NGSS mapping of Whybricks

Alignment guide of the Whybricks ‘But, Why?’ lesson set to the Next Generation Science Standards

Whybricks

Giving physical science form

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This document aims to demonstrate how the Whybricks *But, Why?* lesson set align to the Next Generation Science Standards.

The Whybricks *But, Why?* lesson set is most appropriate for teaching students in upper primary, middle and high school. The lessons best align with the learning objectives for this age range, however, the Whybricks product can be used with younger students to demonstrate additional concepts.

Please note: *The Whybricks product is only recommended for use by students aged 8+ years old.*

Contents

3rd grade – 5th grade

The *But, Why?* lesson set are generally suitable for this age range. However, some of the student lesson materials, including the WOW sheets, are written for independent reading use by students at the older end of this band.

Providing as much autonomy as possible will enable students to have the richest experiences as they build, tinker, and explore the concepts. The lesson teacher guides provide additional suggestions for supporting students.

Performance expectation	Whybricks lesson	Teacher notes
3rd grade PS2: Forces and interactions		
3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	Why do objects slow down?	Students build a variety of objects and observe what happens when forces are applied to the objects. Students investigate what happens when they apply forces of varying strengths and record their observations.
3-PS2-2: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.	Why do some roads have truck escape ramps?	Students explore how different factors (ramp angle, ramp material, car mass, etc.) affect the motion of a car moving down a ramp. The students take systematic measurements and analyse their results. While not explicitly assigned in the lesson, as an extension activity, educators can ask students make a prediction based on their results to predict future movement.

	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. The students take systematic measurements and analyse their results. While not explicitly assigned in the lesson, as an extension activity, educators can ask students make a prediction based on their results to predict future movement.
	Why don't snowboards need wheels?	Students use two snowboards, one bumpy and one smooth, to explore the relationship between friction and motion. The students take systematic measurements and then analyse their results. While not explicitly assigned in the lesson, as an extension activity, educators can ask students make a prediction based on their results to predict future movement.
	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). The students take systematic measurements and then analyse their results. While not explicitly assigned in the lesson, as an extension activity, educators can ask students make a prediction based on their results to predict future movement.
4th grade PS3: Energy		
4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. The students take systematic measurements and analyse their results.

	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). The students take systematic measurements and then analyse their results.
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). The students take systematic measurements and then analyse their results. While not explicitly assigned in the lesson, educators can direct students to set up their experiments to focus on the energy transfer occurring between the swinging hammer and the struck object.
	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. The students take systematic measurements and analyse their results. While not explicitly assigned in the lesson, educators can direct students to set up their experiments to focus on the energy transfer occurring between the catapult and the projectile.
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. The students take systematic measurements and analyse their results.
	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck

		object). The students take systematic measurements and then analyse their results.
	Why don't playgrounds use motors?	This semi-opened project can be structured to focus on energy conversion.
5th grade PS2: Forces and interactions		
5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.	Why don't you float away when you jump?	This lesson is all about the mechanics of gravity, including proving that it pulls objects toward the centre of the earth (downward).
	Why do some roads have truck escape ramps?	An aspect of this lesson explores why a car slows down as it moves up an inclined plane. It discusses gravity on a ramp in detail.
	Why don't snowboards need wheels?	This lesson is about how an object travels down an inclined plane. While primarily centred around friction, the lesson does explore the role of gravity as a pulling force down on objects, including in terms of normal force.
3rd – 5th grade ETS1: Engineering design		
3-5-ETS1-1: Define a simple design problem reflecting a need or a want that	Why don't bridges collapse in the middle?	Students are guided to build three different bridges. Each bridge performs a different function based on material and spatial

includes specified criteria for success and constraints on materials, time, or cost.		constraints. Students are asked to analyse why each one works or fails.
	Why don't you float away when you jump?	Students observe the way hailstones fall. They are then asked to design a solution to slow down the hailstone. The process of iterative design, including specifying criteria for success, is worked through in detail.
	Why is riding a bicycle faster than running?	Students investigate how gears are used to create mechanical advantage. They are then asked to design an object which uses gears to perform a set task. The process of iterative design, including specifying criteria for success, is worked through in detail.
	Why don't playgrounds use motors?	This semi-opened design project can be structured to focus on constraints. The process of iterative design, including specifying criteria for success, is worked through in detail.
3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	Why don't you float away when you jump?	Students observe the way hailstones fall. They are then asked to design a solution to slow down the hailstone. The process of iterative design, including specifying criteria for success, is worked through in detail. While not explicitly assigned in the lesson, educators can direct students to use different materials or designs, then compare the results.
3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects	Why don't snowboards need wheels?	Students build and compare two snowboards which they use in an experiment of their own design, controlling for variables, to examine how friction affects movement. The students take systematic measurements and then analyse their results.

of a model or prototype that can be improved.	Why do swings swing?	Students use a pendulum-style swinging hammer to run an experiment of their own design, controlling for variables. The students take systematic measurements and then analyse their results.
	Why do some roads have truck escape ramps?	Students build and use a car in an experiment of their own design, controlling for variables, to examine how a single independent variable affects movement. The students take systematic measurements and then analyse their results.
	Why do rubber bands snap back?	Students use a catapult to run an experiment of their own design, controlling for variables. The students take systematic measurements and then analyse their results.

Middle school

The *But, Why?* lesson set are designed for this age range.

Providing as much autonomy as possible will enable students to have the richest experiences as they build, tinker, and explore the concepts. The lesson teacher guides provide additional suggestions for supporting students.

Performance expectation	Whybricks lesson	Teacher notes
Middle School PS2: Forces and interactions		
MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.	Why do objects slow down?	Students explore Newton's three laws through a series of set of builds. In the final build, the students explore how applied force affects the build and how the build, in turn, affects the objects in collides with (including the student's hand and the table).
MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). The students take systematic measurements and then analyse their results. Educators can direct students to limit their experiments to focus on the force of the swinging hammer (by increasing its height) and the mass of the struck object.

MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.	Why don't you float away when you jump?	This lesson is all about the mechanics of gravity, including proving that it pulls objects toward the centre of the earth. The lesson explores the idea of mass and the relationship between mass and weight, and investigates why objects on Earth fall towards, and not away, from the Earth.
	Why do some roads have truck escape ramps?	Students build and use a car in an experiment of their own design, examining how a single independent variable affects movement. Mass is the most likely independent variable to be tested.
	Why don't snowboards need wheels?	Students explore the factors, including gravity, that affect how an object travels down an inclined plane. Students conduct an experiment of their own design, examining how a single independent variable affects movement. While tests exploring friction are the most likely to be selected, the role of mass and the effects of gravity on inclines are also viable test options and can be pre-selected for by the setup of available materials provided by the educator.
Middle School PS3: Energy		
MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. The students take systematic measurements and analyse their results. Educators can direct students to limit their experiments to focus on the mass of the projectile and the speed of the projectile.

	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). The students take systematic measurements and then analyse their results. Educators can direct students to limit their experiments to focus on the mass of the struck object and the speed of the struck object.
MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). The students take systematic measurements and then analyse their results. Educators can direct students to limit their experiments to focus on the transfer of energy between the swinging hammer and the struck object.
	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. The students take systematic measurements and analyse their results. Educators can direct students to limit their experiments to focus on the transfer of energy between the catapult and the projectile.
Middle School ETS1: Engineering design		
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles	Why don't bridges collapse in the middle?	Students are guided to build three different bridges. Each bridge performs a different function based on material and spatial constraints. Students are asked to analyse why each one works or fails, taking into account the scientific principles, including normal force and tension, at play in each design.

and potential impacts on people and the natural environment that may limit possible solutions.	Why don't you float away when you jump?	Students observe the way hailstones fall, including studying the scientific principles (including gravity and air resistance) which cause this phenomenon. They are then asked to design a solution to slow down the hailstone, using a step-by-step method of working through the engineering design process. Criteria for success are determined and students work through iterative design to solve the problem of slowing down the hailstone.
	Why is riding a bicycle faster than running?	Students investigate how gears are used to create mechanical advantage. They are then asked to design an object which uses gears to perform a set task. The process of iterative design, including specifying criteria for success, is worked through in detail. The limits of gear ratios and the role of friction in designs, while not explicitly noted in the lesson, can be drawn into focus.
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Why don't you float away when you jump?	Students observe the way hailstones fall. They are then asked to design a solution to slow down the hailstone. The process of iterative design, including specifying criteria for success, is worked through in detail. While not explicitly assigned in the lesson, educators can direct students to use different materials or designs or otherwise, then compare the results.
MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new	Why don't snowboards need wheels?	Students conduct an experiment of their own design, examining how a single independent variable affects movement of an object on an incline. By structuring the initial setup so that different groups of students test different independent variables, this activity can be extended to have students analyse cross results, for example, comparing surface materials

solution to better meet the criteria for success.		and angle combinations that will move one of the two snowboards down the ramp the fastest.
	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). The students take systematic measurements and then analyse their results.
	Why do some roads have truck escape ramps?	Students compare how different factors affect the way a car moves down a ramp. By structuring the initial setup so that different groups of students test different independent variables, this activity can be extended to have students analyse cross results, for example, comparing the car's mass and the ramp's angle combinations that will move the car down the ramp the fastest. An extension challenge of creating an escape ramp could also be devised, requiring students to apply what they learned in their experiments to a new application.
	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. The students take systematic measurements and analyse their results.
MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	Why is riding a bicycle faster than running?	Students investigate how gears are used to create mechanical advantage. They are then asked to design an object which uses gears to perform a set task. The process of iterative design, including specifying criteria for success, is worked through in detail.

High school physics

The *But, Why?* lesson set are conceptual in nature, designed to be used in inquiry-based physics curricula as introductions and real-world applications of physics concepts. The set is appropriate as-is to introduce and reinforce key concepts centred on forces, energy, and motion. The lessons provide a solid framework for students to practice designing scientific experiments and working through the engineering design process. Providing as much autonomy as possible will enable students to have the richest experiences as they build, tinker, and explore the concepts.

At the high school level, you may find that adding extensions to the lessons to increase their scope of study is helpful in aligning the lessons to your educational objectives. Consider including additional student challenges, such as creating models that define equations or solving for various variables.

Performance expectation	Whybricks lesson	Teacher notes
High School PS2: Forces and interactions		
HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	Why do objects slow down?	This lesson explores Newton's three laws of motion at a conceptual level, ideal for introducing the key concepts and seeing the macroscopic affects of Newton's second law as they pertain to mass and acceleration.
	Why do some roads have truck escape ramps?	This lesson explores the forces that act on an object in motion on an inclined plane. Students design and run an experiment where they test the effect of changing one independent variable (for example, the mass of the car) on measurable dependent variables (for example, the acceleration of the car). While not explicitly noted in the lesson, educators may opt to add

		an extension to this lesson asking students to use what they have learned about Newton's second law to mathematically describe and explain what they have observed in their experiments.
	Why don't snowboards need wheels?	This lesson explores friction acting on a pair of snowboards sliding down a ramp. Students design and run an experiment where they test the effect of changing one independent variable (for example, the mass of one of the snowboards) on measurable dependent variables (for example, the acceleration of the snowboard). While not explicitly noted in the lesson, educators may opt to add an extension to this lesson asking students to use what they have learned about Newton's second law, inclined planes and trigonometry to mathematically describe and explain what they have observed in their experiments.
High School PS3: Energy		
HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).	Why do rubber bands snap back?	Students use a catapult to explore the relationship between potential and kinetic energy and how it effects how a launched object moves. Educators can direct students to limit their experiments to focus on the transfer of energy between the catapult and the projectile, as a result from the potential energy gained by the position of the lever and rubber band.
	Why do swings swing?	Students use a pendulum-style swinging hammer to study the relationship between leverage, potential energy, force and the resulting kinetic energy (observed in the movement of a struck object). Educators can direct students to limit their experiments to focus on the transfer of energy

		between the swinging hammer and the struck object, as a result from the potential energy gained by the position of the lever.
HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	Why don't playgrounds use motors?	This semi-opened design project can be structured to focus on energy transfer. The process of iterative design, including specifying criteria for success, is worked through in detail.