Educational Epiphany ™
Districtwide PLC Protocol for **Mathematics**

Teacher/Teacher Team:
Grade/Course: Algebra 2
Date: Week of September 12, 2022

#	Planning Question	Teacher/Teacher Team Response		
	Algebra 2 Coherence Tool: Access the foundational standards to make connections to previously taught skills during the lesson introduction.			
1	Which **state standard** is your lesson progression addressing?	**Lesson 2.4 – Complex Numbers and Operations** **A2.N.CN.A.1** Know there is a complex number *i* such that $i^2 = -1$, and every complex number has the form $a + bi$ with *a* and *b* real. **Foundational Standard:** 8.EE.A.2 **A2.N.CN.A.2** Know and use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers. **Foundational Standard:** 7.EE.A.1	**Lesson 2.5 – Completing the Square** **A2.A.REI.B.3** Solve quadratic equations and inequalities in one variable. **a.** Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, knowing and applying the quadratic formula, and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers *a* and *b*. **Foundational Standards:** A1.A.REI.B.3a, A1.A.SSE.B.3a **A2.N.CN.B.3** Solve quadratic equations with real coefficients that have complex solutions. **Foundational Standards:** None	**Lesson 2.6 – The Quadratic Formula** **A2.A.REI.B.3** Solve quadratic equations and inequalities in one variable. **a.** Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, knowing and applying the quadratic formula, and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers *a* and *b*. **Foundational Standards:** A1.A.REI.B.3a, A1.A.SSE.B.3a **A2.N.CN.B.3** Solve quadratic equations with real coefficients that have complex solutions. **Foundational Standards:** None
2	What **mathematical concepts** are embedded in the state standard?	**Understand that:** • A complex number contains both real and imaginary parts. • The four basic operations can be applied to complex numbers. • The imaginary unit *i* is the number whose square is equation to -1, so $i^2 = -1$. They recognize that complex numbers are written in the form $a + bi$, composed of real numbers a and b and the imaginary unit *i*.	**Understand that:** • A quadratic equation can be solved by completing the square to transform the equation to an equivalent equation, $(x - p)^2 = q$. • Students use a geometric model to represent an algebraic quadratic expression and identify the number needed to complete the square. They use this number to rewrite quadratic equations in the form $(x - p)^2 = q$ in	**Understand that:** • The Quadratic Formula can be used to solve any quadratic equation, including those with complex solutions. • Students derive the Quadratic Formula by completing the square. They understand that this formula can be used to find the solutions to any quadratic equation. • Students understand that they can use the value of discriminant $b^2 - 4ac$ to predict the number and type of solutions

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		• The properties of operations and the relation f$i^2 = -1$ of the four basic operations, are applied to complex numbers, are used to perform operations on complex numbers.	order to solve problems involving quadratic functions. • Students use an algebraic models to complete the square. They square half the coefficient of the linear term to find the number needed to complete the square. • Students understand that completing the square is useful to find the minimum or maximum value of a quadratic expression.	to a quadratic equation. They use complex numbers to represent solutions for quadratic equations with non-real solutions.
3	What teacher **knowledge, reminders, and misconceptions** are assumed in the standard?	**Knowledge:** • This lesson emphasizes a blend of conceptual understanding and application. • Students understand that complex numbers include the real and imaginary numbers and that the properties of operations can be used to add, subtract, and multiply complex numbers. • Students apply their understanding of complex numbers to solve quadratic equations with complex solutions, including involving electrical circuits. • Students solve quadratic equations with complex solutions and understand that a complex number includes both real and imaginary parts. • Students use properties of operations to add, subtract and multiply complex numbers. • Students used complex numbers to represent and solve problems involving voltage sources in an electrical current. • Students generalize when they use their understanding of complex numbers and the relationship between multiplication and division to write an explicit formula that can be used to find the quotient of two complex numbers. **Reminders and Misconceptions:** • Students wrote and solved quadratic equations with real solutions.	**Knowledge:** • This lesson emphasizes a blend of conceptual understanding and procedural skill and fluency. • Students understand that completing the square is a method for solving a quadratic equation and identifying the maximum and minimum values of the function it defines. • Students efficiently determine the value needed to complete the square. They accurately complete the steps to find the solution to a quadratic equation. • Students solve quadratic equations by completing the square. • Students find the minimum or maximum value of a quadratic function by completing the square. • Students use mathematical ides to justify whether or not using completing the square is an efficient method for solving a quadratic equation. • Students attend to precision when they use the definition of absolute value to rewrite the principal square root using both the positive and negative values of the root. **Reminders and Misconceptions:** • Students used inspection or factoring to solve quadratic equations. • Students may try to complete the square without first factoring out the coefficient of x^2. For all problems,	**Knowledge:** • This lesson emphasizes a blend of conceptual understanding and application. • Students recognize when the Quadratic Formula gives complex solutions and write the solutions in the form $a + bi$. • Students interpret the discriminant within the context of real-world problems involving projectile motion. • Students use completing the square to derive the Quadratic Formula and then use the Quadratic Formula to solve quadratic equations with real and complex roots. • Students analyze problems and use stated mathematical assumptions and definitions to construct arguments to justify each step in the derivation of the Quadratic Formula. • Students recognize the strengths and limitations of the Quadratic Formula as a useful tool for solving quadratic equations that cannot be easily factored. **Reminders and Misconceptions:** • Students used factoring and completing the square to solve quadratic equations with real roots. • Students used complex numbers to represent numbers with both real and imaginary parts.

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			before completing the square, have students circle the coefficient of x^2 to remind them to factor out the coefficient if it is not 1.	• Students may think that when the discriminant is negative, there are no solutions. Remind them that a negative discriminant means there are no real solutions, but there are two complex solutions. • When using the Quadratic Formula, students often forget to start with -b, especially when the value of b is negative to begin with. Remind students to be diligent when evaluating the formula.
4	What **objective(s)** must be taught? In what order? Why?	**PBO:** • SWBAT state that there is a complex number i such that $i2 = -1$ IOT distinguish between a real number, a pure imaginary number and a complex number. **(A2.N.CN.A.1)** • SWBAT express complex numbers in the written form a + bi, where a and b represent real numbers IOT identify whether or not solutions to problems are viable within a mathematical or real-world context. **(A2.N.CN.A.1)** • SWBAT know and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers IOT rewrite and simplify complex numbers. **(A2.N.CN.A.2)** • SWBAT solve a quadratic equation in the form $ax2 + bx + c = 0$ with real coefficients, solve by using the quadratic formula or completing the square IOT identify solutions as real or complex and to determine if all solutions are viable in the context of the problem. **(A2.N.CN.B.3)** • SWBAT solve quadratic equations and inequalities in one variable by inspection (e.g., for x2 = 49), taking square roots, completing the square, knowing and applying the quadratic formula, and factoring, as appropriate to the initial form of the equation IOT	**PBO:** • SWBAT solve a quadratic equation in the form $ax2 + bx + c = 0$ with real coefficients, solve by using the quadratic formula or completing the square IOT identify solutions as real or complex and to determine if all solutions are viable in the context of the problem. **(A2.N.CN.B.3)** • SWBAT solve quadratic equations and inequalities in one variable by inspection (e.g., for x2 = 49), taking square roots, completing the square, knowing and applying the quadratic formula, and factoring, as appropriate to the initial form of the equation IOT express the solutions as real numbers or as complex numbers in the form a ± bi for real numbers a and b. **(A2.A.REI.B.3)** **Lesson objectives**: • Transform a quadratic equation into the form $(x - p)^2 = q$ by completing the square. • Complete the square to reveal the minimum or maximum value of a quadratic expression.	**PBO:** • SWBAT solve a quadratic equation in the form $ax2 + bx + c = 0$ with real coefficients, solve by using the quadratic formula or completing the square IOT identify solutions as real or complex and to determine if all solutions are viable in the context of the problem. **(A2.N.CN.B.3)** • SWBAT solve quadratic equations and inequalities in one variable by inspection (e.g., for x2 = 49), taking square roots, completing the square, knowing and applying the quadratic formula, and factoring, as appropriate to the initial form of the equation IOT express the solutions as real numbers or as complex numbers in the form a ± bi for real numbers a and b. **(A2.A.REI.B.3)** • SWBAT create one variable linear, quadratic, rational, or exponential equations and inequalities IOT use them to solve real-world situations. **(A2.A.CED.A.1)** **Lesson objectives**: • Use the Quadratic Formula to solve quadratic equations that have complex solutions.

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		express the solutions as real numbers or as complex numbers in the form a ± bi for real numbers a and b. **(A2.A.REI.B.3)** **Lesson objectives**: • Add, subtract, and multiply complex numbers using the properties of operations and the relation $i^2 = -1$.		
5	What **academic language** must be taught before the teacher models for students? How will the academic language be **taught and assessed**?	**Academic Language:** • **apply** – put to use; do • **appropriate** – suitable or proper in the circumstances • **associative property** – the sum or product is the same regardless of how the numbers are grouped • **coefficient** – the leading number or variable that is multiplied by a variable in an expression or equation • **commutative property** – the sum or product of a group of numbers is the same regardless of the order in which the numbers are arranged • **completing the square** - the process of converting a quadratic equation into a perfect square trinomial by adding or subtracting terms on both sides • **complex conjugates** - number pairs of the form *a+bi* and *a−bi* • **complex number** – numbers that can be written in the form *a + bi*, where *a* and *b* are real numbers, and *I* is the square root of -1 • **complex** – complicated and intricate • **context** – a situation used to describe a mathematical problem • **determine** - to find out something using mathematical processes • **distributive property** – simplifying an expression by multiplying a number/term by each term inside the parentheses	**Academic Language:** • **apply** – put to use; do • **appropriate** – suitable or proper in the circumstances • **coefficient** – the leading number or variable that is multiplied by a variable in an expression or equation • **completing the square** - the process of converting a quadratic equation into a perfect square trinomial by adding or subtracting terms on both sides • **complex number** – numbers that can be written in the form *a + bi*, where *a* and *b* are real numbers and *I* is the square root of -1 • **complex** – complicated and intricate • **context** – a situation used to describe a mathematical problem • **determine** - to find out something using mathematical processes • **equation** – a mathematical statement containing an equal sign to show that two expressions are equal • **express** – to convey or communicate • **factoring** – the process of writing an equivalent expression that shows the factors of the original product • **form** – the visible shape or configuration of something • **identify** – to recognize and name; to make sense of and assign meaning to the data • **inequality** – a mathematical sentence that uses symbols (<,≤, >, ≥, ≠) to show	**Academic Language:** • **apply** – put to use; do • **appropriate** – suitable or proper in the circumstances • **coefficient** – the leading number or variable that is multiplied by a variable in an expression or equation • **completing the square** - the process of converting a quadratic equation into a perfect square trinomial by adding or subtracting terms on both sides • **complex number** – numbers that can be written in the form *a + bi*, where *a* and *b* are real numbers and *I* is the square root of -1 • **complex** – complicated and intricate • **context** – a situation used to describe a mathematical problem • **create** – to produce or generate • **determine** - to find out something using mathematical processes • **discriminant** - the value of the expression $b^2 - 4ac$ of a quadratic equation in the form $ax^2 + bx + c = 0$. The value of the discriminant determines the number of solutions of the equation. • **equation** – a mathematical statement containing an equal sign to show that two expressions are equal • **exponential equation –** an equation that contains the form b^{cx}, with the exponent including a variable • **express** – to convey or communicate

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		• **equation** – a mathematical statement containing an equal sign to show that two expressions are equal • **express** – to convey or communicate • **factoring** – the process of writing an equivalent expression that shows the factors of the original product • **form** – the visible shape or configuration of something • **identify** – to recognize and name; to make sense of and assign meaning to the data • **imaginary number** – the imaginary *i* is the principal square root of -1 • **imaginary unit i**- the complex number whose square is –1 • **inequality** – a mathematical sentence that uses symbols (<,≤, >, ≥, ≠) to show the relationship between quantities not equal • **inspection** – careful examination • **know -** be aware of through observation, inquiry, or information • **problem** – a question that needs a solution • **quadratic equation –** an equation of degree 2, which has at most two solutions • **Quadratic formula -** a formula that provides the solution(s) to a quadratic equation $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ • **real number** – the union of the set of rational and irrational numbers • **real-world** – related to a concrete setting • **represent** – state or point something out • **rewrite -**to revise words, symbols, equations, expressions, etc. in a different way	the relationship between quantities not equal • **inspection** – careful examination • **know -** be aware of through observation, inquiry, or information • **perfect square trinomial -** a trinomial that is the square of a binomial • **principal root -** A number of the form $\sqrt{b}$ • **problem** – a question that needs a solution • **quadratic equation –** an equation of degree 2, which has at most two solutions • **quadratic formula -** a formula that provides the solution(s) to a quadratic equation • radical - an expression containing a root • **real number** – the union of the set of rational and irrational numbers • **solution** – the answer to a problem; the value(s) of a variable that satisfies a given algebraic equation • **solve** – to apply an operation(s) in order to find a value; to find an answer • **square root** – one of two identical factors of a number that is the product of those factors. • **variable** – a quantity that changes or can have different values • **viable** – capable of working successfully **Instructional Practice 2:** Strategies used to teach unfamiliar words will include: • 30 – 30 – 30 (common math-related word parts in the text, problem, or objective) • Point of Use Annotation of the Performance-Based Objective • Universal Language of Literacy	• **factoring** – the process of writing an equivalent expression that shows the factors of the original product • **form** – the visible shape or configuration of something • **identify** – to recognize and name; to make sense of and assign meaning to the data • **inequality** – a mathematical sentence that uses symbols (<,≤, >, ≥, ≠) to show the relationship between quantities not equal • **inspection** – careful examination • **know -** be aware of through observation, inquiry, or information • **linear equation–** an equation that can be written in the form ax + by = c • **perfect square trinomial -** a trinomial that is the square of a binomial • **problem** – a question that needs a solution • **quadratic equation –** an equation of degree 2, which has at most two solutions • **quadratic formula -** a formula that provides the solution(s) to a quadratic equation • **radical -** an expression containing a root • **radicand -** a number or expression under the radical symbol • **rational** – a real number that can be written as a ratio • **real number** – the union of the set of rational and irrational numbers • **real-world** – relating to a concrete setting • **situation -** a set of circumstances in which one finds oneself; a state of affairs

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		• **simplify –** producing an equivalent form; combine like terms and apply properties to make computation easier • **solution** – the answer to a problem; the value(s) of a variable that satisfies a given algebraic equation • **solve** – to find an answer • **square root** – one of two identical factors of a number that is the product of those factors. • **variable** – a quantity that changes or can have different values • **viable** – capable of working successfully **Instructional Practice 2:** Strategies used to teach unfamiliar words will include: • 30 – 30 – 30 (common math-related word parts in the text, problem, or objective) • Point of Use Annotation of the Performance-Based Objective • Universal Language of Literacy • Word and Definition Walls • Word Parts • Context Clues • Point of Use Annotation of the Text (in Real-Time)	• Word and Definition Walls • Word Parts • Context Clues • Point of Use Annotation of the Text (in Real-Time)	• **solution** – the answer to a problem; the value(s) of a variable that satisfies a given algebraic equation • **solve** – to apply an operation(s) in order to find a value; to find an answer • **square root** – one of two identical factors of a number that is the product of those factors. • **use** – take or hold; apply; deploy (something) as a means of accomplishing a purpose or achieving a result • **variable** – a quantity that changes or can have different values • **viable** – capable of working successfully **Instructional Practice 2:** Strategies used to teach unfamiliar words will include: • 30 – 30 – 30 (common math-related word parts in the text, problem, or objective) • Point of Use Annotation of the Performance-Based Objective • Universal Language of Literacy • Word and Definition Walls • Word Parts • Context Clues • Point of Use Annotation of the Text (in Real-Time)
6	What **practice problems** are you planning to use for the I Do, We Do, You Do in Pairs and You Do Without Assistance? What did you learn from working the problems **in advance** of using them in class with students?	**Station Rotation Model Suggestions** **Teacher-Led Station:** Teachers can work with students on additional We Do problems. • Additional Examples – TE pg. 95, pg. 96, pg. 98 • 2-4 Reteach to Build Understanding **Online Station**: Students can watch and engage with Virtual Nerd Video lessons. Students will initially tell what they think the answer to the question is or their opinion regarding an issue, and/or their thoughts based on a prompt. Then	**Station Rotation Model Suggestions** **Teacher-Led Station:** Teachers can work with students on additional We Do problems. • Additional Examples – TE pg. 103, pg. 104 • 2-5 Reteach to Build Understanding **Online Station**: Students can watch and engage with Virtual Nerd Video lessons. Students will initially tell what they think the answer to the question is or their opinion regarding an issue, and/or their thoughts based on a prompt. Then	**Station Rotation Model Suggestions** **Teacher-Led Station:** Teachers can work with students on additional We Do problems. • Additional Examples – TE pg. 110, pg. 111, pg. 113 • 2-6 Reteach to Build Understanding **Online Station**: Students can watch and engage with Virtual Nerd Video lessons. Students will initially tell what they think the answer to the question is or their opinion regarding an issue, and/or their thoughts based on a prompt. Then

		the students will watch the video to decide as to whether their original assertion was accurate, justified, etc. • 2-4: Virtual Nerd™: How Do You Use the Square Root Method to Solve a Quadratic Equation with Imaginary Solutions if $a \neq 0$? • 2-4: Virtual Nerd™: What is the Difference Between Imaginary and Complex Numbers? **Offline Station:** Students would complete problems and exercises selected for the You Do in Pairs part of the lesson. • Lesson Performance Task #50 – Pg. 101 • 2-4 Additional Practice • 2-4 Mathematical Literacy and Vocabulary • 2-4 Enrichment	the students will watch the video to decide as to whether their original assertion was accurate, justified, etc. • 2-5: Virtual Nerd™: How Do You Solve a Quadratic Equation with Complex Solutions by Completing the Square? • 2-5: Virtual Nerd™: How Do You Convert a Quadratic from Standard Form to Vertex Form by Completing the Square? **Offline Station:** Students would complete problems and exercises selected for the You Do in Pairs part of the lesson. • Lesson Performance Task #54 – Pg. 109 • 2-5 Additional Practice • 2-5 Mathematical Literacy and Vocabulary • 2-5 Enrichment	the students will watch the video to decide as to whether their original assertion was accurate, justified, etc. • 2-6: Virtual Nerd™: How Do You Solve a Quadratic Equation with Complex Solutions by Using the Quadratic Formula? • 2-6: Virtual Nerd™: How do You Find the Discriminant of a Quadratic Equation with 2 Complex Solutions? **Offline Station:** Students would complete problems and exercises selected for the You Do in Pairs part of the lesson. • Lesson Performance Task #39 – Pg. 116 • 2-6 Additional Practice • 2-6 Mathematical Literacy and Vocabulary • 2-6 Enrichment
7	What **manipulatives** might be integrated into the gradual release of responsibility (I Do, We Do, You Do in Pairs, You Do Without Assistance)? What did you learn from using the manipulatives **in advance** of using them in class with students?	**Reference:** Interactive Manipulatives • Didax Virtual Manipulatives • Savvas Math Tools • Realize Desmos (Graphing Calculator) • Realize Desmos (Scientific Calculator)	**Reference:** Interactive Manipulatives • Didax Virtual Manipulatives • Savvas Math Tools • Realize Desmos (Graphing Calculator) • Realize Desmos (Scientific Calculator)	**Reference:** Interactive Manipulatives • Didax Virtual Manipulatives • Savvas Math Tools • Realize Desmos (Graphing Calculator) • Realize Desmos (Scientific Calculator)
8	What **graphic organizer(s)** might support students' conceptual understanding of the process outlined by the performance-based objective(s)?	**Reference:** • Graphic Organizer Templates • Google Drawing Graphic Organizers • Teacher Vision	**Reference:** • Graphic Organizer Templates • Google Drawing Graphic Organizers • Teacher Vision	**Reference:** • Graphic Organizer Templates • Google Drawing Graphic Organizers • Teacher Vision

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