problem Situations

Provide students with problems like the ones below. For some ideas on designing the problem activity and linking to assessment, see **Step 4: Assess Student Learning** (p. 17).

- A student had 74% and 78% on the last two mathematics tests. What mark is needed on a third examination so that the student's average is greater than 80%?
- I am thinking of a number, x. When –12 is added to my number, the sum is less than 20. What values would make this true?
- A student babysat for two families and earned $14 and $25. If both amounts are deposited into a bank account, there is still less than $100 in the account. How much was in the account before the two amounts were deposited? Show the solution to the possible values in two different ways.
- A savings account earned a student $24, $25.50 and $27.50 in interest the last three years. How much interest needs to be earned this year so that the four-year average is greater than $30?
- A student has $20 and buys three large hot chocolates. Each drink costs $2.25. The student wants to buy as many cookies for $0.49 as possible with the remaining money. What is the greatest number of cookies that can be bought?
- When doubled, the sum of a number, x, and 3 is greater than $\frac{2}{3}$ of the difference between that number, x, and 1. Find, represent and verify the solution to this problem.
- A student is looking at two different cell phone plans: one that has a base charge of $20 per month with a fee of $0.17 per text message sent and the other plan that has a base charge of $30 per month with a fee of $0.12 per text message sent. If the most that a student can spend is $50 per month, which plan will provide the most text messaging? What is the maximum number of text messages that can be sent on each plan and still be within the monthly budget of $50?

Step 4: Assess Student Learning

Guiding Questions

- Look back at what you determined as acceptable evidence in Step 2.
- What are the most appropriate methods and activities for assessing student learning?
- How will I align my assessment strategies with my teaching strategies?

In addition to ongoing assessment throughout the lessons, consider the following sample activities to evaluate students' learning at key milestones. Suggestions are given for assessing all students as a class or in groups, individual students in need of further evaluation, and individual or groups of students in a variety of contexts.

A. Whole Class/Group Assessment

Problem Menu

Place the problems in Sample Activity 7 around the room and ask students to select some or all of them to solve. Place algebra tiles and balances at each station and ask students to solve the problems in more than one way. A template like the one below helps students solve the problems in a more organized fashion:

Problem:
Facts I know from the problem:
What information do I **NOT** need:
Solution 1:
Solution 2:

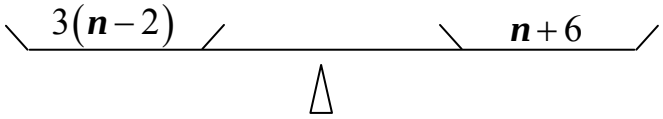
Listen to and observe students as they work through the questions and pose open-form questions that help them arrive at a solution. It is important to consider the form of your question. Closed-form questions often result in right or wrong answers only. Open-form questions, which may begin with how or why, encourage students to look at the process of solving a question rather than just at a solution. Here are some examples of adapting closed-form questions to open-form questions.

Closed-form questions	Open-form questions
Do you understand the difference between an equality and an inequality?	How do inequalities differ from equalities?
Are you clear on when to use the different signs related to inequalities?	How do you decide when to use each of the four inequality signs: $\leq$, $>$, $\geq$ and $<$.
Do you have any questions on when to reverse the inequality sign?	What helps you decide when to reverse the inequality sign?
Solve $2n \leq -6$.	What other inequalities might have the same solution as $2n \leq -6$?

Exit Cards/Questions and Specific Feedback

As you listen and observe your students discussing solutions to the questions, opportunities to assess student thinking are increased. As the first five minutes of class and the last five minutes are often the most critical learning times in a class, consider using an exit card with a similar question in the last five minutes to see how well students understand the outcome worked on that day. The regular use of an exit question helps guide your lesson planning and is a good opportunity to provide short comments and feedback to students. Research shows that if teachers provide specific feedback without a grade, student understanding and performance on summative assessments improve. The following assessments may be used as exit questions to assess student understanding:

Exit question for Activity 1:



1. What values of *n* will make this model tilt or balance? Explain?
2. Write a mathematics statement to illustrate each situation.
3. Explain how an equality is different from an inequality?

Exit question for Activity 2:

Explain how you would know whether to use a closed circle or an open circle when representing an inequality on a number line.

Exit question for Activity 3:

Using your own example, explain the impact of adding, subtracting, multiplying and dividing an inequality by a positive number. To provide more structure to students, you may want to designate a number like 3 or 5.

Exit question for Activity 4:

Explain how the following two inequalities and their solutions are similar and how they are different:

- $n + -3 \geq 5$
- $n + -3 \leq 5$.

Exit question for Activity 5:

Give two examples of inequalities where the sign will reverse when they are solved. Prove why the signs reverse.

Exit question for Activity 6:

Explain the impact of using a negative value as an addend, minuend, factor or divisor on the solution set of an inequality and on the direction of the sign. Show your solution in two ways.

Exit question for Activity 7:

Give an example of a situation or problem that can be represented by an inequality. Write the inequality that represents the problem.

Student Self-assessment Rating Scale

Student self-assessment is an effective way of having students take ownership for their learning. Students must be aware of the goals and outcomes that they are trying to meet as well as how well they meet these goals. Self-assessment involves four stages:

1. The teacher facilitates understanding of and negotiation and co-creation of the criteria for assessing the work.
2. The teachers assists students in defining levels of performance through the development of exemplars, rubrics or rating scales.
3. The teacher coaches students in applying the measures.
4. The teacher provides specific feedback to students about their self-assessment.

Consider using descriptors to complement or replace a numerical scale. For example:

- novice or not yet there
- proficient or on target
- advanced or above and beyond.

Here is an example of a self-assessment.

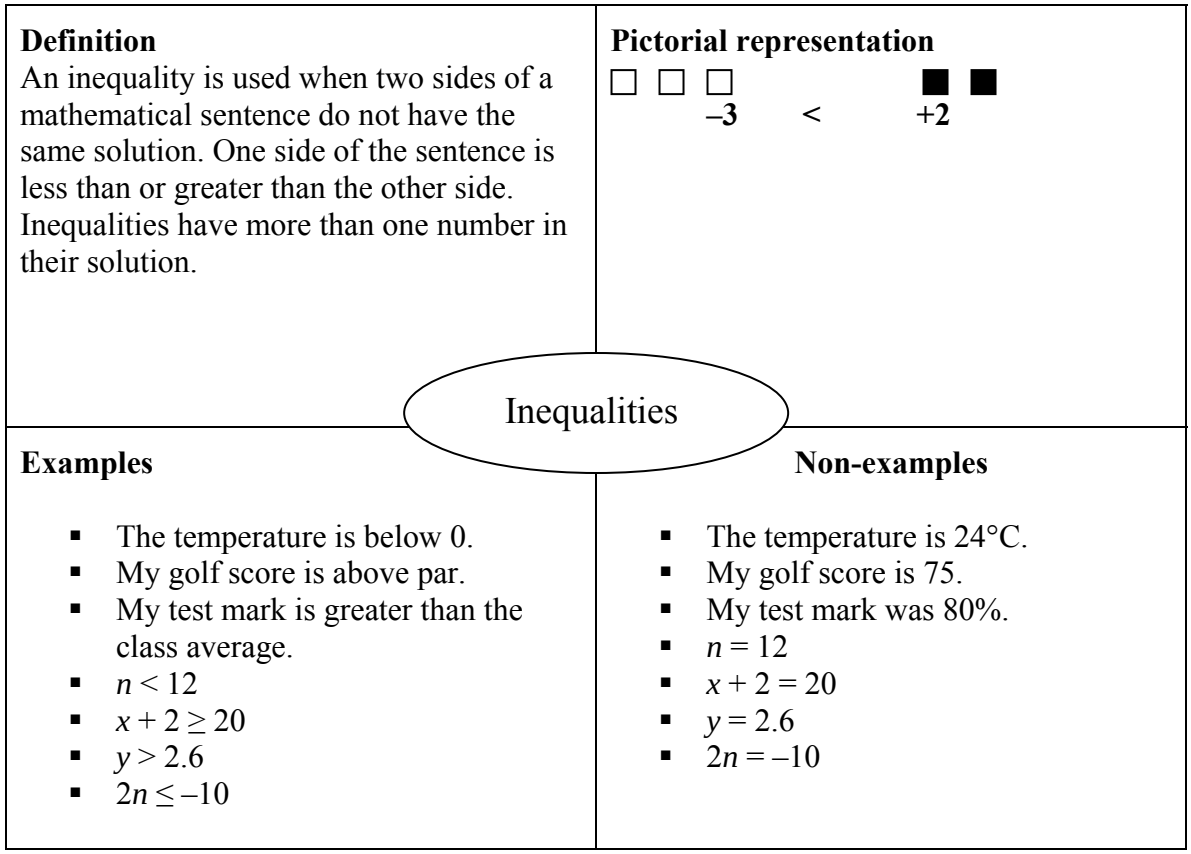
Have students select one of the following three levels for each of the criteria and comment on why their learning best fits into that category:

I am able to:	Novice	Proficient	Advanced	Comment
solve an inequality using algebra tiles				
solve an inequality using steps				
verify my answer to an inequality				
show the impact on an inequality of adding and subtracting both positive and negative values				
show the impact on an inequality of multiplying and dividing by both positive and negative values				
translate word problems into linear equations and solve them				

B. One-on-one Assessment

Assessment Using a Graphic Organizer: Frayer Model

Frayer Models are effective in helping students represent their understanding in a variety of ways, as well as assisting students in organizing constructs and connecting concepts, ideas and procedures that are related. The following is an example of a Frayer Model that a student might construct after the first two sample activities in this planning guide.



C. Applied Learning

Pose opportunities for students to create and solve linear inequality problems that involve travel, money, age or number. Some ideas that may help students get started in the creation of questions is to have them investigate the following:

- the impact that increasing mass has on the length of an elastic; using the same elastic, students should measure its original length and then hang increasing masses on the elastic and measure the changes
- how increasing the length and width of a square or rectangle by two or four units changes the value of the unknowns in the equation
- fuel consumption on a family trip (comparing a small and large vehicle).

Step 5: Follow-up on Assessment

Guiding Questions

- What conclusions can be made from assessment information?
- How effective have instructional approaches been?
- What are the next steps in instruction?

A. Addressing Gaps in Learning

Students who have difficulty solving the basic facts using strategies will enjoy more success if one-on-one time is provided in which there is open communication to diagnose where the learning difficulties lie. Assessment by observing a student solving problems will provide valuable data to further instruction. Success in problem solving depends on a positive climate in which students are confident in taking risks. By building on the existing understandings of each student and accommodating the individual learning styles, success will follow.

If the difficulty lies in solving the basic facts using strategies, use the following strategies:

- Encourage students who are having difficulty using a balance or algebra tile model. Work one-on-one with a student as he or she completes the problem. Ask the student to share his or her thinking while working to solve the inequality. Listen carefully to the language the student uses in order to determine where his or her misunderstanding is.
- If a student has difficulty following an algebraic solution, work first to have the student verbally and/or visually represent the solution process. Then move to translating the process into the algebraic representation.

B. Reinforcing and Extending Learning

Students who have achieved or exceeded the outcomes will benefit from ongoing opportunities to apply and extend their learning. These activities should support students in developing a deeper understanding of the concept and should not progress to the outcomes in subsequent grades.

Consider strategies such as the following.

- Have students investigate the differences between an integral and a rational solution in terms of the solution set and the representation on a number line.
- Have students create problems that can be represented by inequalities.
- Have students create trivia games or other types of review games. If the district has a license for whiteboard technology, students can share their review with the rest of the class electronically.

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