DIGITAL LIGHT PLAY
ADDENDUM
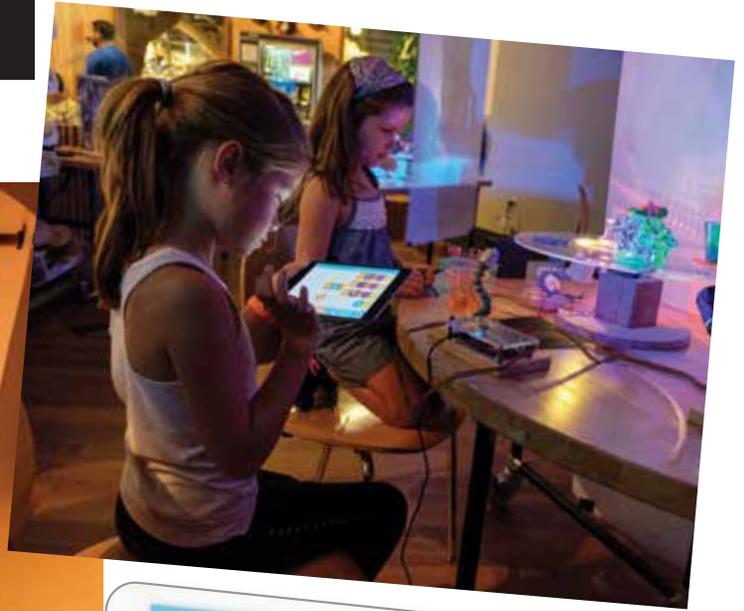
Digital Lightplay is the working title for an expanded version of Light Play (http://tinkering.exploratorium.edu/light-play) that adds programming and computation to the activity. The digital Light Play tools we introduce in this addendum allow to experiment with programming the lights and motors of the light play stations. In addition to investigating and building with light and shadows in the physical world, participants get to tinker with a visual coding platform on an iPad to create color sequences, timed light effects, and add complex motion to the motor. These digital tools open up possibilities and new directions, including narrative and storytelling, puppetry, remote controlled ambient light installations, and perhaps even large scale immersive installations.

Digital Lightplay is a collaboration between the Tinkering Studio, MIT's Lifelong Kindergarten group, LEGO Foundation, and Reggio Children Foundation.

Disclaimer: This addendum is not a "how to" activity guide. It is a summary of the experiments and findings of an extended period of research and development around tinkering in the digital world, with a focus on investigating light and shadow. By sharing this, we hope to inspire discussions and provide ideas for projects and tinkering activities in this area.

the tinkering studio

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MATERIALS, TOOLS, AND HARDWARE

Digital light play is based on our original Light Play activity. We started with the original material set suggested in our Light Play guide and expanded it to include a set of digital tools that offer possibilities for programming, as it was important to us that these tools not distract from the direct investigation of light and shadows as phenomena that is at the heart of Light Play.


Rainbow LED light source

We modified the white LED light source that we use in Light Play (https://www.instructables.com/id/Light-Play-Set/) and turned it into a "rainbow" light that can be programmed to create any color of light. The neck and base of this light are identical to the original light, but we replaced the white LED star with an RGB LED; this is connected to the board with a 6 position ribbon cable and matching plug.

Micro controller board

We developed a custom arduino-based microcontroller board to control and power one motor and three rainbow light sources. This prototype version was mounted on a wooden block with large writing to make it easy to identify the ports for lights 1, 2, 3, and the motor. A clear acrylic plastic top protects the board while not obstructing the view of the arduino board.
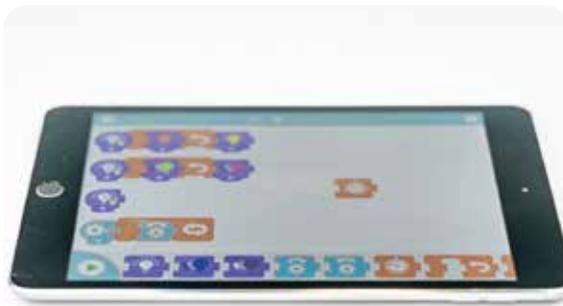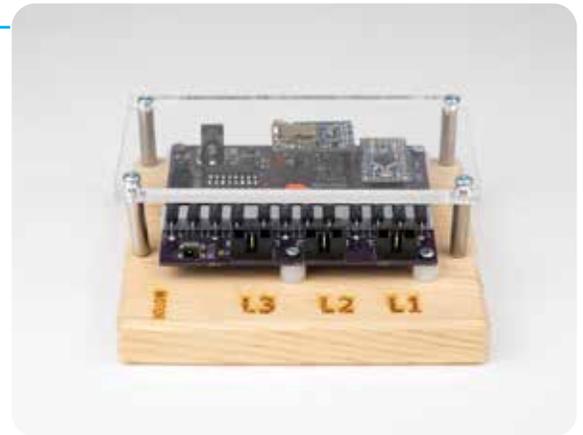
IPad (with Light Play app)

The Lifelong Kindergarten group created a custom iPad app (based on the Scratch Junior programming platform for young children) that allows the control of lights and motor via a wireless bluetooth connection.

THE APP
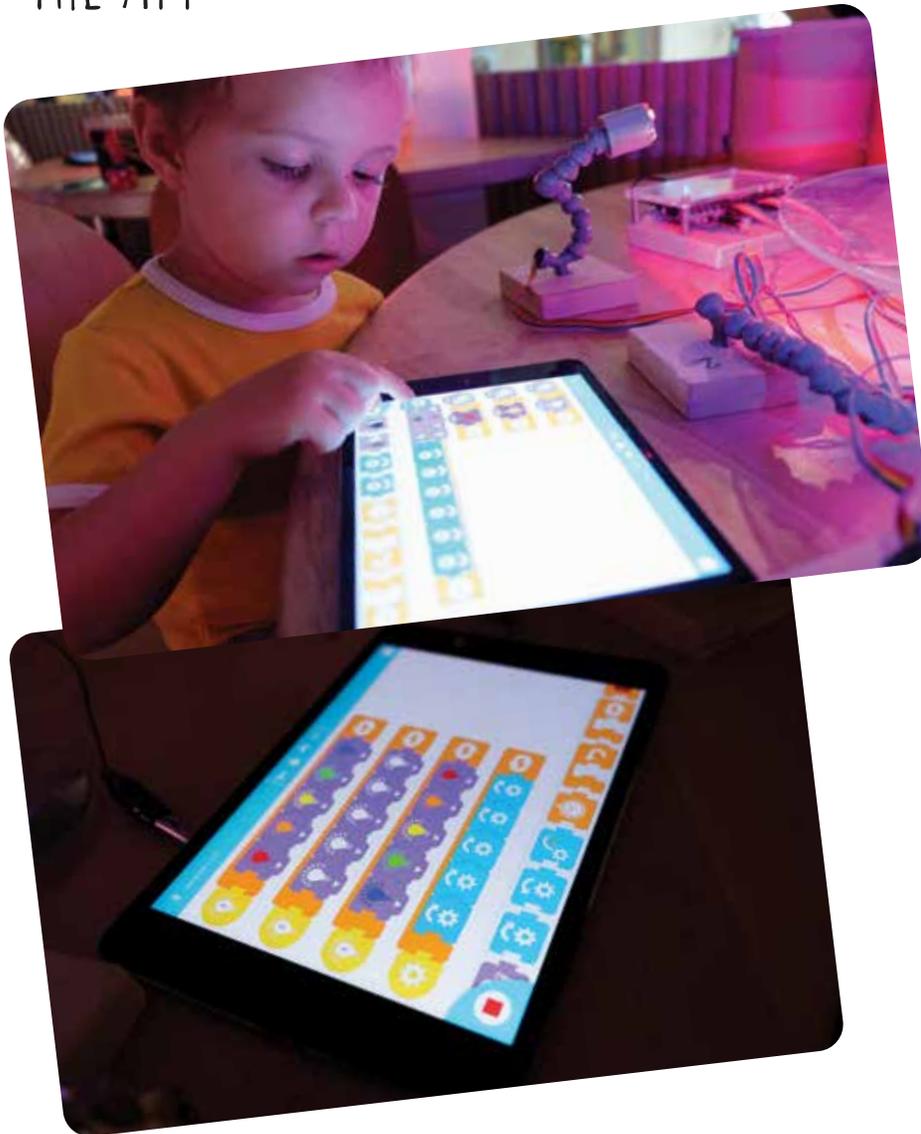
The digital light play app is designed to invite experiments with code and a playful approach to programming. Light play emphasizes the importance of messing about with the effects of light and shadow in an open ended way. The app can provide a non-disruptive way to expand the possibilities of these free-form explorations, as well as engage in a more focused investigation with precise timing of lights and motors once learners are ready for it.
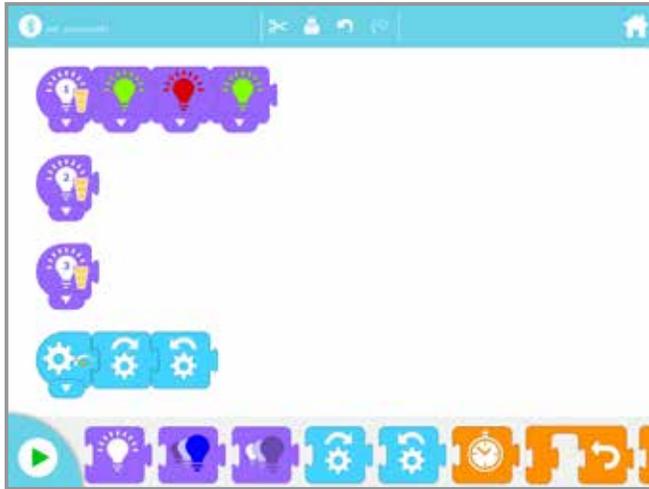
Using a tablet that isn't tethered to the physical components in the light play vignette allows learners to interact more naturally with materials on the table by switching back and forth between the physical and digital world. Its small footprint allows it to not dominate the environment and virtually disappear when in use.

We also found that the app supports a flexible collaboration between learners: it's easy for partners to pass the iPad back and forth, and they can also both actively drive the computational exploration through the touch screen.

The light play app is a custom version of a visual block-based programming environment called Scratch Junior (https://www.scratchjr.org/about/info). Scratch junior is designed to be developmentally appropriate for younger children, and its features match young children's cognitive, personal, social, and emotional development. This concept also drove design decisions around the light play app. For example, code blocks use icons instead of words and the function of the blocks is discoverable without instructions.
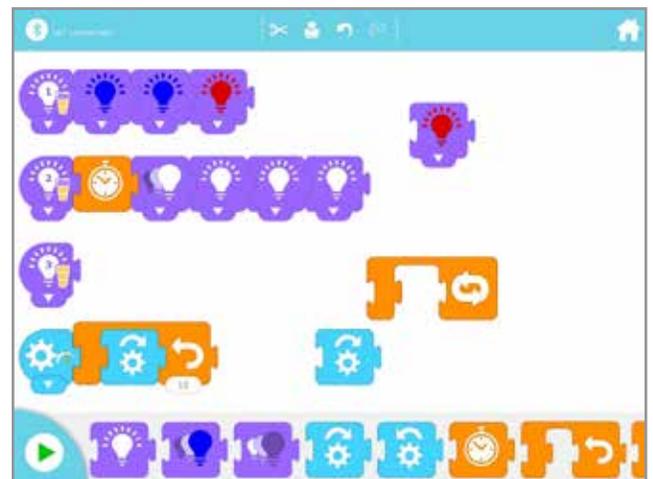
Most of the blocks correspond with the physical objects—the three lights and the motor—and each block acts like a "push button" that turns the object on for one second. Code blocks snap together like puzzle pieces making it easy to create sequences, such as turning a light from green, to red, to green again, or turning the motor one way for 3 seconds and then the other for way for 2.

As learners complexify their light play sequences, the app allows for more advanced programming constructs—such as repeats and loops—to be integrated in the sequence.

Turning one light green, red and green again while rotating the motor clockwise and then counter-clockwise
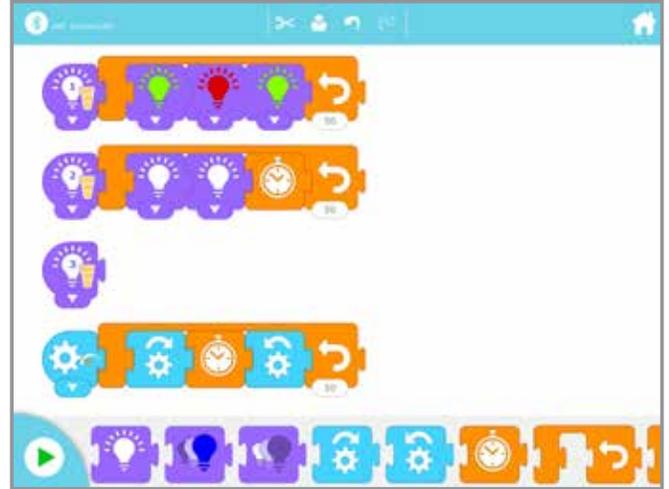
Complex code incorporating loops - lights and motor are programmed to repeat a 3 sec sequence 50 times.

Evolution of the app

One of the big ideas that we took away from designing programmable materials to tinker with was that the relation between the physical objects and how they are represented in code made a big impact on how learners engage. We designed an early version of the app to be a robust programming experience; we created a set of blocks with a solid internal logic, which made sense to those of us who were already familiar with Scratch programming. However, during our R&D tests with visitors at the Tinkering Studio, we realized that the code blocks didn't always match the state of the physical objects. This was a potential source of confusion, and we often saw learners create long sequences of code containing redundant commands that did not result in a change in the physical world.

Thanks to an extended period of R&D and real-world testing, we determined that making sense of the programming interface without too much explanation up front was crucial to a fluid interaction between Light Play in the physical and digital world. We quickly saw that getting feedback from the physical objects learners control with the app was crucial to help them figure out how the software works.

Eventually, we arrived at a version of the app that supports exploration of the code blocks along with the physical

objects (rainbow lights and motor) and also makes the more advanced programming constructs more relevant. Each block acts as a temporary "switch" that turns the corresponding function on for one second, after which it turns itself off. To keep a light on for an extended period of time, for example, learners have to put several blocks in a row; this makes it easy to time lights and motor, but it quickly becomes tedious for medium and long sequences. At this point, it is natural to introduce the concepts of repeats and loops, which become easier to understand and apply because they have real utility within the programming environment: they solve a real problem.
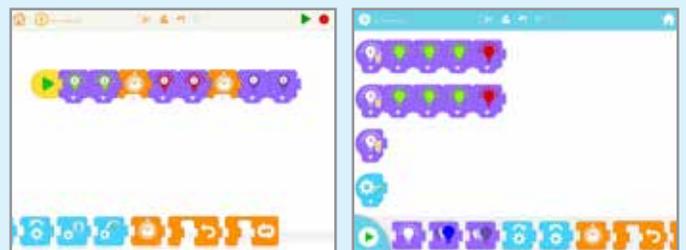
Sequencing two lights to turn green for 3 secs, and then red for 1 sec. Old version with on/off switches vs new version with one second blocks

SETUP
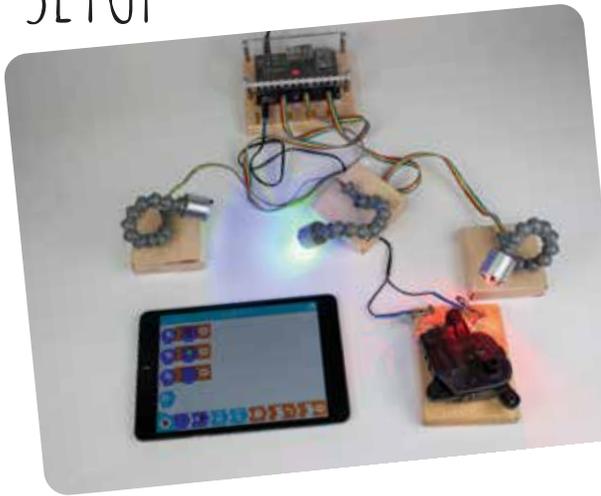
*An example showing how the components are connected*

Digital Light Play shown in use in the Tinkering Studio

FACILITATION

Just like with the original Light Play activity, we invite learners to spend some time experimenting with light and shadow and in the process explore materials and tools, including the light play boards and the iPad app. As learners deepen their tinkering, initial open explorations turn into focused investigations using light and shadow, driven by the learners' ideas. The facilitation techniques and strategies described in our Light Play guide all come into play. In addition, there are specific techniques we find helpful for Digital Light Play.

Spark the Investigation
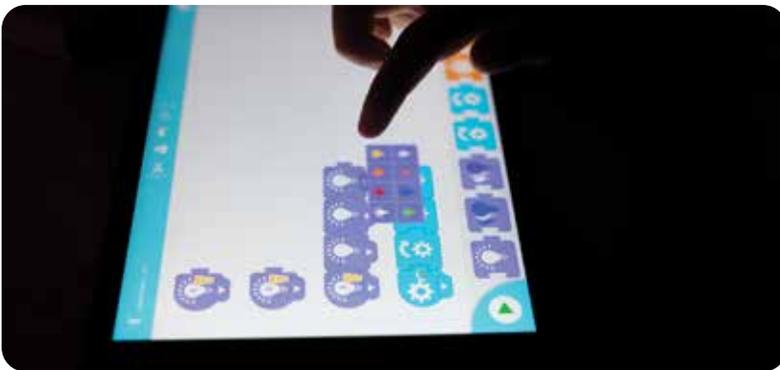
During the early stages of the exploration, when learners are experimenting with the light and shadow materials, we introduce the function of the iPad, lights and motor.

Blocks on the screen help discover how to turn on the motor and that lights can change color.

To support learners exploring the Light Play app by themselves, we place a few blocks on the screen that turn a light a specific color or change the motor direction. We might point out that blocks stick together and can be combined into sequences. We make sure to encourage experiment with the software as well as materials as a way to discover all the possibilities. At this stage, our goal is to introduce a "microworld," or set of blocks that learners can start with and that can be expanded as needed.

Sustain engagement

During the course of the exploration, we like to sustain and deepen learners' interest as they follow their own ideas, this also applies to the programming aspect of the activity.

After learners have been experimenting for a while and more specific goals for their light play vignettes emerge, we often start a conversation about how their project could be fleshed out and expanded by sequencing lights and the motors.

Narrative and storytelling have been particularly rich avenues for sustaining their explorations, but we have also seen learners do careful sequencing of lights in other contexts

Deepen Understanding

The light play app supports beginners in their experiments with code and also provides opportunities for more advanced programming. There are code blocks that allow to create higher level constructs such as loops or nested loops which make the sequences more complex and efficient. When we facilitate we draw learners' attention to these blocks as their code becomes more complex, and introduce more advanced notions such as code efficiency and elegance.
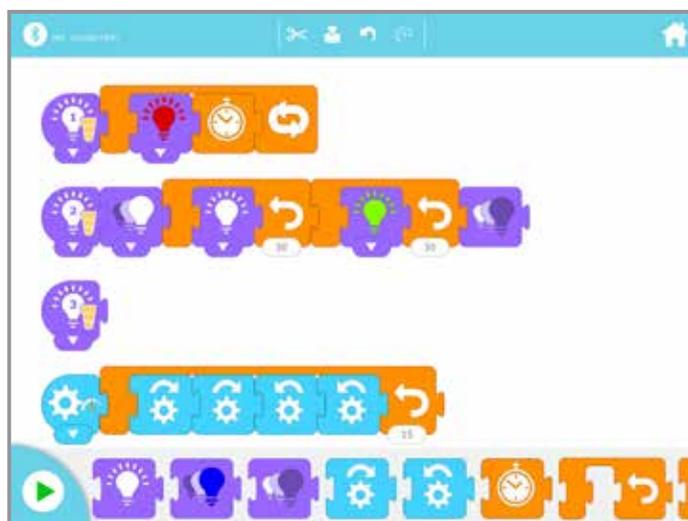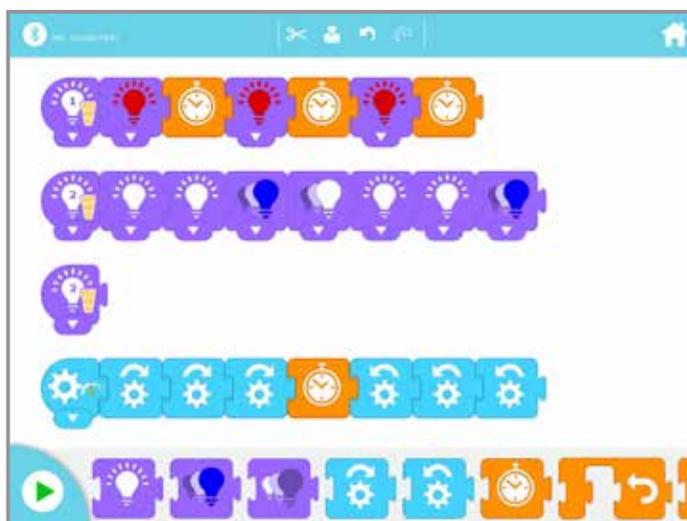
Transition from simple sequences (left) to creating repeating patterns with loops (right)

REFELECTIONS

Combining tinkering with the real and digital world

The Digital Lightplay activity is one of our recent experiments that involves programming and tinkering with code. Overall, we realized that getting immediate feedback in the real world when making changes to code is conducive to the type of free exploration that we value. The Scratch software is well suited for this, since changes in the code are effective immediately without the added step of compiling the code. However, some of the blocks in our custom Light Play app are harder to discover. Some "modifier" blocks, for example, change the intensity of light or the speed of the motor, and therefore don't always result in effects that are immediately noticeable in the real world.

Colored vs white lights

Being able to quickly and easily change the color of the lights can become its own compelling exploration, and younger learners in particular are attracted to the beautiful color washes that result from simply using the app as a fancy "switch" to cycle the lights through various colors. This can happen to such an extent that it becomes detrimental to a deeper engagement with the physical phenomena of light and shadow, and can become a sort of dead end that precludes developing more sophisticated ideas.

We added an optional software toggle to the app that enables a "white lights only" mode, to focus investigation on sequencing and timing on the programming side. This also encourages creating colorful lights via the physical filters and translucent objects in the real world. This provides an extra option to facilitators if they decide that narrowing the scope of the exploration would be beneficial in a particular situation.

Guiding learners to advanced programming

When we facilitate this activity in the Tinkering Studio, we encourage participants to adjust and move lights around to help learners discover the full range of possibilities that the digital light play set provides. We might show examples of how one light can be used as a spotlight for a certain object and another one for providing ambient background lighting. As each light gets assigned a special purpose within a light play story, programming the lights becomes more meaningful, and advanced code constructs come into play.

FINAL THOUGHTS AND FUTURE DIRECTIONS

In approaching this project, one of our main goals was to develop ways to engage with computational thinking ideas and practices without sacrificing the tinkering experience. How can we make sure that the fundamental qualities of the experiences remain a rich, materials-based, learner-driven exploration of a natural phenomenon, and at the same time develop digital tools that allow learners to dive even deeper into exploration and personal expression? We think the design of the Light Play app and the straightforward approach to controlling color and sequencing without too much abstraction maintains a strong direct relationship between the physical objects being manipulated and the digital symbols that allow for computation to be added. In fact, we often had completely analog Light Play setups running alongside the digital ones in the same space, and the transition between the two approaches was often seamless for learners: the iPad app truly became an additional tool for self-expression and investigation,

rather than an end in and of itself. For us, this is one the hallmarks of a successful design: when STEM technologies and concepts become a means to accomplishing the learner's internally driven goals.

In future iterations, we think that providing better tools to develop narratives and storytelling is a promising direction, especially when it comes to audio recording, editing, and playback. Being able to add narration and sound effects, timed with light sequencing, would open up many avenues from storytelling, stage plays, shadow puppetry, and more.

Currently, Digital Light Play relies on custom made components and software that are not widely or easily available; finding affordable ways of accomplishing the same design, for example using off-the-shelf parts, would go a long way to enable more educators to experiment with these ideas.

ACKNOWLEDGMENTS