Sphero Edu

MAKERSPACE GUIDE

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Introduction

This guide was written to provide a school, library or after-school makerspace program enough support to begin using Sphero and maintain some initial momentum. In other words, to help establish an instructional program that leverages Sphero in a makerspace, supporting everything from dedicated maker projects aligned with curriculum to original student-driven inventions / creations to after-school programs and even free play.

Makerspaces - unique classrooms or studios where "maker-centered" learning experiences occur in schools - are extremely popular these days. Sphero is well suited to these environments, according[1] to Laura Fleming, Library Media Specialist, Best-1 Selling Author, Speaker, Educational Consultant, WorldsOfMaking.com:

> **"Makerspaces are being implemented to encourage creativity, innovation, and hands-on learning. Sphero is the perfect addition to design workshops and Makerspace modules, giving students an opportunity to learn by doing, tinker with robotics, and experiment with open-ended programming challenges."**

Furthermore, researchers at Agency by Design (affiliated with Project Zero at the Harvard Graduate School of Education), observed[2] that

> **...while making in the classroom was not a new concept, maker-centered learning suggested a new kind of hands-on pedagogy - a pedagogy that encourages communityand collaboration (a do-it-together mentality), distributed teaching and learning, boundary crossing, and responsive and flexible teaching practices."**

Yes, but how exactly does Sphero make this sort of learning possible? Read on...

[1] Phone conversation, December 2017
[2] Maker Centered Learning, p.4

Sphero Robotics and Maker Centered Learning

When considering using Spheros in a maker-centered learning program, unit or lesson, the most important consideration is: what experience are you trying to create for your students? Are they, in your makerspace, being invited to:

- Create a solution to a real world problem?
- Engage with existing curriculum in exciting, imaginative ways?
- Develop and strengthen programming and procedural thinking skills?
- Build persistence, teamwork and collaboration abilities?

If the answer to any of those provocations is yes, Spheros deserve serious consideration due to their ease of use, flexibility and durability.

Usually expressed in terms of what would educators want their learners to know and be able to do, a learning experience includes everything from free play to creation of complex systems (and the coding that brings them to life). How does giving them access to all Sphero has to offer make that learning activity more enjoyable, powerful, or meaningful?

As a system of smart, interconnected tools, Sphero - a robot, an app, and accessories - can be combined in unique ways to build and control mobile structures, create art, explore scientific concepts and more.

Sphero puts students in charge of their own learning by allowing them to determine where and how to use the device as part of a larger system, product or solution. With an easy-to-use interface, simplistic yet sophisticated design, and extreme durability, Sphero's power as a constructivist learning tool is unmatched. Sphero is also one of the most affordable robotics systems available today.

At its core as a robotics platform, Sphero lends itself to hands-on, experiential learning. Students don't study esoteric programming concepts in some disconnected virtual / theoretical environment; instead, they work with easy-to-use applications to program a physical object to do exactly what they require. They observe the results, then modify the programming until a desired end goal is achieved. This programming takes several forms - everything from drawing patterns on a screen to arranging block programming commands. In the process, students learn programming concepts - the use of sequences, conditional structures, and looping - in a fun, engaging way that simply wasn't possible before Sphero.

Educator Use Case Scenarios

Educator Use Case Scenarios

This guide is being written primarily for educators who teach in maker-centered learning environments. As we have already seen, those environments can take many forms (and therefore shouldn't be considered a limitation - think of it more of a guideline). In terms of the educator creating those experiences, they may fall into one of three general categories:

1. Educators running / teaching in a makerspace. A full-time, dedicated resource that sees classes either of their own or those belonging to other educators with whom they co-teach. In either case, makerspace-specific skills and knowledge define the primary desired learnings in the experience.

2. Educators facilitating classes in a shared makerspace. These teachers may have other responsibilities in addition to facilitating learning in a makerspace. The primary learning goals for students involve a balance between makerspace-specific skills and knowledge and covering content from traditional subject areas .

3. Educators visiting an unstaffed makerspace. These could be regular classroom teachers using a makerspace and its resources with students, operating everything themselves, with the primary learning goals for students being coverage of content from a traditional subject area, in the context of maker-centered learning .

Educator Use Case Scenarios

In each case, the educators in question have different needs. Let's examine each for a moment.

i. Educators running / teaching in a makerspace

The Student Learning Experience is...	Students use Sphero...
Defined by a "maker" mindset, with hands-on projects in a range of areas designed to build and strengthen maker centered skills and dispositions.	As part of substantial maker projects, e.g., components of prototypes for solutions to real world problems, or other original creations.
Conducted as part of a dedicated class with set meeting times. Typically, the only educator in the room.	To learn robotics / coding in the context of and to complete complex, sophisticated obstacle courses not possible or feasible in a regular classroom.
Defined by complex, lengthy challenges or student-driven projects.	To experience and learn traditional curriculum in new and exciting, constructivist ways.
Complicated by the need for storing student project work-in-process.	

Educator Use Case Scenarios

ii. Educators facilitating classes in a shared makerspace

The Student Learning Experience is...	Students use Sphero...
Defined by a balanced focus on both a “maker” and a “traditional” curricular mindset.	As part of “intermediate-level” maker projects (typically medium-range duration or less demanding in terms of complexity) aligned with core curriculum.
Conducted as part of a dedicated class with a variable/ periodic meeting schedule, often with the assistance of or sharing the space with one or more educators.	To learn robotics / coding in the context of and to complete obstacle courses not possible or feasible in a regular classroom.
Defined (often, but not always) by less complex, shorter challenges or student-driven projects	To experience and learn traditional curriculum in new and exciting, constructivist ways.
Complicated by the need for storing student project work-in-process.	

iii. Educators visiting an unstaffed makerspace

The Student Learning Experience is...	Students use Sphero...
Defined by a focus on “traditional” curricular activities imagined in new ways using maker tools.	As part of “introductory-level” maker projects (typically shorter in duration or less demanding in terms of complexity) focused on core curriculum; making is secondary.
Conducted as part of a regularly scheduled academic class.	To learn robotics / coding in the context of and to complete obstacle courses not possible or feasible in a regular classroom.
Defined (often, but not always) by less complex, shorter challenges or student-driven projects	To experience and learn traditional curriculum in new and exciting, constructivist ways.
Less impacted by the need for storing student project work-in-process, as lessons often are completed in one visit.	

Getting Started

To utilize this guide effectively, it will be helpful first for you to consider where and how your learners will be making. Spheros can integrate nicely into projects, or work well as a standalone activity. Specifically how this manifests in terms of your lessons is influenced somewhat by the space you have available in which to work. So, let's start with some questions about your program / learning space / environment.

While we're on the subject of physical space, It's important to remember that a "makerspace" can be ANYWHERE learners are allowed to create their own learning. Corner of a classroom? That's a makerspace. Dedicated room with every high-tech digital fabrication tool available?That's a makerspace. Library-Media Center with tools, supplies and designated areas for making? Yes, that's a makerspace, too. Here's a definition:

"A makerspace is a metaphor for a unique learning environment that encourages tinkering, play, and open-ended exploration for all." - Laura Fleming, Library Media Specialist, Best-Selling Author, Speaker, Educational Consultant, New Milford Public Schools That said, the physical space your students have available to them - and the resources & supplies within it - will influence the activities students can undertake.

Where do your learners make? (What physical space do you have available?)

- Formal makerspace: a dedicated space, studio or classroom where making is the sole or primary activity.
- Informal makerspace: a space for making that coexists within another learning space.
- A classroom: as the name implies, a traditional classroom, primarily used for other traditional types of learning, where making is part of another academic subject.
- A library: either at a school or public library.
- Cafeteria / auditorium or other shared space.
- Somewhere else: a community center or other public/private facility.

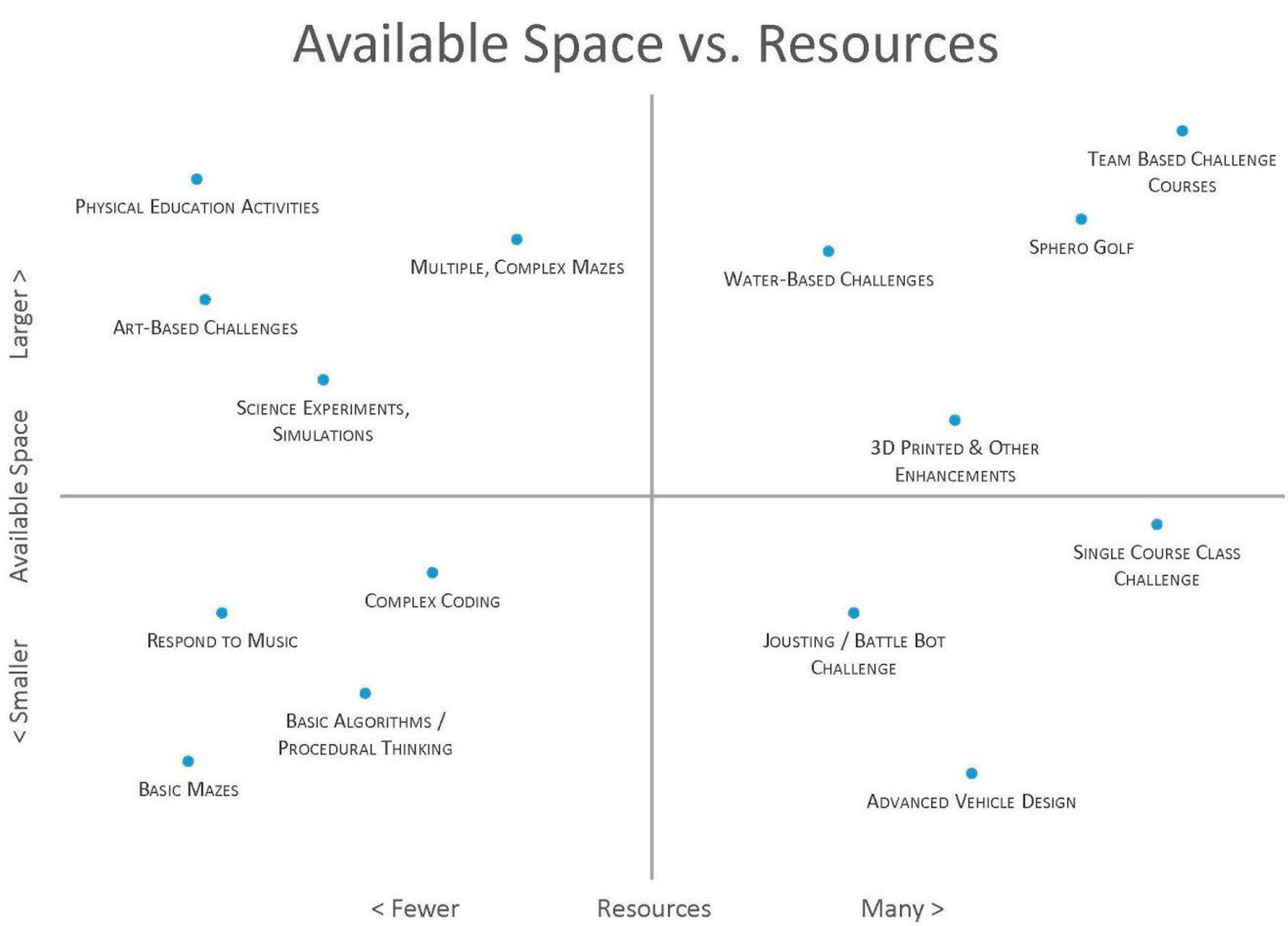
In that learning space, how many of these features or capabilities can you access?

- Floorspace (push those desks out of the way!)
- Large open indoor areas (carpeted or tiled)
- Storage (for materials and work-in-process)
- Outdoor areas
- Hallways
- Water / sinks
- Large work tables
- Electrical power
- Cardboard & other found materials

Makerspace Size, Equipment and Learning Experiences: Some Considerations

When it comes to planning makerspace experiences with a Sphero, the size of the physical space and the resources available within it have a direct impact on the types and duration of experiences you can design. Fortunately, there is a wealth of activities on https://edu.sphero.com/ , with more being added every day, by the community as well as SpheroEdu staff. But, how do you know which activities are best suited for your environment?

This chart may help.



By looking at Sphero activities in context of size of the available makerspace and the amount of resources contained within it, this chart makes it easy to see which activities might be best suited in each scenario.

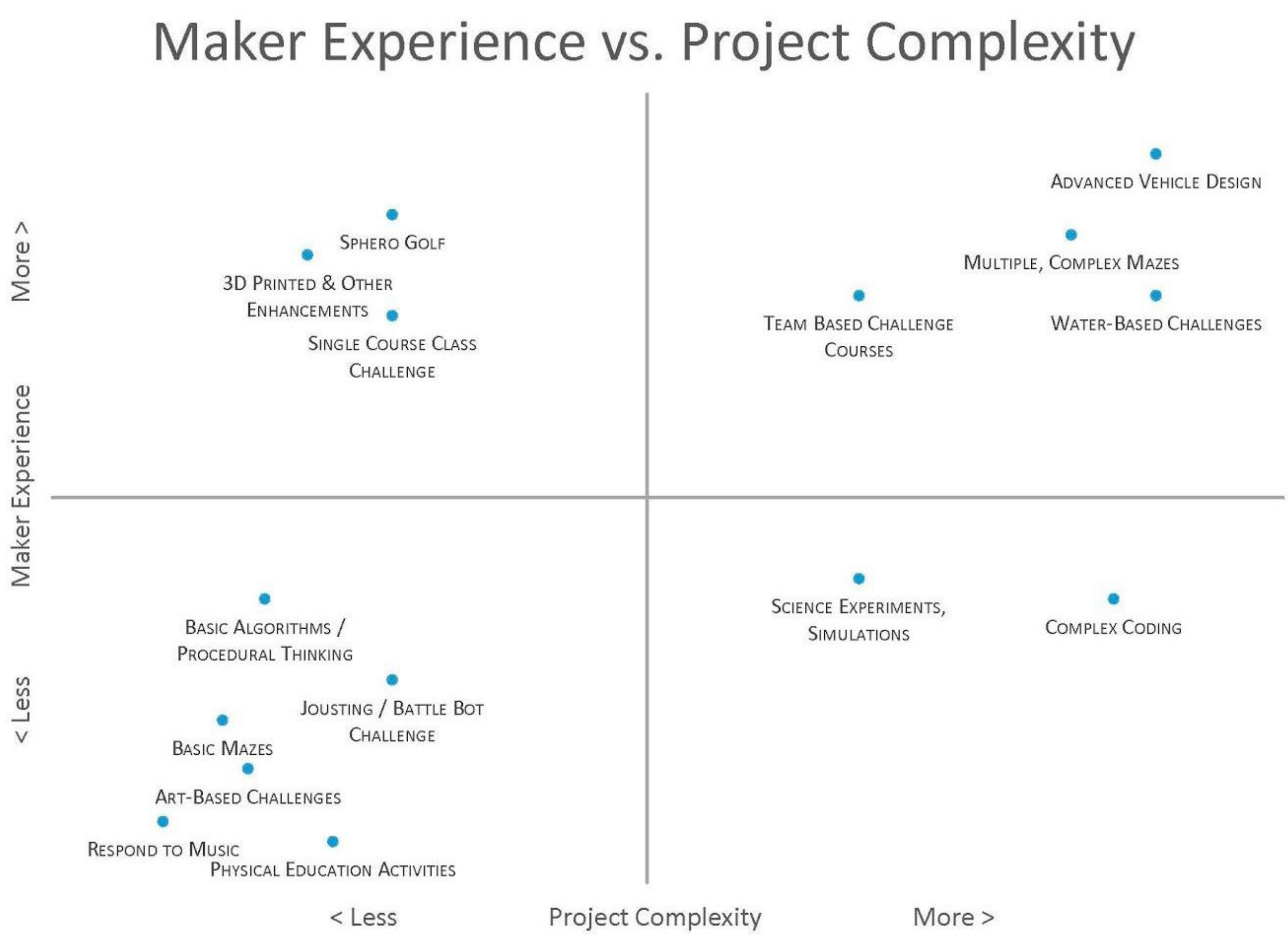
Makerspace Size, Equipment and Learning Experiences: Some Considerations

Another consideration for those planning makerspace activities is level of experience and desired complexity of projects. What is your experience as a maker / how familiar are you with maker tools & equipment?

- Very experienced - you have been teaching and learning with maker tools & equipment for a significant amount of time
- Somewhat experienced: you are comfortable with tools and resources used for making.
- Just getting started - for all intents and purposes, you're new to making.

Finally, what type of experiences / projects are you interested in having your students undertake?

- Highly complex: students will be utilizing Spheros' most advanced capabilities (programming, use of sensors, etc.) potentially in combination with the most sophisticated tools in your makerspace
- Moderately complex
- Less complex



Sphero, the Makerspace, and You Pt. 1

Part 1: The inherent educational value of free play with Sphero

Unfortunately, in a classroom or school, it's not uncommon to hear a teacher say, "stop playing and get back to work!" Play, however, is how we learn - and also essential with a Sphero, especially when using the device for the first time. Approaching tasks with a playful mindset affects how learners problem solve, brainstorm creatively, and interact with each other in pursuit of an objective. Put another way, play is actually "interdisciplinary learning through contextualized critical thinking and problem solving."[3] In essence, it's easier to 3 create effective, memorable lessons when play is the focus.

Relationships drive teamwork, informing how students interpret a problem, identify constraints, and evaluate potential solutions, resulting in deeper learning. By its nature, Sphero makes this possible in ways that are fundamentally different from traditional instruction: students are able to experiment, make educated guesses and see the results immediately, providing instant feetback. Is it playful coding or code-filled play? It's both!

Incorporating standards and identifying objectives remain the most important overall goals when designing a learning experience. However, engaging content - powered by play with Sphero - puts students in charge of how they get there.

So, when introducing Sphero to students who have never used it, feel free to let them explore on their own - whether that means using 'drive' mode for control, drawing a path for the robot to follow, or experimenting with block-based code.

[3] https://ww2.kqed.org/mindshift/2014/05/01/how-games-based-learning-teaches-problem-solving-in-context/

Sphero, the Makerspace, and You Pt. 2

Either way, they are exploring computational thinking - which can be expressed as a combination of the first three of the top ten skills the World Economic Forum said that people will need in 2020[4] to thrive in our increasingly computerized world:

- Complex Problem Solving
- Critical Thinking
- Creativity

A well-designed play activity can easily accommodate development of these three skills. Consider, for example, a simple challenge involving asking teams of students to design a maze for Sphero to navigate in the shortest amount of time possible. The creation of the maze, its materials, obstacles, structure ... how the Sphero behaves as it interacts with the course ... all provide fertile ground for each of these domains. In the next section, we will explore ways makerspace lessons - powered by Sphero - can help students develop these skills and more.

Part 2. Sphero as a physical component in a Maker project

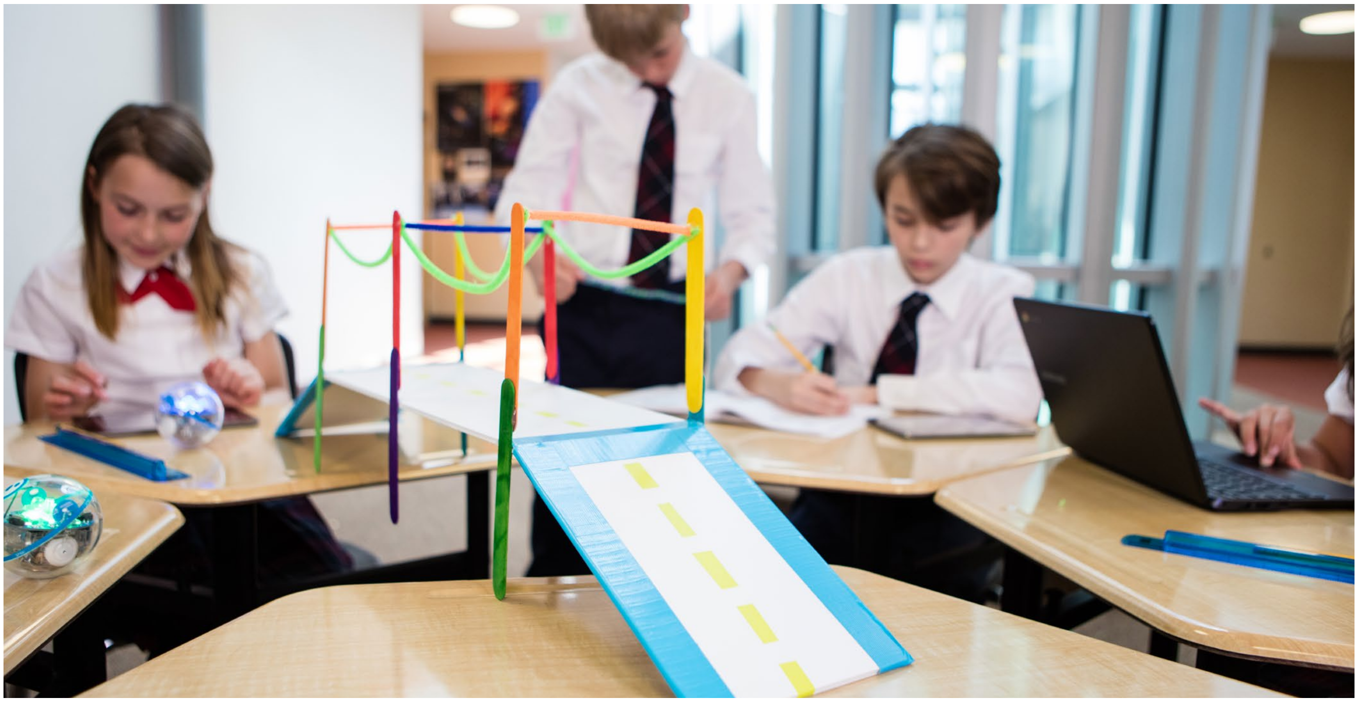
So, you have decided to incorporate Sphero into a maker project. Terrific! What Sphero capabilities led you to make that choice? Its physical, independent movement? The ability for it to propel student-designed vehicles, on land or in water? The way it interoperates with other devices? Your answers have implications for the design of the lesson and the maker-centered learning goals to be realized. Let's consider some examples.

Navigating a Maze. Perhaps the most popular Sphero activity of all, mazes can be anything from the most simplistic (involving little more than tape or other obstacles placed on the floor) to incredibly complex (custom built platform-based creations using wood, styrofoam, fabric or cloth, cardboard, paint, found materials and more.) For simple mazes, Sphero is the focus, as learners can use any of the various available modes (draw, drive, code) to navigate to the objective. Students are in charge of the learning as they work together to determine how to control the Sphero, with greater and greater precision, adjusting for real-world impacts like friction and momentum. The learning experience is primarily defined by their interaction with the Sphero and its software; however, teamwork, problem solving, and critical thinking all come into play as they program the robot to eventually achieve the objective.

More complex mazes add the element of physical maze construction to the learning experience.
Depending on your available tools, materials, and amount of instructional time, mazes can be everything from mild (as in this example [goo.gl/YmFqDn] from Grant Wood AEA in Cedar Rapids, Iowa, USA) to wild (this elaborate Sphero Golf Course [https://goo.gl/y7CnJK] was created at NCW Schools, Halstad, Minnesota, USA). At the extreme,

[4] https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/

Sphero, the Makerspace, and You Pt. 2



students could even design and 3D print components for their maze/courses, as in this example [https://goo.gl/FT9p5N], adding even more connections to maker-centered learning. (Want even more inspiration? Check out this list [https://goo.gl/b9YHQ4] of various 3D designs on the 3D design repository Thingiverse.com that are all tagged 'Sphero'.)

Build your own Sphero Controller. Another interesting possibility for the maker-centered classroom is to design and build interfaces to Sphero using other devices. In this example [https://goo.gl/YL1KwH], a MaKey MaKey is used to control a Sphero. In this experience, students learn not only how the MaKey MaKey interoperates with the Sphero, but how to construct functional interfaces using conductive and non-conductive materials.

Sphero as a vehicle motor / source of propulsion. Another popular activity well suited to a makerspace involves students designing land (or water) based vehicles in which Sphero is the source of propulsion. In their simplest form, vehicles or structures are designed to simply rest on top of or around Sphero, which then propels the structure as it moves. More elaborate designs, including chariot designs like this example [https://goo.gl/Zod45M], can tow a payload. Even more sophisticated designs use K*Nex or other building materials, including custom 3D designed and printed parts like these [https://goo.gl/xJzvDU].

So, as you can see, the resources available in many makerspaces - from found/upcycled materials to building supplies, simple tools and sophisticated devices like 3D printers - can greatly enhance the student learning experience with Sphero.

Sphero, the Makerspace, and You Pt. 3

Part 3: Sphero as a discrete instructional tool (e.g., learning robotics & coding)

Robotics and coding are popular topics in makerspaces these days. It's a natural fit: hands-on, minds-on learning facilitated by a available tools and materials makes it easy to create and test structures, both physical and logical. Sphero does double duty in a makerspace as a coding platform as well as a complete and self-contained robotics system. This is crucial because computational thinking is the foundation for developing programming skills.

Consider for a moment the fundamentals of computational thinking and how they relate to Sphero projects / activities:

1. **DECOMPOSITION.**
   For Sphero: Does the activity encourage the student to break a larger problem into smaller problems to come up with a solution?

2. **PATTERN RECOGNITION.**
   For Sphero: Does the activity encourage the student to identify common patterns like movement, speed, light, time, or direction?

3. **PATTERN GENERALIZATION AND ABSTRACTION.**
   For Sphero: Does the activity encourage the student to make connection about common patterns? For example: The student

4. **ALGORITHM DESIGN.**
   For Sphero: Does the activity encourage the student to create logical steps that can be automated based on those patterns and connections? For example: if/else statements [https://goo.gl/Us3t7k], for/while loops [https://goo.gl/pRmqLA], and more advanced concepts like scope and higher order functions. [https://goo.gl/uVLcwa]

Sphero, the Makerspace, and You Pt. 3

So, when designing an activity of your own - or, perhaps modifying one from the collection of activities at edu.sphero.com ask yourself the questions above. Perhaps even include them in your lesson planning. For each one, if you don't find that aspect of the lesson strong enough, explore ways to enhance it.

Let's look at an example. Helmets For The Win! [https://goo.gl/U3xaLn] Is a terrific example that utilizes Sphero's sophisticated IMU (inertial management unit, a.k.a. sensors) to measure forces generated when a Sphero is dropped inside a variety of mini-helmets. So:

- Does the activity encourage the student to break a larger problem into smaller problems to come up with a solution? **Yes. How do these impacts cause damage? What effect might different types of cushioning materials have on the results, and why? How could these be tested?**
- Does the activity encourage the student to identify common patterns like movement, speed, light, time, or direction? **Yes. All are observable and measurable.**
- Does the activity encourage the student to make connection about common patterns? **Yes. These types of helmet impacts are common in a variety of sporting situations and are generalizable to other sports.**
- Does the activity encourage the student to create logical steps that can be automated based on those patterns and connections? **Yes. By designing and breaking down the testing process, students will be able to identify the parts that can be automated and controlled.**

With this information, students have the proper context to begin looking at how to model the components of the problem such that Sphero could be used to gather actionable data to help identify potential solutions.

Sphero, the Makerspace, and You Pt. 4

Part 4: Sphero as a data collection tool

As we've already discussed, Sphero has a range of sophisticated, durable sensors [5] that perform a variety of data gathering functions. These include:

- An IMU - inertial measurement unit (accelerometer and a gyrometer) - which stabilizes the robot while it moves and can be used as inputs to sense freefall, jumps, tricks, and human handling of the robot);
- a collision detection algorithm, and
- a locator (real-time 2D position and velocity information).

This means that when Sphero streams data directly to an app [https://goo.gl/MW7X5o], it's generating real-time information that students can use to understand and model the world around them. Examples:

1. Observe and learn math concepts [https://goo.gl/MBJ43D]
2. Gather data during tests of structures during simulated earthquakes [https://goo.gl/tp7caL]
3. The impact of friction [https://goo.gl/ya6E8g]

Sphero Supports data collection by completely eliminating the need for expensive and complicated sensors / monitoring equipment and the technology needed to get those readings into actionable formats.

[5] https://sdk.sphero.com/sphero-robot-basics/robot-tech/

What You Need

Now that you have decided to use Spheros and what the learners will be doing, it's time to identify what they'll need to have available to use. There are three basic categories:

1. Number and Type of Spheros
2. Tablets/ Phones/ Software for Device Control & Programming
3. Materials for the Spheros to interact with or be built around

Number and Type of Spheros

Sphero, Sphero Mini, BB-8, BB-9E share the same spherical design; Ollie is cylindrically shaped. Each has different features, capabilities, and advantages/disadvantages. Depending on the size of your class and the challenge(s) they will likely encounter, one may be a better cho xice than another. Consider this chart:

Capability / Parameter	Sphero	Ollie
Water Resistance	Submersible, can be used in any water environment	At most, can be driven over slightly wet surfaces
Usable with fluids / paints	Yes	No
Extremely Dirty / Dusty Environments	No problem	Not advisable
Ability for fine / precise control (positioning, direction)	Limited due to momentum while operating, and friction (or lack thereof)	Easier to control more precisely; each drive wheel can be operated independently and the device has generally greater traction
Speed	Top speed of 4.5 mph	Top speed of 14 mph
Combination with other designed objects	Limited due to difficulty 'attaching' anything to the sphere; most often, objects are placed 'around' the Sphero which then rolls and propels the object	Cylindrical design generally allows for custom accessories to be designed and used, example: link
Ability to Program (write code)	Block programming interface; Javascript	Block programming interface; Javascript
Available Sensors	Accelerometer and gyrometer	None
Battery Run Time (usable time between charges)	60 minutes	60 minutes
Charging Time	3 hours to charge if completely exhausted.	3 hours to charge if completely exhausted.
Visual Features	Change Color	N/A
Tricks / Ability to 'Stunt'	Minimal; requires interacting with other objects (ramps, etc.)	Can 'stunt' on its own, as well as interact with other objects (ramps, etc.)
Durability	**Extremely Durable**	**Very Durable**

What You Need

Specific note on charging: sphero robots charge via Micro-USB cables and dedicated AC wall plugs. Computers can be used to charge them as well but this will increase charging time due to the typically lower voltage output of a computer USB port.

Tablets/ Phones/ Apps for Device Control & Programming

Spheros are controlled by apps that run on smartphones or tablets. Student devices are often used. If your budget permits, dedicated tablets (or even retired/donated cell phones) can be utilized. The larger the screen, the better. These devices obviously need dedicated chargers as well as periodic updates.

Chromebooks can be used with Sphero Edu directly thanks to the Chrome Extension.

Interactive and Building Materials to Accompany Sphero

Whether students are creating obstacle courses for Spheros to navigate, propulsion systems for vehicles on land or water, or intricate "smart" objects built around Sphero's sophisticated sensors and controls, students will need materials with which to build. These include, but are not limited to:

- Found materials: cardboard, paper tubes, scraps of wood, paper, wire or plastic hangers, etc.
- Purchased materials: felt or fabric, foam, hot glue, pool noodles, paper, paints, wood, fasteners, pipe cleaners, PVC and other forms of piping, string, yarn, tape, etc.

Once you have identified these various elements, you'll be able to plan for their acquisition and safe storage, so that you and your students will be able to use Spheros reliably and often.

Conclusion

Sphero is so much more than it appears to be at first glance. It's a simple yet sophisticated robotics platform with a wide range of powerful sensors that make advanced data collection almost effortless (and fun!) It is so easy to use that learners of any age can begin working with it right away, from simply controlling - driving - the device via the app, all the way to writing complex programs with the text canvas. And that's just the beginning.

Sphero really shines in a makerspace due to its versatility. Used alone, it is a great way for students to develop discrete maker skills like programming. But, it is also a capable power source for a variety of land- and water-based vehicles (very popular in makerspaces), which can be created with simple found materials or sophisticated 3D printed designs. The only limit is the materials in your makerspace - and your imagination!