Why don't playgrounds use motors? The teacher guide

Whybricks
Giving physical science form

microbric
motivate • create • educate

Contents

Document number: 3.2.4.7.12.1 Rev.1.0

About Whybricks

Whybricks is an education-focused construction system consisting of 2,100 pieces (210 pieces per student). Each Whybricks kit contains everything needed to enable 10 students to work individually.

Each Whybricks kit contains interlocking building blocks, beams, pegs, gears and other parts. The individual Whybricks pieces are designed with studs and holes which are compatible with any LEGO brick compatible building system.

Why use Whybricks?

The Whybricks kit, along with the supporting lessons, can help students tangibly access topics that can otherwise feel abstract. Whybricks allow students to explore physical science and engineering phenomenon in a hands-on and engaging way. By enabling students to explore topics through physical activity, students engage in kinaesthetic learning, allowing them to experiment with productive trial-and-error and bridge potential gaps between theory and practice.

The Whybricks lessons use the Whybricks kit to help to support or elevate understanding for any type of learner. The Whybricks kit offers a way to bring hands-on learning in as a functional part of each Whybricks lesson plan.

Managing Whybricks in your classroom

Whybricks offers educators flexible teaching options. Both the Whybricks kit and lessons are intentionally versatile to allow teachers the freedom to implement the materials however best suits their classroom's needs.

The components of each Whybricks kit are supplied with the intention of being a 'pool of parts' for the teacher to use as you see fit. The parts can be organised and stored as best suits your classroom and students. Some ideas for managing the Whybricks kits in your classroom include:

- Create individual 210-part student kits for each student.
- Make up packs with just the parts needed for a specific lesson activity or project.
- Make 'STEM boxes' with instructions and pieces for a challenge for rotation stations.

- Divide up the full kit, arranged by part type, into a storage tray-style storage system, allowing students to find and use the parts they need.
- Provide only a selection of parts in a mixed pack for semi-open and open-ended projects, limiting students from being overwhelmed or distracted by other parts and providing an engineering constraint.
- Keep all the parts mixed together in a single pile free-for-all.

About the 'But, Why?' lessons

This lesson is a *But, Why?* Whybricks Lesson. What does that mean?

Try this.

Ask 10 students the question 'why do people use wheelbarrows?' You will likely end up with 10 versions of the answer 'because it makes it easier.' And they are right, of course!

Your students already know a lot about how the world works. They know that when they let something go, it falls down. They know that riding a bicycle is faster than walking. What they might not know, or may not be able to articulate, is why these things are true.

Now imagine the conversation again:

> You: Why do people use wheelbarrows?
>
> Student: It makes it easier.
>
> You: It makes what easier?
>
> Student: ... Doing... the work. You know, carrying heavy stuff, or big stuff.
>
> You: But, why?

These lessons will help you flip the script

The *But, Why?* Whybricks Lessons are designed to help teachers transfer agency over learning to students. These lessons help you take your students on a learning journey by asking them 'why?' and supporting them in discovering and presenting their answers using sound engineering and scientific practices.

These Whybricks investigations start by getting students to communicate what they already know about observable phenomenon. By asking students 'why?' up front, the Whybricks investigations help educators determine and celebrate what students already understand. This intuitive understanding is then built upon inside the investigation. Each lesson supports students in growing their grasp of the reasons that underpin the 'why' of what they have already discovered.

The *But, Why?* investigations help students invest in their learning through active and hands-on sciencing (because science is a verb now!) and engineering. The 'why' question format drives the inquiry nature of each investigation, exploring different aspects of physical science and engineering.

Pedagogy approach

The pedagogy behind the *But, Why?* Whybricks lessons set is to deliver physical science education holistically. Through the investigations, students will:

- encounter facts (for example, Newton's second law is mathematically expressed as F=ma),
- exercise a scientific mindset (for example, making observations by answering 'what do you notice?' and developing questions by considering 'what do you wonder?'),
- participate in scientific and engineering practices (for example, by planning and carrying out an experiment or by developing and iterating a design), and
- make real-world connections between the world around them and the material they are learning.

The methodologies used in the investigations are inspired and informed by:

- The PQRST approach developed by DaNel Hogan and Brooke Meyer https://stemazing.org/pqrst/
- The inquiry in the classroom approach as codified by Trevor Mackenzie https://www.trevormackenzie.com/

With great appreciation and heart-felt thanks for your collaboration for constructive disruption.

Creative Commons licence

Licence and attribution details

Using the guides and the lessons

Each *But, Why?* Whybricks investigation is slightly different. As every investigation explores different physical science and engineering topics, the layout and activities of each one differs to best enable meaningful learning to be achieved. There is no set order in which the investigations should be explored and no wrong-way of adjusting an investigation to suit your students or curriculum.

This guide offers support for educators to get the most out of this lesson.

Overview of the student materials

Each *But, Why?* Whybricks investigation is intended to be student-centred and led. With the exception of the teacher guides, the educational materials are all 'student materials' and are designed for independent use by students.

The student materials for this lesson can be downloaded from https://whybricks.com/lesson-set/but-why/

There are three types of interrelated printable student materials:

- Whysheets
- Notice and Wonder sheets
- WOW sheets

An overview of each type of document follows.

About the Whysheets

The core of each *But, Why?* Whybricks investigation is its Whysheet. Much more than a worksheet, a Whysheet is the students' (and educators') guide for the investigation.

---

[1] Creative Commons licence information can be viewed at http://creativecommons.org/licenses/by-sa/4.0/

Every Whysheet starts with the 'why' question the investigation is centred around. Students answer the question to the best of their ability, drawing on what they already know. The goal isn't to get it 'right' but to codify what they already understand and, over time, get them to think about what they don't understand as well.

The Whysheet will then walk the students through the investigation step-by-step.

Any WOW sheets related to the investigation will be referenced in the Whysheet as will suggestions for when to use the Notice and Wonder sheets. If there is a set Whybricks build, step-by-step build instructions will also be included as an appendix to the Whysheet. You can also encourage students to improve on the set builds, further exploring and applying aspects of physical science and engineering.

The Whysheets, along with the Notice and Wonder sheets, are designed to capture learning evidence as it happens during the investigation, rather than be a 'now that you have finished everything, write in the correct answer' style worksheet. Encouraging students to view the Whysheet as their tool to help them through the investigation will help them take ownership over their learning.

About the Notice and Wonder sheets

The Notice and Wonder sheets are templates designed to work alongside any *But, Why?* investigation. These sheets offer places for students to note observations 'I notice ...' and capture questions 'I wonder ...' throughout the investigation. The Whysheets will indicate key opportunities in an investigation when students will benefit from making notes in a Notice or Wonder sheet, but students should feel free to use these sheets throughout their learning journey, especially for capturing new questions they begin to wonder about as they progress.

Along with the Whysheet, the Notice and Wonder sheets form an important part of capturing learning evidence and empowering student agency in each investigation. All of the Notice and Wonder sheets serve the same purpose, but different versions are available to offer educators flexibility in adapting these to their students' needs.

The Notice and Wonder sheet set includes an educator's overview and recommendation section with additional information.

About the WOW sheets

The WOW in the WOW sheets stand for 'Why? Oh, Whoa!'.

WOW sheets are a way of inserting teaching into an investigation flexibly. For example, you might choose to provide copies of the WOW sheets for students to read in-depth or just reference to find the answers they need. You can also replace WOW sheets with your own lecture or other fact-delivery method on the topic, explaining and exploring as deeply as you see fit.

These sheets are basically reference cards. Each WOW sheet contains information about a specific topic or fact. The WOW sheets help students to discover and understand key information, enabling them to apply what they learn back into the investigation. Examples of the content covered in WOW sheets includes definitions of terms (e.g. 'What is mass?'), explanations of facts (e.g. Newton's third law) and formulas in context (e.g. calculating acceleration, part of the 'What is acceleration?' WOW sheet).

WOW sheets can be used in several ways. You can use them to help guide class-wide explanation sessions or allow students to access them independently when and if they need the information. The WOW sheets can introduce concepts, serve as quick 'refresher' reference cards or be used retrospectively to demonstrate broader applications of elements encountered inside an investigation.

The Whysheets will indicate key moments in an investigation when students may benefit from using a specific WOW sheet. You may also find it helpful to have the WOW sheets available for students to access at any time.

Overview of the teacher guide

This teacher guide offers overview information plus per-investigation support for educators to get the most out of each lesson.

Remember that the *But, Why?* lesson set is intentionally flexible. There is no set order in which the investigations should be explored. Likewise, while the teacher notes offer additional support for educators, by design they are not overly prescriptive.

The *But, Why?* investigations aim to inspire students to 'think like a scientist' or 'think like an engineer'. Rather than simply explaining how something works, the lessons encourage active participation in learning by conducting experiments and problem-solving. Armed with these experiences, the students are the ones doing the sense-making.

As you might expect, trial-and-error is an inherent part of this approach. To get the most out of their Whybricks lesson, you should support your students as they work through productive struggles without jumping in and 'saving them' from these exciting learning opportunities. Give students a chance to impress you, and themselves, with the thinking they can do. However, you know your students best! Always feel free to adjust any investigation to suit your students or curriculum as you see fit.

For each *But, Why?* investigation you will find teacher notes specific to the investigation that include:

- An overview of the investigation
- A list of the topics covered
- A list of the WOW sheets needed (both those explicitly noted in the student Whysheet plus any additional recommendations)
- Recommendations for running the investigation
- Additional notes specific to the investigation (including sample answers to specific Whysheet questions)

Love these lessons? Hate them? Have an idea for a lesson activity?

The team behind Whybricks would love to hear from you! You can share your feedback and ideas with us through the contact form on our website at https://whybricks.com/support/contact-us/

Why don't playgrounds use motors?

Overview

This semi-open-ended lesson offers students a chance to demonstrate their understanding of physical science forces and simple machines in an engineering creation of their own design. Perfect for use as a capstone-style project, students create a piece of playground equipment that demonstrates at least one physical science principle. Using the engineering design process, students iterate and test a design out of Whybricks, then also create a plaque to sit alongside their design, explaining the science at work.

Topics covered

The topics covered in this lesson will vary depending on the designs students select. Expected topics include:

- Simple machines
- Mechanical advantage
- Potential and kinetic energy
- Newton's laws of motion
- Engineering design

WOW sheets

Explicitly noted	Also recommended
No WOW sheets are explicitly noted in the lesson. However, the following are hinted at: • What is gravity? • Friction • What is tension? • Potential and kinetic energy • Newton's first law • Newton's second law • Newton's third law • Inclined plane • Wedge • Screw • Levers • Wheel and axle • Pulley	• What is force? • What is mass? • What is acceleration? • What is weight? • Mechanical advantage • Gears • What is normal force? • What is air resistance?

Additional equipment

Beyond making a full range of Whybricks available, there is no set equipment list for this project. Student designs will determine the additional supplies required.

Alternatively, you can decide on the available supplies in advance. Show students the available building materials and explain that these are the only options for use in their designs. This is an excellent way of introducing the idea of constraints into the engineering design process.

Delivery recommendations

The Why question

Before you begin the investigation, have students think about and answer the 'why' question. Offering everyone quiet independent thinking time to start is a good way to ensure all students have the chance to consider what they already know. You can then have students share with a partner, a group or the class if you like. If students start to raise questions, encourage them to capture them on a Wonder sheet.

Welcome to the playground

This short introduction section sets the scene for the investigation, asking students to begin to connect what happens on a playground with physical science. You may choose to supplement this with a discussion, a video, or some other engaging 'hook' to inspire students.

Design your own playground

The bulk of this investigation is an engineering design challenge. The goal of the challenge is to design and engineer a piece of playground equipment that demonstrates at least one physical science principle. This can be based off of existing equipment or can be an imaginative new design.

Students also need to communicate what is happening in their design in terms of the science at work. They will create a written plaque for this purpose.

This section is laid out in five steps:

1. Brainstorm
2. What is the science?
3. Test design
4. Iteration (i.e. 'Build, test, learn, repeat')
5. Make the plaque

When it comes to 'engineering', there's a temptation to jump straight into building. However, engineers are problem solvers first and foremost. Understanding what the goal is, what constraints there are and how success will be measured are important parts of the engineering design process. The steps in this investigation are designed to help students work through the engineering design process in a painless but meaningful way.

Suggestions on how you can run each step follows, however, feel free to adjust this challenge to suit your class.

Step 1: Brainstorm

Not all students will feel confident about an engineering design challenge. A brainstorming session is a great way to get the creative juices flowing. Tell students that this is just about coming up with ideas, which is all about being imaginative, using their creativity and thinking about possibilities. Whether or not these will work isn't the current concern – there's a whole other step for that!

Depending on your students' confidence with making, you may want to allow the first few rounds to be completely open: allow them to generate ideas by getting their thoughts to flow freely. Let them know that all ideas are acceptable, no matter what they are. Encourage students not to make decisions about whether the ideas are possible or judge the ideas while they are brainstorming.

One way to do this is to run a timed brainstorming session. Set a timer for 45 seconds – that's all the time students have for the first idea before they must move onto the next. Allow students to capture ideas however they like: draw, write down a description or a bit of both. Tell them the main rule is that they are not allowed to NOT come up with ideas. Remind them that there are no 'bad' ideas during a brainstorming session! As soon as the timer goes off, reset it and have students move on to the next idea.

After a few rounds, pause. Introduce the materials students will have available to them to use in the engineering challenge. Then start the brainstorming session up again, this time encouraging students to think about possibilities using the available materials. You can keep the timer set to 45 seconds or increase it slightly as you see fit.

Step 2: What is the science?

This step is a chance for students to analyse their brainstormed ideas in terms of their understandings of the mechanisms at work in each design. Have students review each of their ideas and note down what they believe is going on in each one in terms of forces at work, simple machines, and any other factors. If students are unsure what the science in a design is, encourage them to note this fact. They can always do a bit of research (using the WOW sheets or beyond) to help them learn more as needed.

Once all the brainstorming and science alignment is complete, give students a few minutes to analyse the ideas they came up with. Looking at all of their ideas together can help students evaluate their ideas, choosing which ones they feel are better than others and noting any areas where more research is required before a build could begin. This can help students in selecting one idea to use as a starting place in designing their creation.

If you are going to have students work on the rest of the design challenge in pairs or groups, this is also a good time to get the groups together. Sharing ideas and discussing their thoughts at this stage will help students in the next step as they design their test.

Step 3: Design the test

There's no way to know whether or not a design is successful without criteria and a test. That's what this step is all about. This step is often overlooked in engineering projects, but is critically important.

A key parameter of the test is established in the goal for this design challenge on the Whysheet (engineer a piece of playground equipment that demonstrates at least one physical science principle). Students will need to determine some test for their equipment that shows the principle they have selected. Their test needs to measure the performance of the equipment in some way.

If, for example, students want to demonstrate the transfer of potential and kinetic energy, their creation needs to move or function in some way so that both potential and kinetic energy states can be observed.

Like all things in engineering, students may encounter issues while designing the test. Whatever test students devise, remind them that it is important that they note the procedure and how they measure carefully so this can be repeated across their designs.

Depending on your students, you may choose to guide your class through this step. In helping students create their tests, noting any dependent and independent variables, materials and equipment that will be used, and the experimental procedure. The experimental procedure should be detailed enough to allow data collection (if using) and to be able to be repeated exactly as described.

A note about testing:

It's generally considered good practice to run five (5) trials of a test and then average the results together.

Step 4: Iteration

This step is where students get into the heart of the engineering design process as they build, test, learn and repeat.

Depending on the materials available to them for use in their designs and the tests that students have created, this step can vary widely even in a single class. Some students' initial iteration may be quite solid, and their further iterations are mainly refinements. (Remind students also that they can 'take a step back' to a previous iteration, undoing something they tried to go back to a better result and then iterate from that point.) Other students may decide to switch tactics completely after one or two attempts. Still others may try completely different ideas with each iteration to see what works. These are all valid approaches. If you are looking for students to approach this step in a particular way, offer guidance as students proceed to direct the learning outcomes you are seeking to achieve. Otherwise, allow students the freedom to tinker, experiment, fail and learn!

A note about testing:

It's generally considered good practice to run five (5) trials of a test and then average the results together.

A note on printing step 4 of the Whysheet:

Pages 8-17 of the student Whysheets include ample space for the full note capture of five iterations. You do not need to print all these pages if students capture the relevant information in a notebook or similar system elsewhere. Having the template available for students to refer to is recommended.

Step 5: The plaque

This step serves as a wrap-up for the design challenge and provides an opportunity for students to practice science communication and demonstrate what they have learned.

Space is provided for students to first summarise their most successful design, explaining the design and what makes it a success. Students are then prompted to write up the science in their design in a longer form version. Finally, students bring the two parts together in their plaque.

While a template space is provided in the student sheets, you may choose to have students create their final plaques outside the lesson sheets, so that the final version can easily be displayed next to the creation for in-class showcases or other presentations.

A wrap-up reflection section completes this investigation.

Additional notes

Outside resources

These resources can serve as great wrap-ups to this investigation and 'provocateurs' to get students thinking about new questions. As links can disappear over time, a description of the content is included so that you can find a replacement if needed. An example 'I wonder…' question is also provided.

1. **The physics playground** https://www.youtube.com/watch?v=HDJTexx7QWE
   - **About the video:** This video shows Jeff Goodman's 'physics playground' in North Carolina, USA. The space is designed to allow students to see physics phenomenon in a unique way and on a larger scale.
   - **I wonder** how you could make some of these creations into things you could play on?
2. **Lake Macquarie Variety Playground tour** https://www.youtube.com/watch?v=PXQoQcj94pU
   - **About the video:** Take a tour of the Lake Macquarie Variety Park in Australia. The park is designed to cater for the needs of all ages and abilities and includes a playground which has many elements that are wheelchair accessible.
   - **I wonder** why more playgrounds don't include accessible designs?
3. **10 amazing playgrounds from around the world** https://www.youtube.com/watch?v=AQCVkhZp8bk
   - **About the video:** Featuring 10 unique playgrounds, this video looks at the different designs and equipment that are used in play spaces across the globe.
   - **I wonder** how designers create entire new playgrounds?