SUMMARY REPORT

Photo: Scratchfoundation.org

Learning through Digital Play:

The Educational Power of Children Making and Sharing Digital Creations

The LEGO Foundation

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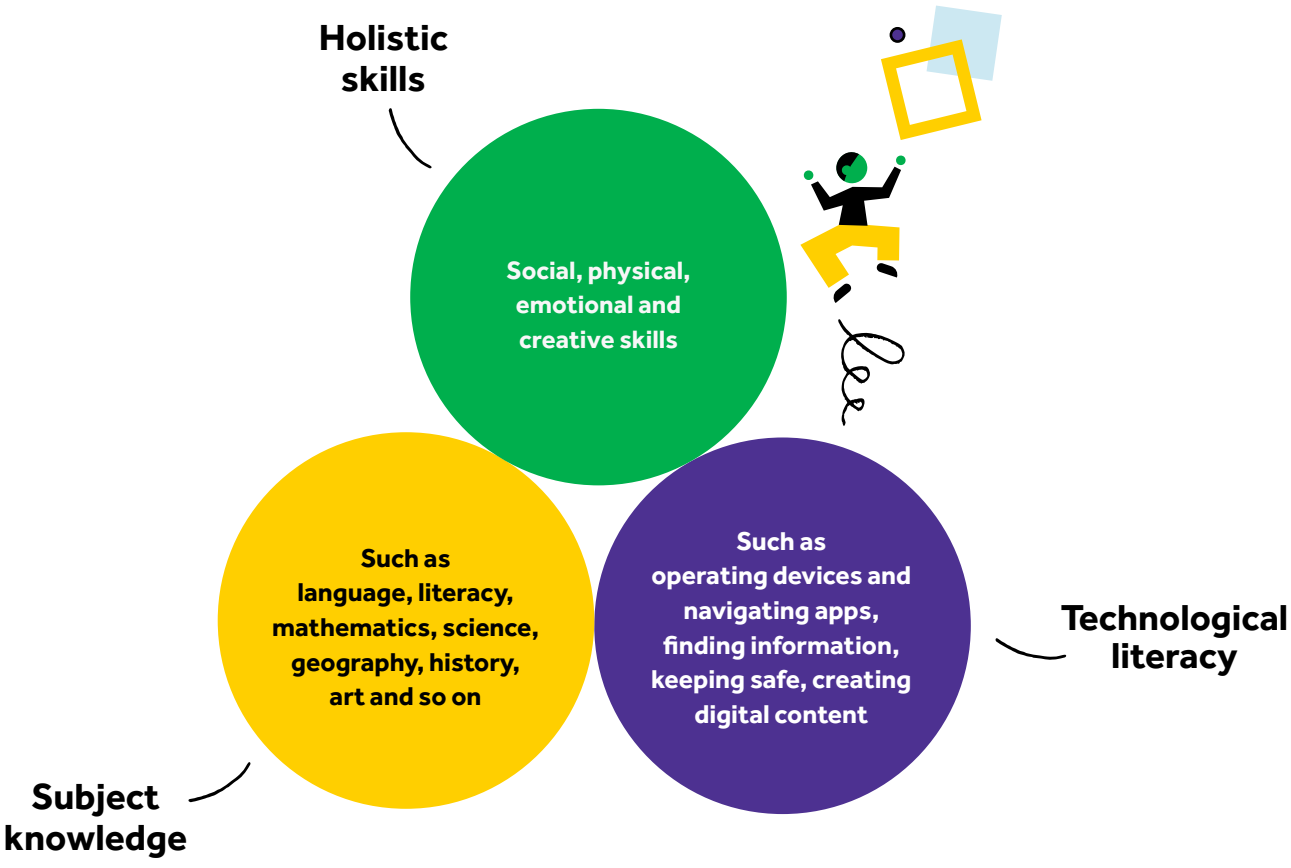
Full research report available on
www.LEGOfoundation.com

Summary

Learning through play with creative technology has real educational power, for educators and children alike.

By making and sharing digital creations, children can gain holistic skills such as collaboration, problem-solving and creativity – as well as subject knowledge and technological literacy.

Educators have a great opportunity to harness the potential of creative digital technology – engaging and motivating students, and transforming the way they learn.



New research shows that learning through play using creative digital platforms – such as Scratch, Minecraft and LEGO® MINDSTORMS® – can have real educational power: by making and sharing digital creations, children can develop a broad range of holistic skills – such as communication, collaboration, problem-solving, self-regulation and creativity – that they need in a world of rapid change, as well as gaining knowledge of academic subject areas and technological literacy.

As an educator, you can harness the unique ability of these creative digital technologies to engage and motivate children. You can use technology platforms to teach many different subjects, working with many different curricula. You can use them as another way of assessing students' progress. And through digital technology you can help to bridge the gap between children's schools, homes and communities.

As digital technologies are increasingly involved in education, both in the classroom and beyond, educators urgently need evidence showing how these technologies can best be used. With our long-standing research focus on the power of learning through play, the LEGO Foundation is well placed to provide this evidence, and contribute to the conversation about the best way to integrate technologies in education.

The potential of creative digital technology goes far beyond traditional forms of educational technology, which put users in the passive role of receiving information.

The best creative technology platforms empower learners with:

- → **choice, initiative and agency**
- → **tools to create their own content**
- → **gentle guidance towards learning opportunities**
- → **an environment that supports curiosity and playfulness.**

These platforms can be used to teach traditional content and specific skills. But they do so much more: they allow children to explore, create, try out ideas and share them, think deeply about subjects and express themselves. At their best they are deeply social and creative.

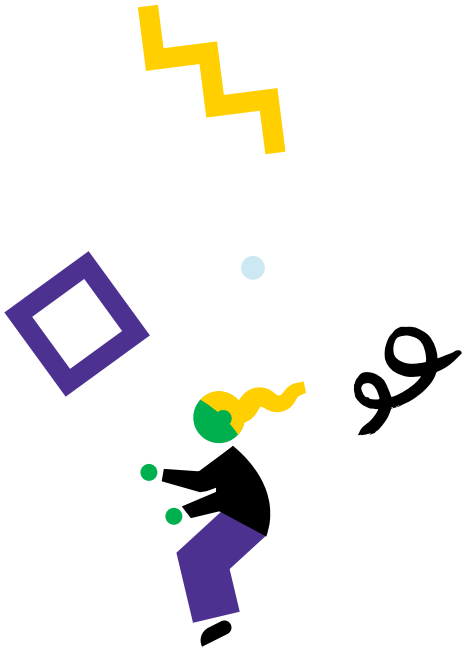
The new research report, published by the LEGO Foundation and entitled *Learning through Digital Play: The Educational Power of Children Making and Sharing Digital Creations*, looks in depth at three great examples of creative digital technology platforms designed for children:

- → **Scratch (a visual programming language and online community)**
- → **Minecraft (an open-ended 'sandbox' game that allows users to create, explore and interact in 3D virtual worlds)**
- → **LEGO MINDSTORMS (a robotics construction kit that includes a programmable brick which connects and controls the other parts)**

The report shows how educators currently use Scratch, Minecraft and LEGO MINDSTORMS in different settings, and presents good evidence for the educational benefits that they provide.

It gives practical examples that you can follow, in integrating creative digital technology in children's education.

Finally, it draws out the essential features that the three platforms have in common: features that you can use as guidance in choosing a digital educational environment, or creating one yourself.



The educational benefits of creative digital technology platforms

As the report shows, engaging with creative technology platforms brings a wide range of benefits, for children and educators alike. These include:

→ Giving children the **holistic skills** (creativity, critical thinking, collaboration, self-regulation and self-expression) that they need, not just to become good people and good citizens, but to succeed in a world of rapid technological, economic and social change

→ Imparting **subject knowledge** in a wide range of academic disciplines and across curriculum topics

→ **Technological literacy** – teaching coding, engagement with technologies and computational thinking, by using approaches from computer science to solve problems across a wide variety of disciplines

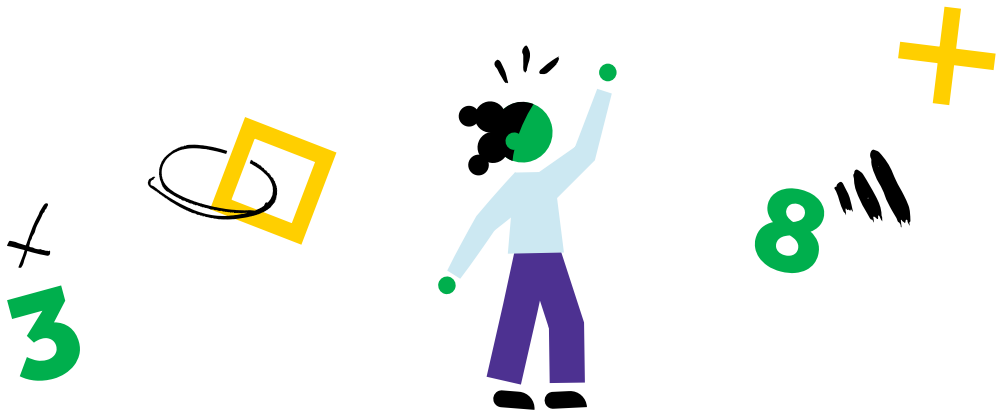
→ Increasing **student engagement and motivation** – the opportunity to drive projects that are creative and personally meaningful gives students a real spark

→ Being **adaptable** to individual students and environments (digital technology can be shaped around particular academic subjects, or in response to a sudden change in educational environment such as the need to embrace remote learning during a pandemic)

→ Being able to **cross boundaries**, bridging the gap between schools, homes and communities (students can draw on what is personally meaningful to them, and are able to continue working on projects in different places, making possible collaborations and conversations about a project with a range of people in different settings)

→ Making possible an **authentic assessment** of students' work (creating digital content can reveal useful information about children's knowledge, skills, attitudes and learning, helping them to reflect on their own capabilities in deciding what to do next, and helping educators to guide their future learning)

→ Children building a **deeper understanding** when they engage with topics through playful learning. Research shows that children understand more deeply when they actively engage with topics by making connections to their own experience, can try out ideas with others, and are driven by a love of learning.



How the report can help you

In the research report *Learning Through Digital Play: the Educational Power of Children Making and Sharing Digital Creations* the authors, James H. Gray (Jim Gray) of the MIT Media Lab and Bo Stjerne Thomsen of the LEGO Foundation, look at three great examples of creative digital technology platforms that are designed for children.

The report is informed by research carried out over recent years by the LEGO Foundation, and is based on literature reviews, as well as interviews with experts on the design and use of the three exemplar platforms and related issues of learning through play.

The report examines digital technology platforms for children in three broad categories: creative computer coding, digital games and educational robotics. The research shows that there is good evidence for the educational power of each of the three platforms. Each helps children to develop a wide range of holistic skills, technological literacy and subject knowledge. And each enables educators to engage and motivate students, to make authentic assessments of children's learning, to incorporate elements of different curricula, and to bridge the gap between children's schools, homes and communities.

The report describes the particular features of Scratch, Minecraft and LEGO MINDSTORMS which help children to develop a wide range of essential skills and knowledge. It includes many concrete examples that educators can learn from, giving a sense of how the platforms are used in the classroom and beyond.

At the same time, the report identifies four essential features that these platforms have in common: features that any high-quality digital learning environment needs to have. Each gives children agency, provides them with guidance, enables creation and nurtures playfulness.

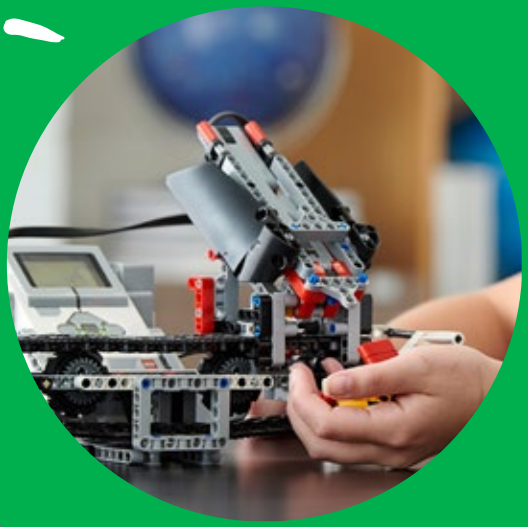
These **four essential features** – **agency**, **guidance**, **creation** and **playfulness** – can be used as a framework for educators, to guide them in putting together and using digital learning environments.

Finally, the report includes specific recommendations for educators, in choosing, using and designing high-quality, powerful digital learning environments for children.

How educators use Scratch, Minecraft and LEGO® MINDSTORMS®

The report focuses on three widely used technology platforms, which help children gain subject knowledge and a broad set of essential skills.

The three examples discussed at length in the research report are the creative coding platform **Scratch**, which gives children the opportunity to create their own stories, games and animations with the help of an online community, the open-ended sandbox game **Minecraft**, in which children build and explore vast virtual worlds with their peers, and **LEGO® MINDSTORMS®**, which enables children to work collaboratively to build robots that can carry out tasks and interact with people.



Why these platforms?

These three platforms are the focus of the report for a variety of reasons.

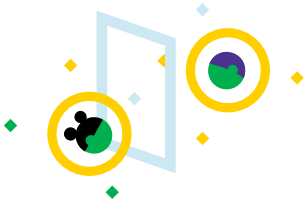
They all enable a broad, diverse range of types of play, helping children to develop a wide range of skills and knowledge. They appeal to children across different age groups. They can be adapted to many different types of subject content.

At the same time, each of these three platforms is an exemplar in its particular area, inspiring other platforms with similar features. Each is widely used in schools. And each has been widely studied, with extensive research on how they are used in learning. Together, they represent a wide range of what technology platforms are capable of, when it comes to learning through digital play.

The educational power of the three platforms

Importantly, unlike some traditional forms of educational technology ('EdTech') that put users in the passive role of receiving new information, these more complex, open-ended platforms all empower learners with:

Choice, initiative and **agency**



Gentle **guidance** towards learning opportunities

Tools to **create** their own content

An environment that supports curiosity and **playfulness**

These platforms can be used to teach traditional content and teach specific skills, but they do more than that: they allow children to explore, create, try out ideas and share them. The best examples of children learning through play with digital technologies have this in common: they enable children to express their own thoughts and ideas, to make their own content, and to share what they make with others.

The forms of content that can be created using the three platforms vary, from digital artefacts (virtual worlds, computer programs, multimedia projects, etc) to physical objects in the form of robotic devices of various kinds. This content can also be shared in a variety of ways, helping users to build their interpersonal relationships and receive feedback on their creations.

Each piece of created content enables children to examine its features, discuss it with others, assess its quality, plan improvements, consider their capacity to make the changes they want, and plan how they will do things differently next time. Throughout the process, they can also reflect on what they have created, how they did it, what it means to them and to others, and what they have learned.

Scratch

Scratch is a visual programming language and online community that is designed for young people from 8 to 16 years old (with ScratchJr being aimed at children aged between 5 and 7), and enables them to create their own animations, games, stories and interactive media. Scratch is used in schools, homes and community centres around the world.

Children can go from interacting with games made by their peers, being inspired by other people's creations, to creating and sharing their own content, bringing their projects to life by snapping together colourful blocks of code.

Scratch provides open access to millions of children's projects and their underlying code. While it is possible to join the Scratch community simply to observe and play with the projects of others, the essence of Scratch lies in encouraging children to engage with content, combining and recombining it and understanding how it is made, and creating their own.

Scratchers (as users are called) can then share their projects for others to see and interact with. Members can also comment on and vote for others' projects.

How Scratch empowers learners

There are many ways for Scratchers to receive guidance: within the Scratch community, they can read comments about their projects written by other Scratchers, 'See inside' or 'Remix' any project to explore how it works, or view tutorials when they want to learn about a particular approach. When it is used as a part of classroom learning, students receive guidance through teacher's feedback, through group work or by observing peers.

Scratch supports a wide range of projects – creating stories, games and animations, or holding contests – to appeal to users with particular interests (such as Anime, or role-playing games). Scratchers can incorporate content from their everyday lives that is meaningful to them, and connect with others who share their interests.

Scratch users can learn how well their code works by running it and observing the results, through a process of testing and trying out. Tinkering with code is a fundamental feature of Scratch.

The skills and knowledge that children gain from Scratch

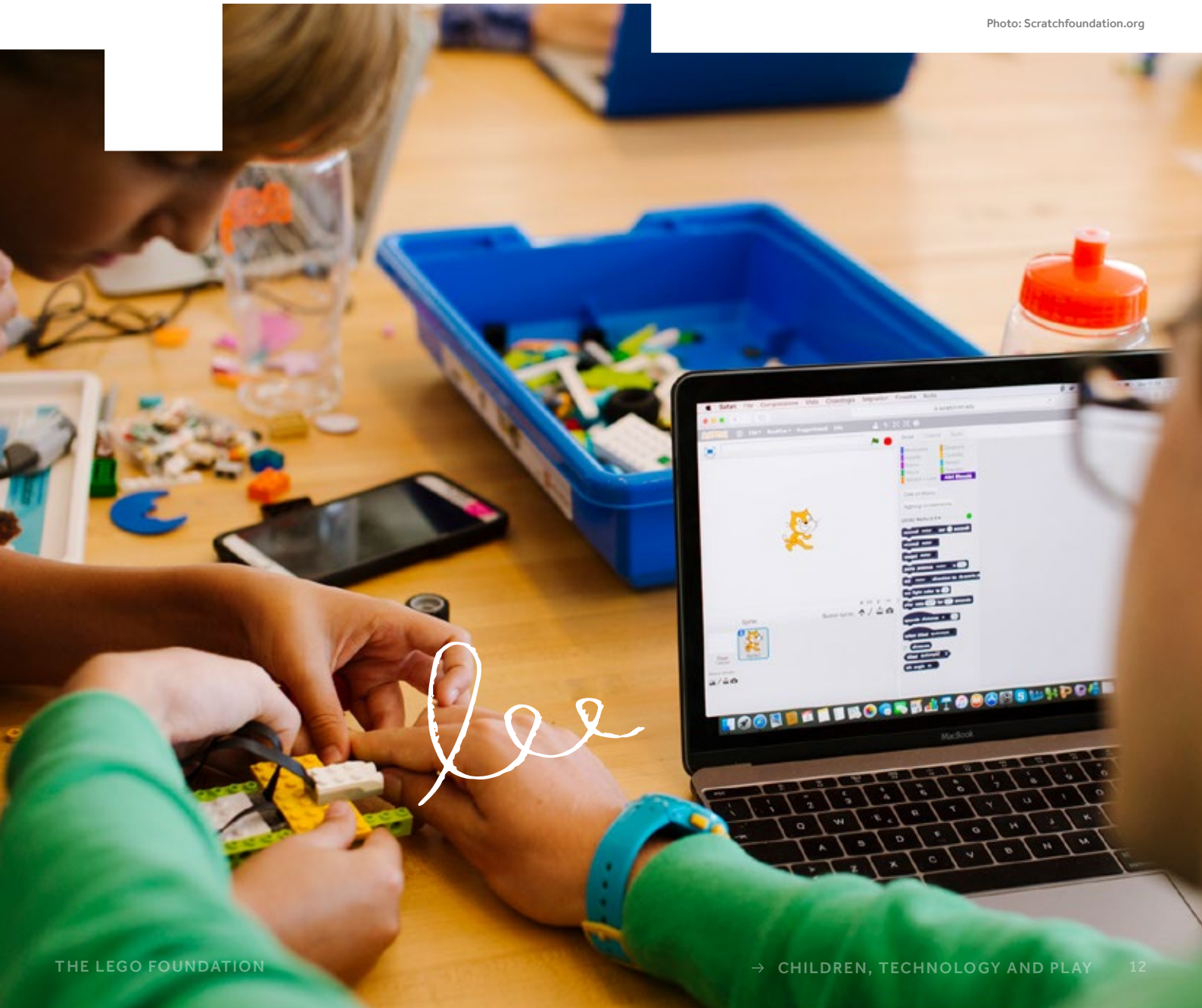
Using Scratch has been shown to help children develop wide-ranging skills such as innovation, collaboration and self-expression. In particular, teachers have said that creativity is one of the general, '21st-century skills' that their students gain through using Scratch.

Scratchers have been observed "gaining skills to express themselves, connecting with others and eventually seeing ways that they could apply these skills to help others and pursue their goals". Scratchers are able to work collaboratively on the same project, by taking turns doing the coding.

Scratch has frequently been shown to help with technological literacy, teaching children coding and computational thinking – using approaches from computer science to solve problems across a wide variety of disciplines. ScratchJr is used in schools to give younger children an early start in understanding and being comfortable with digital technology.

The subject knowledge that Scratchers gain, meanwhile, is as varied as the subjects of Scratch projects. Scratch projects can be used for school assignments – for example, to produce a guided tour through the layers of the Earth to learn about geology.

Photo: Scratchfoundation.org



Minecraft

Minecraft is an open-ended 'sandbox' game that allows users to create, explore and interact in 3D virtual worlds made up of landscapes, buildings, machines, creatures, characters and other players. Everything in the Minecraft world is built from colourful cube-shaped blocks. Users control their own character who can move around the world and act in various ways: 'mining' stone to make a house or building simple electronic circuits to move pistons or turn on lights.

How Minecraft empowers learners

There are modifications designed to enable children to explore particular topics, such as dinosaurs and sustainability. The Minecraft Education Edition in particular adds school-related features to support teaching, learning and assessment: it enables collaborative learning either as a whole class or in small groups (allowing up to 30 players in a Minecraft world at the same time).

Students can document their projects and reflect on learning using camera and portfolio features. They can share their work with teachers, and teachers can set assignments and guide student activities using chalkboards with written text, as well as through non-player characters (NPCs) who interact with students using pre-programmed dialogue. Any academic subject can be covered by teachers using pre-built worlds or by building their own.

Social interaction is another key aspect of Minecraft, made possible by players using text to chat in real time, enabling them to coordinate what they are doing. Players in the same location (such as a classroom) can interact face-to-face during their Minecraft activities. Beyond their immediate setting, players can also interact with their peers, teachers and others, making possible remote assessment of academic assignments, for example.

The skills and knowledge that children gain from Minecraft

Benefits of playing Minecraft include the development of such holistic skills as self-regulation, cooperation, critical thinking and problem-solving, as well as increased creativity. Collaboration is a particular feature of Minecraft, with players moving easily between working together or apart as projects progress.

Researchers have found evidence of cooperation (for example, helping to troubleshoot game issues), and increased creativity in children who engage with Minecraft. As one student put it, "in Minecraft, we're more together, we're tighter, and we work much better in teams than on other projects".

Minecraft has been shown to help children gain technological literacy, for example by navigating the hierarchical menu structures, and understanding the logic of different modes which individuals need to grasp in order to play. In particular, Code Builder in the Education Edition enables children to learn computer coding and computational thinking.

Building knowledge in academic subject areas is another potential benefit of Minecraft, especially when participating in Education Edition lessons, or customised worlds (Mods) designed around particular academic disciplines.

Research has shown that fifth-grade students learned geometry better using Minecraft, regardless of ability level, while another study has shown that Minecraft helped elementary school students to improve their reading and writing.

LEGO® MINDSTORMS®

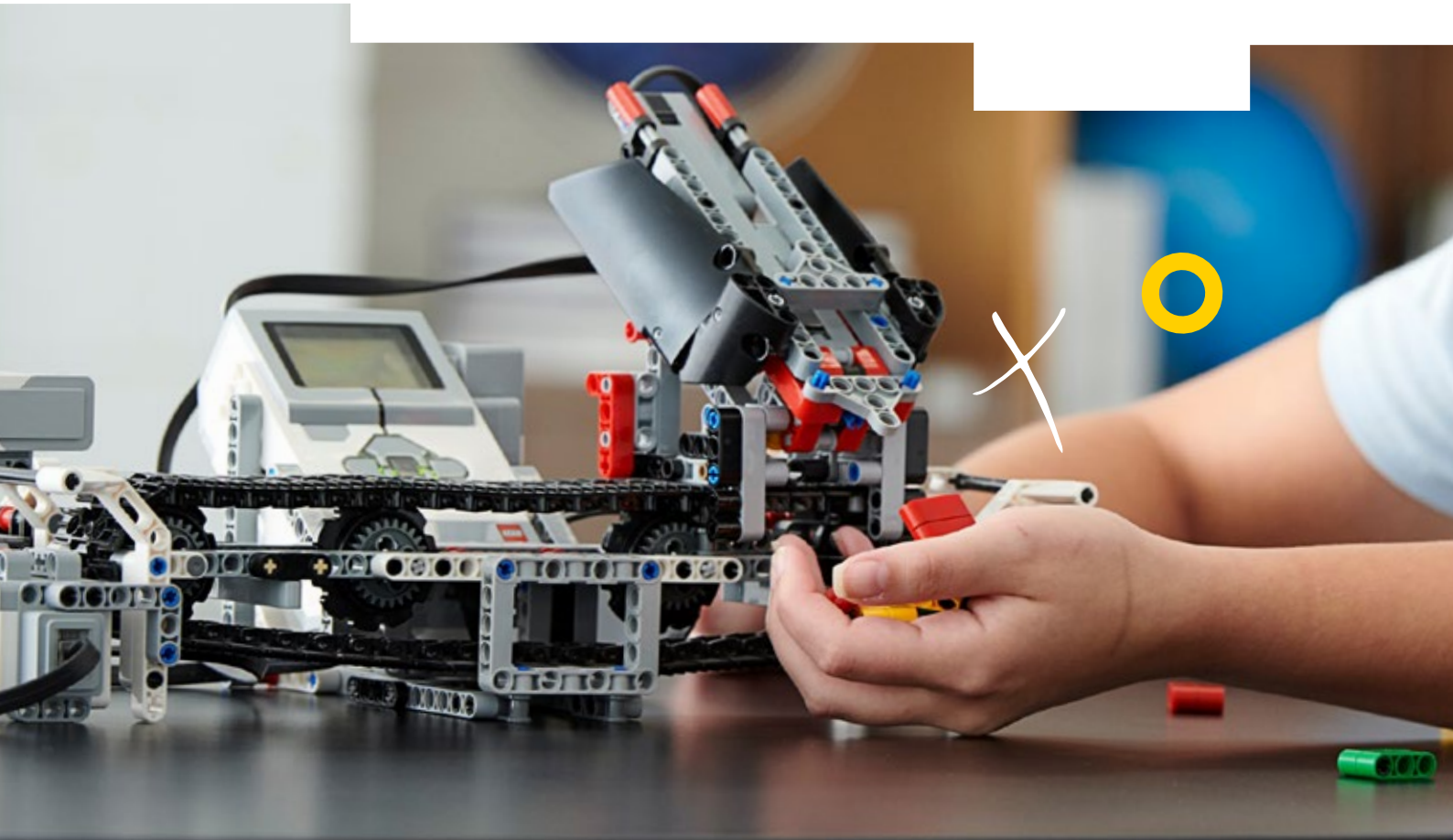
LEGO® MINDSTORMS® involves robot construction kits that include specialised LEGO building bricks, motors, sensors and a programmable brick that connects and controls the other parts. Code for the control brick is written on a separate computer or tablet, using a visual programming language. With these tools, a builder can create a functioning vehicle, animal, home or other creation that can sense, move and process information.

The combination of physical creation and digital programming, as well as the interaction of the robot with its environment, helps to make LEGO MINDSTORMS products engaging for children. Given the more visible nature of the robot compared to a computer screen, it is easier for a number of people to see it and collaborate on it.

How LEGO MINDSTORMS empowers learners

Children can customise their designs to make them meaningful, recreating their favourite fictional character for example. Since LEGO bricks are as easy to take apart as they are to put together, children can easily try things in different ways: rather than there being one correct way to complete a build, children can build and rebuild. Creating interactive robots that function autonomously gives children particular joy.

LEGO MINDSTORMS and other robot construction kits are used in schools as well as in many informal educational settings such as after-school and museum programmes, and dedicated clubs. A good example is the *FIRST* LEGO League, a global non-profit organisation that operates after-school robotics programmes for young people aged 6 to 18. The mission of *FIRST* is to inspire young people to innovate, to build their science, engineering and technology skills, and to help them become well-rounded individuals, by boosting their self-confidence, communication and leadership skills.

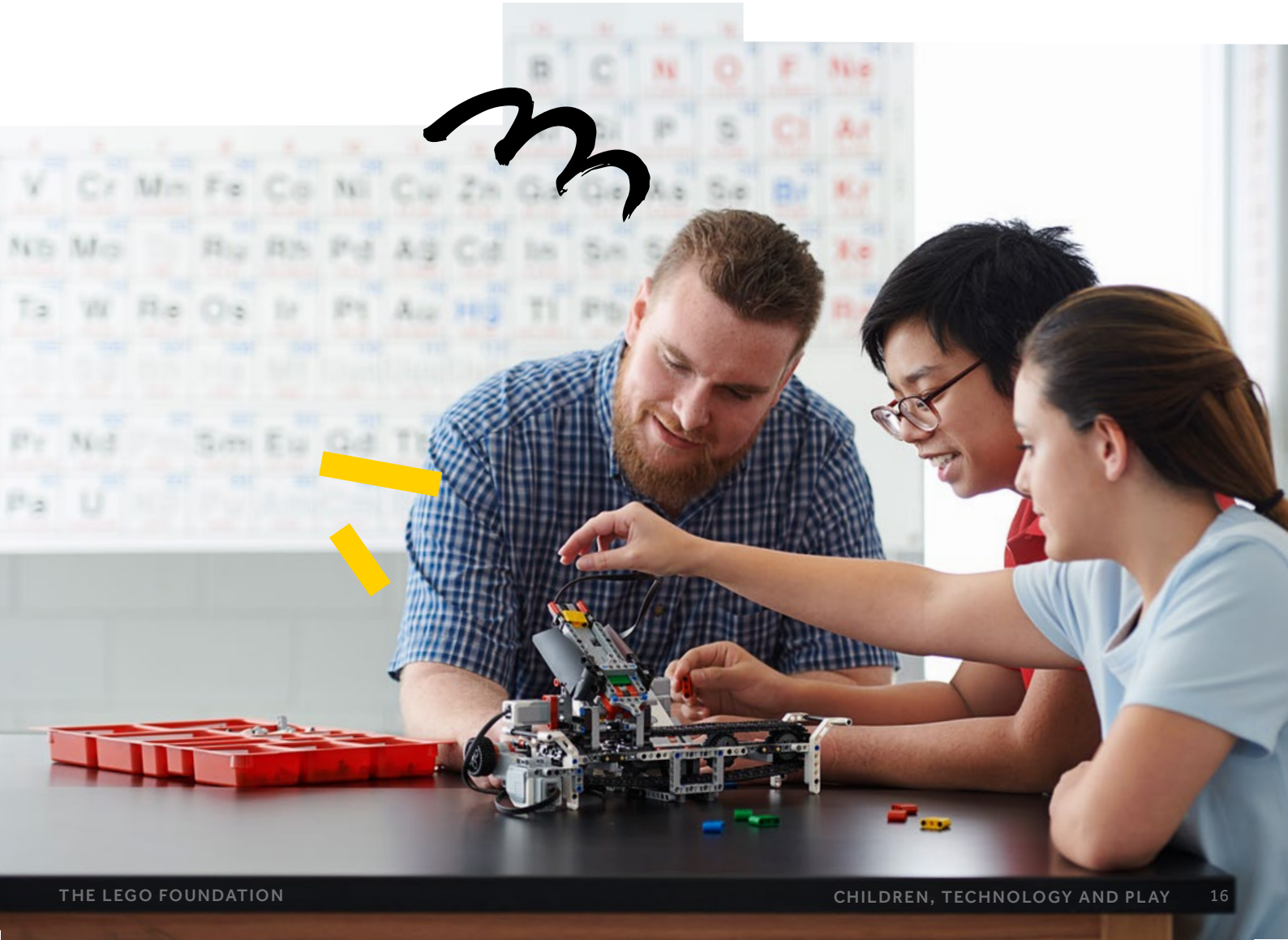


The skills and knowledge that children gain from LEGO MINDSTORMS

Numerous research reviews have shown that LEGO MINDSTORMS helps children to develop wide-ranging skills, including creativity, collaboration, communication, problem-solving and self-reliance. Collaborative problem-solving is a particular strength. As one student put it: "we were faced with various problems while designing and programming the robots to complete the task. As a group, we had to develop new solutions to these problems."

LEGO MINDSTORMS helps children to develop some engineering and computer coding skills, and also has a positive effect on their motivation, and attitudes towards careers in STEM subjects (Science, Technology, Engineering and Mathematics) in particular.

In terms of subject knowledge, the report gives examples of students exploring principles of evolution and natural selection by building robots that are more or less well adapted to their environments. Other studies show students developing subject knowledge with the help of LEGO MINDSTORMS in surprising ways: in one study, a student noted that "I learned how to calculate the circumference of a circle better while calculating the path the robot should take on the mat".



Four principles for a digital learning environment

The report shows in detail how technology platforms such as Scratch, Minecraft and LEGO MINDSTORMS are especially well designed to support the wide range of holistic skill development, subject area knowledge and technology literacy that today's children need.

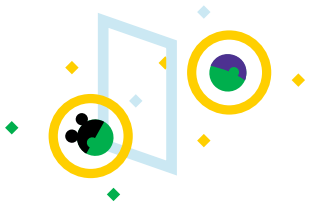
At the same time, there are certain essential features that these digital environments have in common.

These features provide a useful set of criteria that educators can use in assessing the value of an existing platform in supporting learning through play, in planning and facilitating how these platforms are used by learners, or in designing and creating any other educational environment with similar learning goals.

These four features are:

Agency

Children's ability to make choices, and act for themselves in a self-motivated way – in the digital world this can mean having choices over how to use a technology, where to move within a platform, what to create, and how to communicate with others.



Guidance

Guidance from other people, or feedback that is incorporated within the digital technology itself. Technology often incorporates guidance and feedback, which children can use to improve the quality of their work.

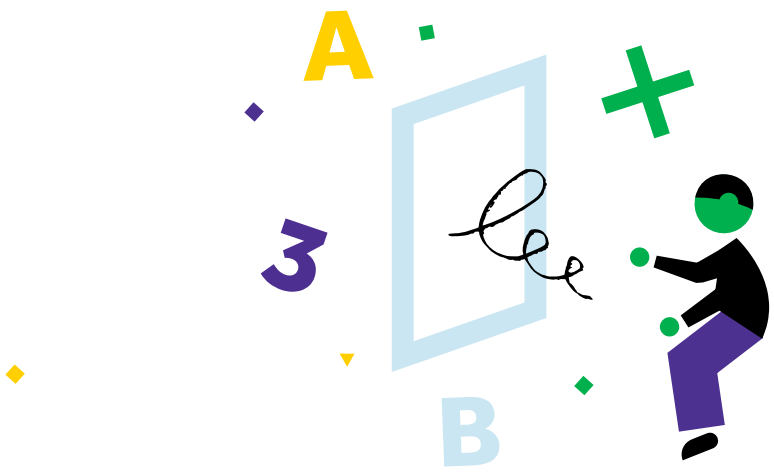
Creation

Creation of artefacts as pieces of self-expression that can be shared. In relation to digital technology, this can mean creating virtual worlds, computer programs, robots and other digital creations.

Playfulness

The feeling of safety, trust and freedom needed to support a playful experience with joy, curiosity, experimentation, exploration and creativity.

Integrating digital play in education: what you can do



→ Use platforms such as Scratch, Minecraft and LEGO MINDSTORMS, that support **playful learning**, to help **integrate development of a broad range of skills and subject knowledge** into your curriculum.

→ **Consider the '3Cs'** in your planning and use of platforms: their **content** (the tools, media, curriculum materials they work with), the **context** (when, how and where the platforms are used), and the **child** (the unique needs and qualities of individual learners).

→ Design and support activities around digital technology platforms that give children opportunities for **agency**, **guidance**, **creation** and **playfulness**.

→ Use the **five characteristics** of playful learning to evaluate children's educational environments and activities, and assess the quality of their resulting learning experiences. Use creative technologies which connect children's digital play experiences in their **home**, **school** and **community** to extend and deepen their learning experiences.

→ Use **actively engaging educational approaches** such as project-based learning, collaborative learning and inquiry-based learning to structure learning through digital play.

→ Use student-created content, such as projects, portfolios and exhibitions, as the basis for **authentic assessments**.

Why is the LEGO Foundation involved in research on children's play?

For several years now, the LEGO Foundation has been working with research institutions to understand the process of learning through play.

There is a growing body of evidence that playful learning involves children learning deeply, leading to them gaining a wide range of skills and subject knowledge, and helping children to thrive as individuals while also contributing positively to the societies they live in.

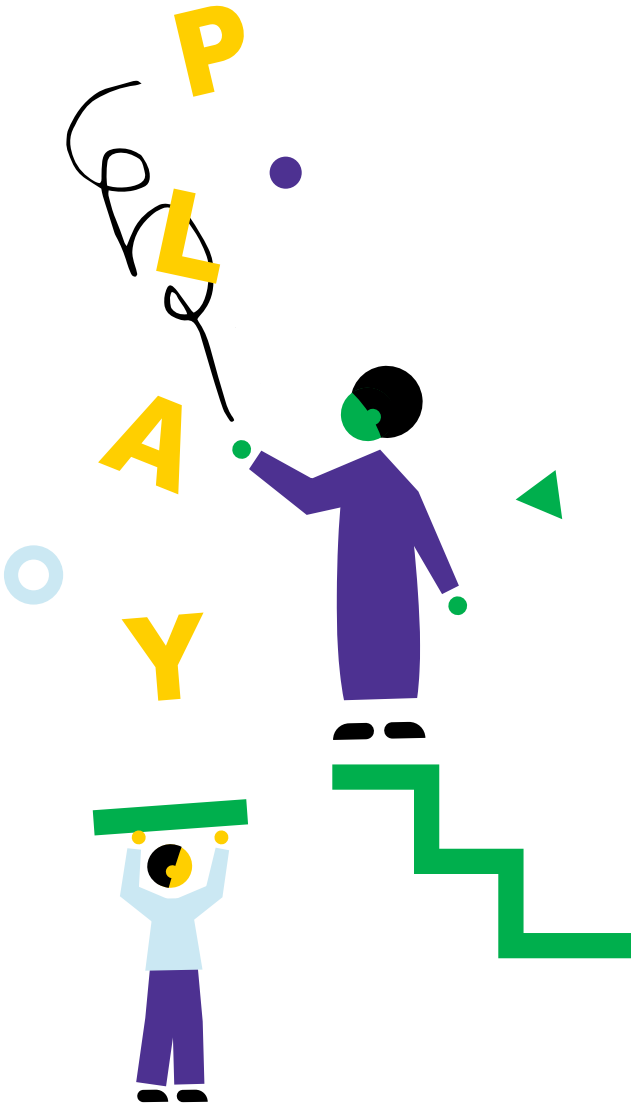
Why focus on creative digital technology platforms for children?

Increasingly, digital technology is being integrated into education, with many EdTech products and services being used in schools, communities and homes.

Undoubtedly, technology can support educators, schools and education systems. But too often, something is lacking from the educational technology that is used. By putting children in the position of passive recipients of knowledge, it leaves no room for creativity and personal engagement; for *play*. Yet the evidence shows that learning through play can help to engage children deeply, enabling them to develop a wide range of subject knowledge and skills.

To help children gain the creativity, critical thinking and technological literacy that they need, we have to make better use of creative digital technology to support children's learning, as an integral part of their education. Engaging creatively and playfully with digital technology has the power to change children's lives for the better.

There are opportunities to use digital technology to transform the way that children engage in learning, but educators sometimes struggle to find good examples of platforms they can use, and practical ideas for using them.



Who is the research aimed at?

The *Learning through Digital Play* report has educators as its primary audience: educators who are looking for new ways of engaging with children, and want to be more confident in using technologies for learning. As well as schoolteachers and school principals, educators can include parents who are involved in their children's remote or home learning. The report provides recommendations that can help educators to navigate the many different kinds of digital technology platform that are available.

How we understand learning through digital play

Of course, children's learning does not depend upon a particular technology in isolation. It is also important to bear in mind what researchers have called the 'three Cs':

- **the *Content* that the technology makes available**
- **each individual *Child's* specific attributes as a learner (for example, their developmental level, pre-existing knowledge and motivation), and**
- **the *Context* that technology is used in, including setting (home, community, school), curriculum and teaching approach.**

At the LEGO Foundation, our understanding of digital play is based on evidence about learning through play in general, which we have built up through our work with research partners.

For children, the experience of learning through play has five important characteristics. It is:

- ***Joyful*, including when it involves overcoming challenges**
- ***Meaningful*, by connecting to children's lives and real-world experiences**
- ***Engaged*, involving active, 'minds-on' thinking**
- ***Iterative*, allowing children to test ideas and try things out**
- ***Social*, involving interaction and collaboration with others**

When these elements are strongly present in play, deep learning is the result: learning that stays with children and gives them the skills and knowledge that they can apply to real-life situations.

The same qualities that apply to any playful experience, making it rich and valuable, also apply to digital play specifically. The five characteristics of learning through play are a powerful lens for looking at digital technologies, and asking whether they support high-quality and deep learning. Is children's experience of them joyful, meaningful, engaged, iterative and social?

The **LEGO** Foundation

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Email us at: LEGOFoundation@LEGO.com

LEGO Fonden
Højmarksvej 8
DK-7190 Billund

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