Standards Alignments - Edgy

Note:
This document is meant to help educators understand the relationship between the gameplay of Edgy and the educational goals being met by its players. This knowledge will help you combine Edgy with complementary activities that round out students' understanding. This document references Common Core Math standards[1], as well as softer content standards that are met by group gameplay and feature heavily in some state standards, such as those for Kentucky[2]. There is also a note at the end about color theory, although this is much more specific than the standards addressed by, for example, the National Core Arts Standards[3].

Common Core Mathematics Standards labels look like:
CC.2.NBT.4
[Common Core Prefix].[Grade Level].[Subtopic].[Standard Number]

Kentucky Core Academic Standards labels look like:
KCAS.4.1
[KCAS prefix].[Overarching Educational Goal].[Standard Number]
(Note that this notation is not uniform across the entire KCAS document, only for the standards referenced here.)

Edgy helps students meet standards in grades 2-5 (most are for grade 3), and is playable by students in grade 2 or higher. To give a sense of scope, Edgy helps 3rd grade students master about a fifth of the mathematics standards for their grade level all by itself. Research in cognitive psychology indicates that spaced rehearsal and active recall (e.g. for flash cards or tests) are some of the most effective strategies for learning[4]. Edgy encourages both of these, suggesting that it may be one of the most effective ways to understand multiplication.

The depth of understanding with respect to each concept is given with an approximate SOLO level[5]. The SOLO taxonomy has similar structure to Webb's Depth of Knowledge or Bloom's Taxonomy, and translations to those metrics is relatively straightforward. In the following table, the **bold text** indicates

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[1] http://www.corestandards.org/Math/ "Mathematics Standards | Common Core State Standards Initiative | Preparing Students for College and Career" Accessed February 16, 2017
[2] http://education.ky.gov/comm/ul/pages/kentucky-core-academic-standards.aspx (See the link near the top for "Kentucky Academic Standards") Accessed Februrary 16, 2017
[3] http://nationalartsstandards.org/ Again, note that Edgy does not teach visual arts, but does help students reinforce theory of primary and secondary colors in physical media.
[4] Dunlosky, John, et al. "Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology." Psychological Science in the Public Interest 14.1 (2013): 4-58. For a layperson's summary, see the Time article at http://ideas.time.com/2013/01/09/highlighting-is-a-waste-of-time-the-best-and-worst-learning-techniques/
[5] Biggs, John B., and Kevin F. Collis. *Evaluating the quality of learning: The SOLO taxonomy (Structure of the Observed Learning Outcome)*. Academic Press, 2014.

the SOLO level that can be typically inferred from competent play. The underlined text indicates the level of the standard.

Standard	Game Element	SOLO Levels	Recommendations
CC.2.NBT.4 Compare two three-digit numbers based on meanings of the hundreds, tens, and ones digits, using >, =, and < symbols to record the results of comparisons.	determining the winning score at the end of the game	1. Prestructural: Can't determine the winner. 2. Unistructural: Determine the winner of a two-player game. **3. Multistructural:** Determine the winner of a 3-player game 4. Relational: Sort the players by final score, using <, =, > notation. 5. Extended Abstract: Use predicted score to choose moves.	Encourage students to write down the final scores and use the >, < notation to indicate higher/lower scores, and = to indicate ties.
CC.2.NBT.5 Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.	adding the points earned each turn to the cumulative score; computing differences between scores	1. Prestructural: Can't keep score across turns. 2. Unistructural: Add individual places, but without carrying overflow digits. 3. Multistructural: Correctly add 3-digit numbers **4. Relational:** Keep score and compute the difference between scores. Manipulate the arithmetic to make it easier. For example, re-expressing as a sum or difference of round numbers. 5. Extended Abstract: Determine >, =, < from score difference.	Encourage students to see how much of a lead they have. For example, how many points would a player have to earn in order to take the lead?

CC.2.G.2 Partition a rectangle into rows and columns of same-size squares and count to find the total number of them.	figuring out how many tiles to draw after a turn	1. Prestructural: Don't see relationship between size of added rectangle and number of tiles used. 2. Unistructural: Count number of tiles played in last turn. 3. Multistructural: Count number of tiles in all grids in play to determine how many tiles are left. 4. **Relational:** Understands that the same number of tiles may sometimes be combined into rectangles of different shapes. 5. Extended Abstract: See that adding to grids with the largest dimensions usually gives the most points.	Encourage students to think about the size of grids in terms of the number of tiles in them, rather than the length of their sides.

CC.3.OA.1 Interpret products of whole numbers, e.g., interpret 5 × 7 as the total number of objects in 5 groups of 7 objects each. For example, describe a context in which a total number of objects can be expressed as 5 × 7.	forming grids; calculating points	1. Prestructural: Count individual tiles. 2. Unistructural: See grids as W rows of length L. 3. <u>Multistructural:</u> See grids as W rows of length L, or L columns of width W. **4. Relational:** See that W x L = L x W because it is the same grid viewed from different angles, and has the same number of tiles either way. 5. Extended Abstract: See that addition is also commutative because a turn can extend a grid in either direction along an axis and the total will stay the same.	Encourage students to count their points by rows, and then to count their points by columns.

CC.3.OA.5 Apply properties of operations as strategies to multiply and divide. Examples: If 6 × 4 = 24 is known, then 4 × 6 = 24 is also known. (Commutative property of multiplication.) 3 × 5 × 2 can be found by 3 × 5 = 15, then 15 × 2 = 30, or by 5 × 2 = 10, then 3 × 10 = 30. (Associative property of multiplication.) Knowing that 8 × 5 = 40 and 8 × 2 = 16, one can find 8 × 7 as 8 × (5 + 2) = (8 × 5) + (8 × 2) = 40 + 16 = 56. (Distributive property.)	counting points (commutation) extending grids (distribution)	1. Prestructural: Don't see that there are multiple ways to construct the arithmetic to compute the number of tiles in a grid. 2. Unistructural: Partition a grid into rows or columns and compute the corresponding product (commutation). 3. Multistructural: Partition a grid into additive pieces along a major axis (such as the pre-existing grid and a player's extension of it), and sum the results of the two products (distribution). 4. **Relational:** Understand that the total grid can be partitioned into different rectangles, and those rectangles can be added together to compute the total. 5. <u>Extended Abstract:</u> Express computations symbolically and use the properties of multiplication symbolically to simplify the problem.	Help students to explicitly see the relationship between partitioning a rectangle (or several identical rectangles to illustrate association) and symbolic notation. Use examples drawn from gameplay to help students gain an intuition for how and why these properties work.

CC.3.OA.7 Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 × 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers.	computing points each turn	1. Prestructural: Can't multiply or divide. 2. Unistructural: Multiply or divide using task-specific strategies. 3. **Multistructural:** Fluently multiply 1-digit numbers. 4. <u>Relational:</u> Recognize that the results of a given multiplication and division are related. 5. Extended Abstract: Use the results of 1-digit multiplication in multiplication of larger numbers.	To facilitate students connecting multiplication and division, ask questions like, "How many rows would this grid need to have to be work this many points?"

CC.3.MD.7.a Find the area of a rectangle with whole-number side lengths by tiling it, and show that the area is the same as would be found by multiplying the side lengths.	computing points each turn	1. Prestructural: Don't see a relationship between area and rectangle size. 2. Unistructural: Area of a rectangle can be computed by tiling. 3. <u>Multistructural:</u> Compute the area by multiplying length by width. 4. Relational: Use the interrelationship of repeated addition, multiplication, and computing rectangular area as a tool for making problems easier to understand or compute. 5. **Extended Abstract:** Infer properties of multiplication from properties of rectangular area.	To reinforce the grounding of multiplication in rectangular area, use visuals of rectangular area to help explain properties of multiplication.

CC.3.MD.7.c Use tiling to show in a concrete case that the area of a rectangle with whole-number side lengths a and b + c is the sum of a × b and a × c. Use area models to represent the distributive property in mathematical reasoning.	extending grids	1. Prestructural: Compute grid area by counting tiles. 2. Unistructural: Compute grid area by multiplying side lengths. 3. <u>Multistructural:</u> Compute grid area by adding the number of played tiles to the number already there, computed by multiplication. 4. **Relational:** Understand that the sum of the areas of any partition of a larger shape will always equal the area of that larger shape. 5. Extended Abstract: Partition a shape into rectangles to compute the area.	Encourage students to think about things that do not change no matter how many times you do a particular process. For example, adding and subtracting 1 does not change a sum. Moving a shape's position does not change its area. etc.

CC.3.G.1 Understand that shapes in different categories (e.g., rhombuses, rectangles, and others) may share attributes (e.g., having four sides), and that the shared attributes can define a larger category (e.g., quadrilaterals). Recognize rhombuses, rectangles, and squares as examples of quadrilaterals, and draw examples of quadrilaterals that do not belong to any of these subcategories.	forming edge groups	1. Prestructural: Don't see the relationship between shape properties and the categories they belong to. 2. Unistructural: Understand categories based on the number of sides. 3. Multi-structural: Understand subcategories based on additional shape properties. Recognize a variety of quadrilaterals. 4. Relational: Understand that shape categories can combine. For example, squares can be defined as rectangles that are also rhombuses. 5. **Extended Abstract:** Understand the set of shapes that do not have any of these interesting properties.	To help students develop a rich understanding of shapes, have them draw their own cards with their own shapes based on required categories.

CC.4.OA.4 Find all factor pairs for a whole number in the range 1–100. Recognize that a whole number is a multiple of each of its factors. Determine whether a given whole number in the range 1–100 is a multiple of a given one-digit number. Determine whether a given whole number in the range 1–100 is prime or composite.	computing points; planning a turn	1. Prestructural: Don't understand the relationship between factors and whole number division. 2. Unistructural: Use task-specific strategies for determining if one number is a factor of another. 3. Multistructural: Combine task-specific strategies to test if any of a small set of numbers are factors of a given number. 4. **Relational:** Understand the relationship between factors and whole number division. 5. <u>Extended Abstract:</u> Label small numbers as prime if they have no other prime factors.	Help students to see the connection between edge length and factors in a rectangle. Ask students what grid sizes can be formed without exceeding the 12 dimension limit. (If you ask this question for numbers less than 169, the answer corresponds to whether or not the number is prime, provided that you have enough tiles.)

CC.4.G.2 Classify two-dimensional figures based on the presence or absence of parallel or perpendicular lines, or the presence or absence of angles of a specified size. Recognize right triangles as a category, and identify right triangles.	shape labels and groups	1. Prestructural: Don't see a relationship between angle and line properties and shape labels. 2. **Unistructural:** Understand that all shapes with a specific label share a line or angle property. For example, all right triangles have a right angle (pair of perpendicular edges). 3. <u>Multistructural:</u> Classify shapes based on their angle or line properties. 4. Relational: Given a list of properties, draw an instance of that shape. 5. Extended Abstract: Apply shape properties to shape categories. For example, all squares have two pairs of parallel lines.	To encourage students to classify shapes based on different properties, impose additional rules on Edgy groups. For example, "Quadrilateral edge groups can only be formed if all of the tiles have the same number of parallel lines."

CC.5.G.3 Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category. For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.	shape labels and groups	1. Prestructural: Think about shapes on an instance-based level. 2. Unistructural: Think about shapes in terms of properties they have. 3. **Multistructural:** Recognize that there are relationships between properties of shapes. Recognize mutual exclusivity (for example, all triangles are not quadrilaterals, etc.). 4. Relational: Recognize that some properties always coincide with others. Think of properties of shapes as categories. 5. Extended Abstract: Understand the notion of sets, that properties define sets, and that the sets defined by some properties are included in the sets defined by other properties.	To help students think abstractly, explicitly introduce the mathematical definitions of shape properties. Have students draw their own versions of Edgy tiles with their own shapes and associated properties.

KCAS.4.1 Students effectively use interpersonal skills.	general gameplay and especially trading	1. Prestructural: Little to no communication during the game, or poor sportsmanship. 2. Unistructural: Communicate to facilitate gameplay, by talking about turns, points, tile groups, and rules. 3. <u>Multistructural:</u> Recognize the resources and incentives of other players to effectively trade with them. 4. **Relational:** Use communication strategies to try to convince other players to trade more favorably. 5. Extended Abstract: Teach other students about the game or while playing the game.	Encourage higher levels of communication by having students play in small teams. Talk about strategies to use when trading.
KCAS.5.4 Students use a decision-making process to make informed decisions among options.	planning turns	1. Prestructural: Don't understand what constitutes a legal move. 2. Unistructural: Search tiles for playable groups. 3. <u>Multistructural:</u> Choose between different groupings of tiles to maximize points in a turn. 4. **Relational:** Recognize the opportunity cost of using a tile on a given turn when it might be useful to make a better play next turn. 5. Extended Abstract: Form a plan by assessing other player's options as well.	Encourage students to talk to each other about strategy. For example, this can be done by having students pair up and play from a single hand.

[Not a formal standard] Students predict the secondary color produced by mixing two primary colors.	color groups	1. Prestructural: Don't understand that the result of color mixing is determined by the primary colors used. 2. **Unistructural:** Produce a desired secondary color by mixing two primary colors: 3. Multistructural: Adjust the hue of a color by incrementally mixing in a primary color. 4. Relational: Determine how close two colors are according to their relative hue. 5. Extended Abstract: Understand color composition in terms of a color wheel of paints.	For younger students, help them to focus on the basic aspects of the game (grouping by counting the number of sides, grouping by color combinations) by keeping score for them, or setting an alternative game objective, like most types of groups formed in one turn.

Application of the SOLO taxonomy to new domains can be difficult and subjective. If you have a more robust mapping to the SOLO taxonomy, please contact ir Games through their website (https://irllc.games). Also contact us if you are interested in doing pedagogical research or outcomes-based assessment related to Edgy.