BRINGING TINKERING TO SCHOOL

IDEAS FOR ACTIVITIES

TINKERING EUROPE 2

WITH THE SUPPORT OF ERASMUS+
PROGRAMME OF THE EUROPEAN UNION

Bringing Tinkering to School: Ideas for activities
2019*

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* This document is the first version of the outcome of the work between partners and teacher ambassadors. It accompanies the testing of the activities but precedes the implementation of the activities at the multiplier events. Therefore it will be updated at the end of the events if and where changes of the contents are deemed necessary.

WITH THE SUPPORT OF ERASMUS+
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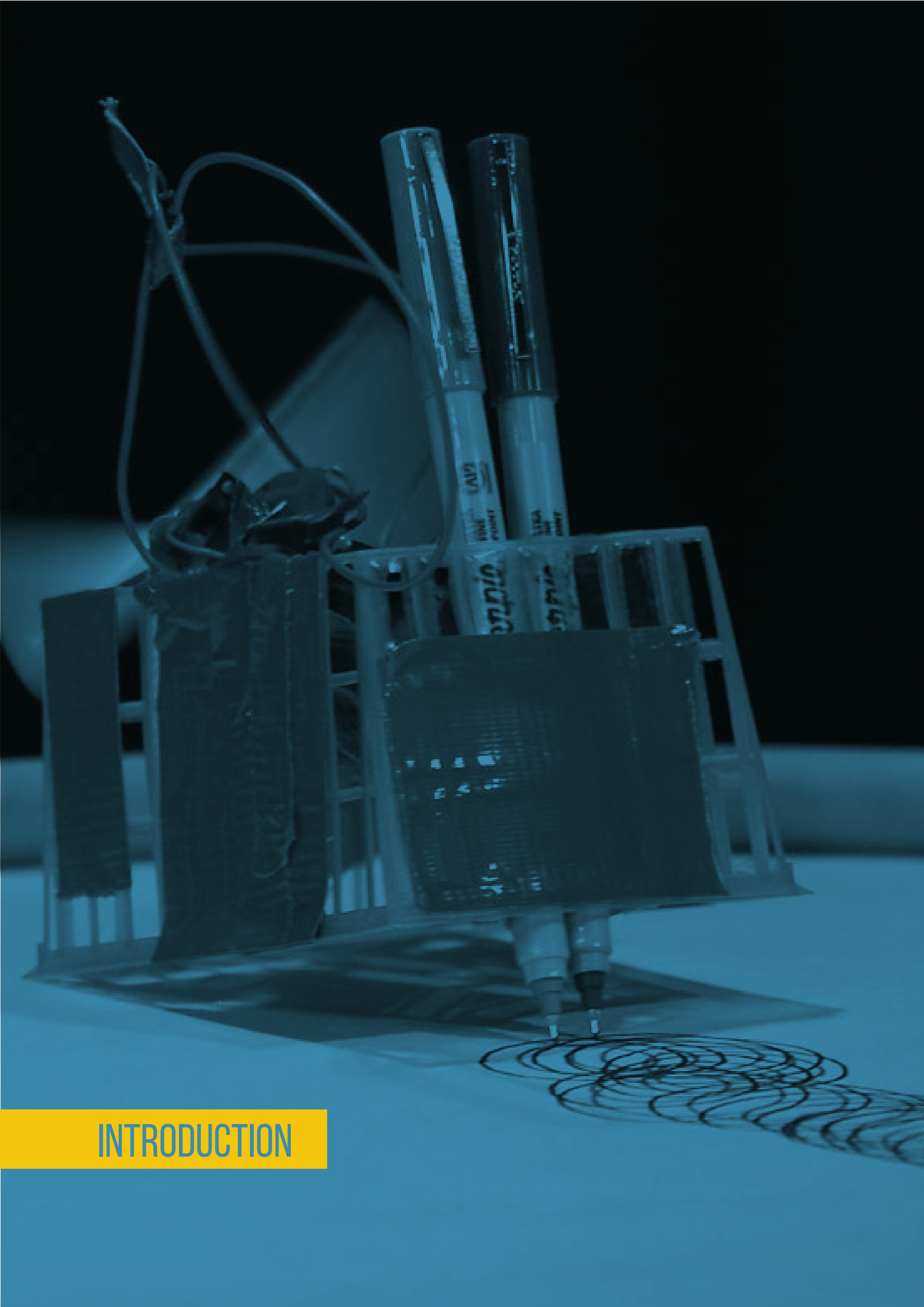


INTRODUCTION

1

INTRODUCTION

Tinkering creates a bridging point between a learner's personal interests and experiences and a broad range of possible learning outcomes. It offers valuable opportunities to engage all students in STEM and fosters a more inclusive STEM education. In this way, it is very much aligned with a Science Capital Teaching Approach: fundamentally, it is a highly personalised pedagogy, which allows the learner to follow their own interests and set their own goals.

This resource has been designed to help teachers integrate the Tinkering approach and the Science Capital framework in their practice aiming to implement a more inclusive science learning. It is divided in two parts.

The first part gives an overview of the Tinkering approach and of Science Capital, and is a shorter version of the resource "Tinkering and Science Capital: Ideas and Perspectives" produced by the project (the whole version can be found at: http://www.museoscienza.org/tinkering-eu2/resources.asp).

The second part lists the Tinkering activities that have been identified by the partners and tested at the museums with the students of the schools that were involved in the project.
The activities are selected among the ones designed by the first European project dedicated to Tinkering and the ones designed by the Tinkering Studio at the Exploratorium of San Francisco.

2

TINKERING AND SCIENCE CAPITAL: HOW TINKERING CAN SUPPORT INCLUSIVE TEACHING AND LEARNING IN STEM

WHAT IS TINKERING?

Tinkering is an innovative learning approach that involves creating physical things using diverse tools, materials, ideas and methods. The activity design, materials and facilitation style combine to create a highly engaging learning experience with diverse outcomes. The learner is encouraged to play around with materials and tools. But this playfulness should not be mistaken for something trivial: Tinkering is highly constructive and purposeful. It encourages learners to pursue a project, idea, or personal goal according to their interests and personal motivations. It also challenges the learner to embrace moments of being stuck and unstuck. In this way it can help develop 21st century skills such as problem-solving, creativity, confidence and resilience. (Bevan, Gutwill, Petrich, & Wilkinson, 2015; Harris, Winterbottom, Xanthoudaki, & de Piper, 2016; Petrich, Wilkinson, & Bevan, 2013; Wilkinson & Petrich, 2014)

Tinkering activities often cross different curriculum areas allowing learners to work with subjects like physics, maths, art, engineering and technology in an integrated way. Participants in Tinkering will also find themselves asking the sorts of questions asked by scientists, such as 'I wonder how this works' or 'I wonder what would happen if I do this?'.

While Tinkering activities vary in their style and content, they have common core features:

1 Something physical is created using tools and materials.
2 The atmosphere should be playful, innovative and creative
3 Learners follow their interest and can therefore pursue their own path of learning
4 Outcomes are highly variable and sometimes unexpected.
5 Although there is a broad goal given at the start, Tinkering activities are designed so that learners can add in or set their own goals. Therefore, they can progress through the activity in a way that is interesting and personally meaningful to them.
6 The learner works on the activity by trying things out. They might start by improvising but through a process of iterative design, they can move from improvising to planning designing, testing, redesigning and refining.

The Tinkering Studio at the Exploratorium in San Francisco are the pioneers of Tinkering. Based on observations of hundreds of people taking part in Tinkering activities, they have developed a framework which describes the sorts of learning that Tinkering experiences develop (figure 1). This can be a useful guide to help identify moments of engagement, learning and skill acquisition when watching or trying out Tinkering. It could also be used with students after a Tinkering experience to help them reflect on their learning.

FIGURE 1 / THE TINKERING STUDIO'S LEARNING DIMENSION OF TINKERING, FROM:
HTTPS://WWW.EXPLORATORIUM.EDU/TINKERING/OUR-WORK/LEARNING-DIMENSIONS-MAKING-AND-TINKERING

3

TINKERING AND INCLUSIVE TEACHING

3.1
SCIENCE CAPITAL AS A THEORY

Recent educational research is helping to explain why some students feel more at home with STEM (Science, Technology, Engineering and Maths) in school, and why some students are more likely to want to pursue STEM than others. Outside influences –such as having a network of people to talk with about science, parents who work in STEM-related jobs, and trips to science museums - all interact to shape whether a young person will aspire to participate in STEM (Archer, Dawson, DeWitt, Seakins, & Wong, 2015; Archer et al., 2010; Archer, DeWitt, & Willis, 2013; DeWitt & Archer, 2015; DeWitt, Archer, & Mau, 2016; Godec, King, & Archer, 2017; King & Nomikou, 2017). These influences from home and the wider community have been categorised into eight dimensions of what is termed 'science capital', shown in figure 2 (Godec et al., 2017).

Research has shown that students with high levels of science capital (students who have access to science resources in their lives outside of school) tend to identify with and aspire to participate in STEM, both in school and beyond (DeWitt & Archer, 2015, DeWitt et al., 2016). On the other hand, students with fewer STEM opportunities and resources outside of school students (with relatively lower levels of science capital) are more likely to feel disconnected with STEM education because it does not resonate with things that they are doing or talking about it their wider lives (DeWitt & Archer, 2015; DeWitt et al., 2016). This has implications for inclusive STEM education.

FIGURE 2 / IDEAS FOR INCORPORATING THE DIMENSIONS OF SCIENCE CAPITAL CAN BE INCORPORATED INTO SCIENCE TEACHING. FROM GODEC ET AL., (2017)

SCIENCE CAPITAL DIMENSIONS	IDEAS FOR HOW TO BUILD THE DIMENSION OF SCIENCE CAPITAL IN STEM LESSONS
1 SCIENTIFIC LITERACY	• A young person's knowledge and understanding about science and how science works. This also includes their confidence in feeling that they know about science.
2 SCIENCE-RELATED ATTITUDES, VALUES AND DISPOSITIONS	• The extent to which a young person sees science as relevant to their everyday life.
3 KNOWLEDGE ABOUT THE TRANSFERABILITY OF SCIENCE	• Understanding the utility and broad application of scientific skills, knowledge and qualifications.
4 SCIENCE MEDIA CONSUMPTION	• The extent to which a person, engages with science-related media including television, books, magazines and internet content.
5 PARTICIPATION IN OUT-OF-SCHOOL SCIENCE LEARNING CONCEPTS	• How often a young person participates in informal science learning contexts, such as science museums, science clubs and fairs.
6 FAMILY SCIENCE SKILLS, KNOWLEDGE AND QUALIFICATIONS	• The extent to which a young person's family have science-related skills, qualifications, jobs, and interests.
7 KNOWING PEOPLE IN SCIENCE-RELATED JOBS	• The people a young person knows (in a meaningful way) among their wider family, friends, peers, and community circles who work in science-related roles.
8 TALKING ABOUT SCIENCE IN EVERYDAY LIFE	• How often a young person talks about science with key people in their lives (friends, siblings, parents, neighbours, community members).

3.2
SCIENCE CAPITAL AS A TEACHING APPROACH

A new 'Science Capital Teaching Approach' has recently been developed by teachers and researchers in the UK (Godec et al., 2017) and is summarised in figure 3. In this approach students who have low science capital are not seen as having something wrong that needs to be fixed. Rather, the focus is on adapting the teaching and learning context so that it better connects with and more deeply values the existing interests and experiences of the students (Godec et al., 2017). The approach recognises that what might be interesting and relevant for one student may not be for another. The teacher therefore needs to find ways to make the STEM classroom environment one that welcomes, connects with and deeply values everyone's interests and perspectives, not just those who already feel that they are a 'science kind of person'.

This does not mean creating new curriculum, but rather it requires a shift in the teacher's mindset and practice so that they 'broaden what counts' as teaching and learning in the science classroom (Godec et al., 2017). At a very basic level, this approach asks educational practitioners to explore and understand all of the wider experiences that influence a young person's science identity and STEM aspirations (the eight dimensions of science capital), in order to create learning experiences that value a broader range of lived experiences and which help young people to understand how their lives can and do relate to STEM in a personally meaningful way.

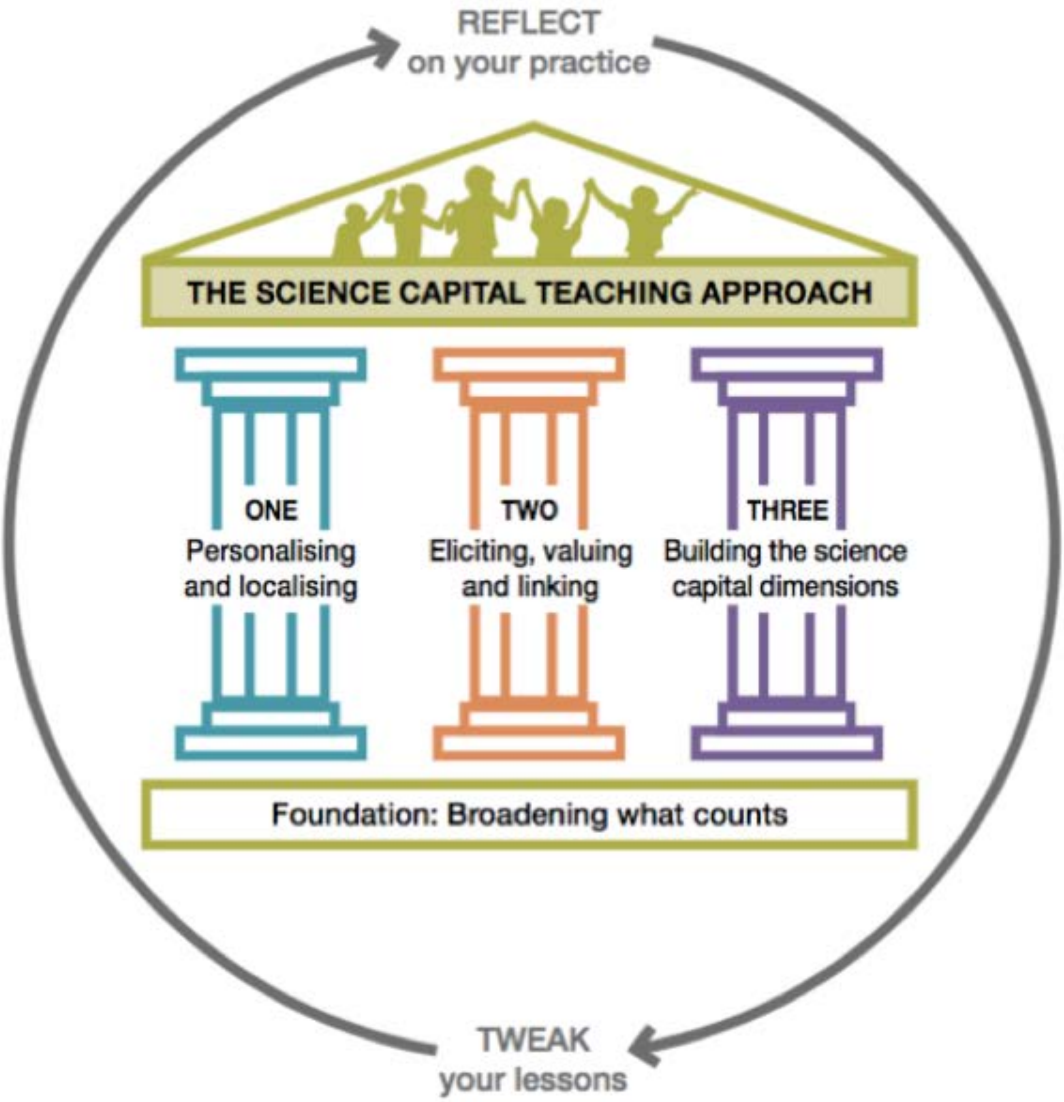


FIGURE 3
THREE PILLARS MODEL FOR UNDERSTANDING THE SCIENCE CAPITAL TEACHING APPROACH. FROM GODEC ET AL. (2017)

You can find more information on this teaching approach from https://www.ucl.ac.uk/ioe/departments-centres/departments/education-practice-and-society/ science-capital-research/pdfs/the-science-capital-teaching-approach-pack-for-teachers

3.3
TINKERING AND SCIENCE CAPITAL

Tinkering has large potential to engage students who are facing social, economic or cultural disadvantage with STEM. It creates a bridging point between a learner's personal interests and experiences and a broad range of possible learning outcomes. In this way, Tinkering is very much aligned with a Science Capital Teaching Approach: fundamentally, it is a highly personalised pedagogy, which allows the learner to follow their own interests and set their own goals. Table 1 explores the relationship between Tinkering and a Science Capital Teaching Approach.

FIGURE 4 / THREE PILLARS MODEL FOR UNDERSTANDING THE SCIENCE CAPITAL TEACHING APPROACH. ADAPTED FROM GODEC ET AL. (2017)

SCIENCE CAPITAL TEACHING APPROACH LEVEL (ADAPTED FROM GODEC ET AL 2017)	TINKERING IN THIS CONTEXT
FOUNDATION LEVEL: BROADENING WHAT COUNTS • recognising a broad range of experiences, skills and behaviours as having a legitimate place in the stem classroom • ensuring all students feel they can contribute information and ideas from their lived experiences and that these are valid and will be valued.	• By using Tinkering in the STEM curriculum, practitioners can demonstrate that personal attributes such as curiosity and resilience, and skills such as questioning, and testing ideas are valued in STEM, and that STEM is not just about learning facts or getting the 'right' answer. • The playful, creative nature of Tinkering and its focus on iterative design (design, make, test, tweak, refine, re-design) encourages an understanding of the experimental nature of STEM, and of learning through mistakes and unexpected outcomes – rather than simply learning facts or getting the 'right' answer for tests and exams. • The environment in which Tinkering takes place is one that is welcoming, supportive and which values ideas and individual contributions, including personal responses. • Facilitators aim to share and celebrate moments of wonder as well as interesting thoughts and experiences that learners have.
PILLAR 1: PERSONALISING AND LOCALISING • Helping students see how their interests, attitudes and experiences outside of school relate to STEM. • Practitioners build STEM learning experiences from students' existing interests and ideas and make connections with students' local lives and communities. • Personal contexts link the learning to the 'here and now 'of students' everyday lives. This can help students who may not perceive themselves as 'sciencey' to relate to STEM.	• Tinkering is a highly personal experience that aims to spark and maintain interest by allowing the learner to set their own goals and follow their interests. • Participants follow a personal project that is individually meaningful and builds from their existing knowledge and ideas. • Tinkering can provide opportunities to create personalised learning experiences that draw upon individual interests or career aspirations. • Tinkering facilitation attempts to help the learner build connections between their Tinkering experience and outside interests.
PILLAR 2. ELICITING, VALUING AND LINKING • Using open questioning techniques to elicit knowledge that comes from the context of students' home and community life. • Following-up on comments and linking these to STEM learning contexts to help demonstrate that these experiences are valued and valid. • Making efforts to include all students in lessons, especially those who might be quiet or shy.	• The Tinkering environment (everything making up the Tinkering activity including the materials and facilitation) provides a safe, non-judgemental space for learners to express themselves and their ideas with complete freedom of expression. • The Tinkering environment is a 'flat space' where teachers facilitate, and often collaborate with learners, rather than directing the learning journey. • Facilitation of Tinkering is structured around open questions. It also celebrates and values what the learner is feeling, experiencing and trying out, rather than focussing on 'correct' or pre-determined outcomes. • Tinkering deeply values personal experience. The learner to pursues individual interest and engages in activities that are personally meaningful as they negotiate their own goals and create their own learning pathways. • Tinkering does not require or assume any formalised STEM theory or technical scientific terminology. Language barriers are reduced, and students can 'get stuck in' even if they have lower levels of existing science literacy. • Tinkering can be a hook for talking about or illustrating scientific processes, facts, formulae and theories, but this is not the starting point, nor the intended outcome, and so students who may not feel that 'science is for me' are less at risk of feeling alienated and may feel more empowered to take part.
PILLAR 3: BUILDING THE SCIENCE CAPITAL DIMENSIONS • Reflecting on the eight dimensions of science capital and to trying to link to these to build these sorts of resources and ways of thinking.	• Tinkering often takes place in out of school contexts. This could contribute to dimension 5. • Tinkering can encourage learners to talk about science in their everyday lives. This could contribute to dimension 8. • Tinkering activities often demonstrate the transferable nature of STEM skills because they connect and work across different media, methods and disciplines. This could contribute to dimension 3. • There are many possible scientific literacy gains for learners taking part in Tinkering. For example, students might learn about the properties of materials when choosing what to use, or they might gain a deeper understanding of the importance of controlling variables when testing a hypothesis. This could contribute to build dimension 1.

TINKERING ACTIVITIES AT SCHOOL

4

TINKERING ACTIVITIES AT SCHOOL

The project recommends a range of Tinkering activities that can be used at school, especially in disadvantaged contexts, as we believe they have a strong potential to encourage a more inclusive science education approach.
These activities, presented below, have been identified by the partners and tested at the museums with the students of the schools that were involved in the project. The activities are selected among the ones designed by the first European project dedicated to Tinkering and the ones designed by the Tinkering Studio at the Exploratorium of San Francisco.

MARBLE MACHINES

A Marble Machine is a creative ball-run contraption, made from familiar materials, designed to send a rolling marble through tubes and funnels, across tracks and bumpers, and into a catch at the end. We often suggest a goal of getting the marble to travel from the top of the board to a target at the bottom as slowly as possible. But that's only one possible starting point for what can quickly turn into an addictive experience. You can set many challenges for yourself, the fun is in trying to solve them: make the marble travel uphill for a section or go up and then come back down; try to make a loop-de-loop, or an elevator to bring the marble back to the top of the board; or even use multiple marbles for more complex chain-reactions.

Description and the activity guide at:
https://www.exploratorium.edu/tinkering/projects/marble-machines

LIGHT PLAY

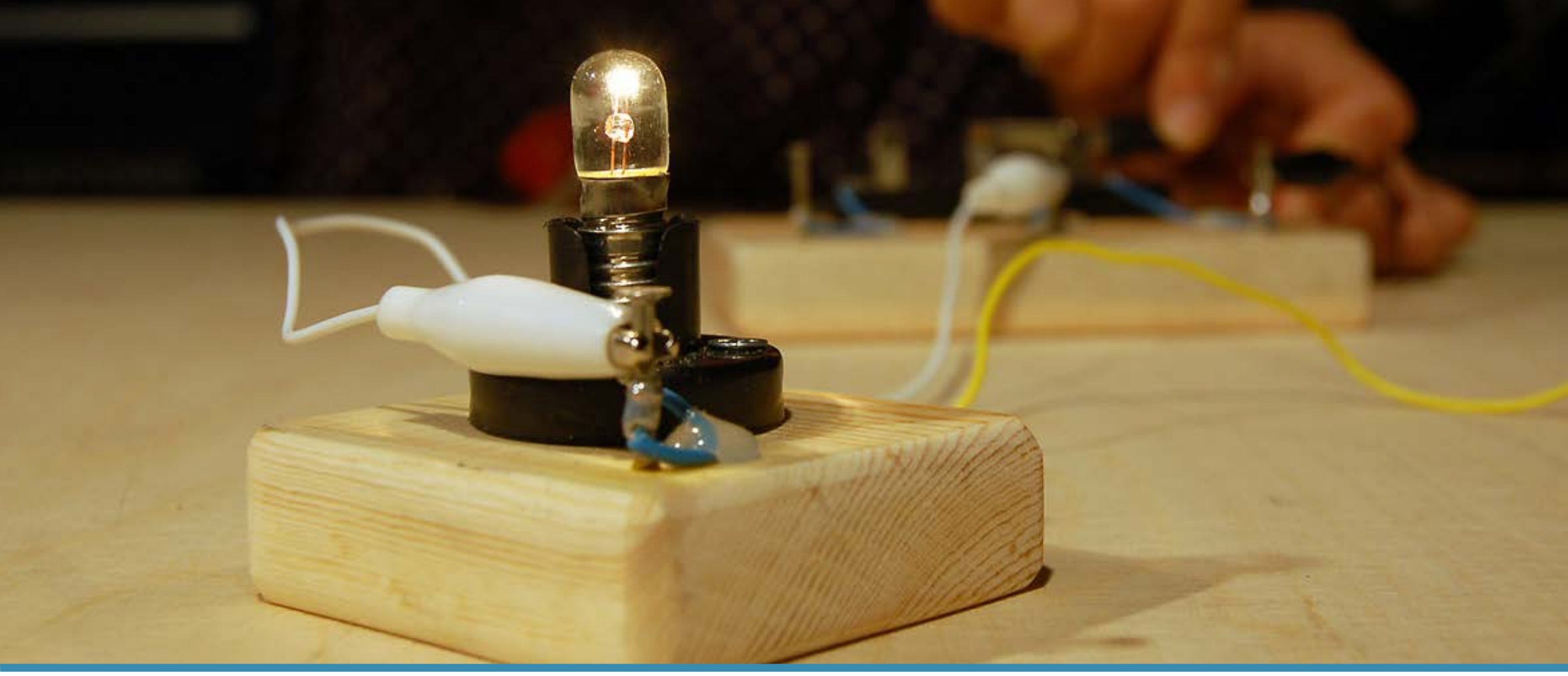
Light Play is an exploration with light, shadow, and colour by constructing a kinetic art vignette. Everyday objects are used as shadow makers with simple to use light sources and slow-moving motors to create graceful light and shadow scenes. At the end of the activity a collaborative wall of illuminated kinetic creations is made from the individual investigations.
Light Play lets you explore light, shadow, and motion using a variety of simple materials and light sources. Beginning with gently guided explorations of shadows, single and multiple light sources, three-dimensional objects and translucency, participants gain the proficiency and "light vocabulary" to express their ideas, and their creativity is sparked. They will work toward building kinetic light and shadow vignettes, and eventually combine them into a collaborative installation.

Description and the activity guide at:
https://www.exploratorium.edu/tinkering/projects/light-play

SCRIBBLING MACHINES

Scribbling machines are motorized contraptions that move in unusual ways and leave a mark to trace their paths. They are made fr¬om simple materials and set in motion by the vibrating offset motor causing them to bounce, spin, bump and move in interesting ways.

Description and the activity guide at:
https://www.exploratorium.edu/tinkering/projects/scribbling-machines



CIRCUIT BOARDS

Experimenting with batteries, bulbs, buzzers, switches, and other electrical components is a great way to start tinkering with circuits. Real parts mounted on sturdy wood blocks are designed for anyone to start creating electrical connections between everyday objects.
From the basic elements you can deepen the experiments by adding potentiometers, double-pole double-throw switches (DPDT), motors, resistors, and other scrounged inputs and outputs that can do interesting and sometimes surprising things when connected. The set of circuit boards is not only a compelling way to work with electricity, but the parts can also be used in many other tinkering activities.

Description and the activity guide at:
https://www.exploratorium.edu/tinkering/projects/circuit-boards

PAPER CIRCUITS

Make simple or complex electrical circuits on a piece of paper!
Copper tape and surface-mount LEDs allow you to turn a fully functional circuit into a light-up greeting card, origami animals, or three-dimensional pop-up paper sculptures that have working lights in them.

Description and the activity guide at:
https://www.exploratorium.edu/tinkering/projects/paper-circuits

MORE

If you want to find out about additional Tinkering activities, see:
https://www.exploratorium.edu/tinkering/
http://www.museoscienza.org/tinkering-eu/resources.asp

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