Making a Maker{School}

Make a Maker{School} was a collaborative project[1] carried out between 2021 and 2022 in Arbourthorne Community Primary school in Sheffield, England. The aim was to develop and pilot a maker-based curriculum including the development of Continuing Professional Development resources for teachers. The project was then rolled out to a further nine schools in the Sheffield City region.

The Make a Maker{School} project builds on the success of the University of Sheffield's MakEY project which aims to provide support for early years settings, schools, libraries, museums and community centres that wish to develop and deliver makerspaces. A makerspace is a space that enables users to tinker, design and make a range of artefacts. Engagement in makerspaces can develop knowledge across a wide range of disciplines, including Science, Technology, Engineering and Mathematics (STEM), and they foster the kinds of skills that are important for the future success of pupils.

There is an increasing recognition that digital competences, skills and knowledge are important for cultural and economic growth, self-fulfilment, social inclusion and civic engagement. Further, there has been an emphasis in recent years on the need for individuals to develop transversal '21st century skills', which include: communication; collaboration/ team working; creativity; problem solving and flexibility. We need to ensure children and young people are sufficiently well prepared for this future and are able to develop the skills and knowledge required for future employment. It has long been acknowledged that there needs to be more innovative and creative approaches to STEM education if it is to attract diverse groups of learners. STEM subjects can be made more appealing to traditionally marginalised groups through the integration of STEM with art and design, known as STEAM.

[1] University of Sheffield, Centre for Innovation in Voluntary Action, Erase All Kittens

This article reports on the work carried out by school leaders, teachers and university researchers to develop and pilot the makerspace curriculum and the impact the project had on teacher practice and children's development.

Developing the Maker{School} Model

The first goal of the Make a Maker{School} project was to engage the participating teachers. A small number of early years teachers from the school had been involved in a previous maker project (MakEY), but we were keen to explore how this could be widened to reach all teaching staff across the school. In total, forty five teachers, teaching assistants and pastoral staff took part in a suite of training and workshops focusing on makerspaces. Teachers were also invited to attend an optional three week free online course on the Futurelearn platform developed by the Maker{Futures} team. During a series of eight after school twilight sessions, teachers learned about the pedagogies of maker-based learning and participated in skill building sessions covering the use of tools, woodwork, digital design, and digital literacies. The teachers were also asked to share project ideas that were then developed collaboratively to form part of the Maker curriculum.

The Maker{School} Model

The Maker{School} Model incorporates a number of key pedagogical aims.

Seven principles

Firstly, the child is placed at the centre of making. Developing as a maker is more than simply learning the skills and knowledge to manipulate materials, use tools, and code software. Our

belief is that it is important to use the characteristics we want to nurture as a starting point in learning how to ‘think like a maker’. Our work is guided by seven key principles:

1. *Playful* - juggling with multiple possibilities, focusing on process over outcome
2. *Experimental* - trying things differently, taking risks and making mistakes, asking what if?
3. *Spacious* - engaging deeply by slowing down to think, reflect and refine
4. *Hands on* - Using our whole bodies and thinking and learning by doing
5. *Meaningful* - caring about what we learn by drawing on our interests and experiences
6. *Authentic* - navigating the constraints and possibilities of the real world y making concrete responses to genuine challenges
7. *Inclusive* - learning how to collaborate, support and lead by seeking out and valuing the knowledge and expertise of our communities

Key areas of making

The skills and knowledge required for making depends on what you want to make, and that depends upon what needs making. The need arises out of a problem and as problems come in all shapes and sizes, it is important that maker education covers a wide base of both skills and knowledge. The Maker{School} curriculum focuses on five key areas of practical skills:

1. Materials and tools
2. Computing, coding and robotics
3. Digital literacies
4. Digital design and fabrication
5. Electronics

It is important to note that although these five disciplines are grouped as separate entities, maker education and making often blur the boundaries between each area as projects develop and disciplines are intertwined as tinkering occurs and solutions are sought. Some makerspaces choose to focus on specific areas, but we believe that it is useful for children to have some experience in each of these areas.

The Maker{Spirit}

Maker education is much broader than the acquisition and application of practical skills. It is a valuable opportunity to nurture a wider set of personal characteristics and attributes. Sometimes referred to as a type of 'mindset' or 'out of the box' thinking, we believe that given the right environment and opportunities, everyone can develop a way of being that helps us to see the world as full of possibilities. This is our Maker{Spirit}. The Maker{School} Model is built around creating a learning environment where this spirit can thrive.

Diagram 1 – The Maker{Spirit}

Three elements

The Maker{School} model is based on an enquiry based approach, and learning by doing. Teaching children maker skills and knowledge is done through a three stage process: Exploration, Skill Builder and Tinker time.

This is child-led time to play, explore and become familiar with materials and processes. Exploration time promotes curiosity and provides opportunities to get to know materials, technology, software, and tools. Teachers can support children's exploration by asking open ended questions such as: What happens if ... ? How many ways can you ...? What do you think this might do? How could we use this?

These are sessions of focused, instructional learning to gain or deepen specific skills and knowledge. Teachers are encouraged to learn new skills alongside the pupils. Skill builder sessions may be facilitated through a teacher, video tutorials, visitors, books, and guides. These structured sessions are short and focused. An example of a skill builder session would be how to design a 3D model for 3D printing.

Tinker time builds on the curiosity, confidence and competence developed throughout the exploration and skill builder activities. It gives pupils the opportunity to engage deeply in creative thinking, problem solving and iteration. Tinker time provides the time, purpose, and space for children to consider real world problems, rapid prototype and find innovative solutions. The emphasis is on the process of making rather than on the finished product. This approach deepens learning and gives agency to each maker.

Maker{Cycle}

To help guide pupils through the problem solving, making process they use the Maker{Cycle} to evolve and iterate their ideas and prototypes. Children begin to understand that entering into a process of continual improvement produces their best work. By developing a culture of trial and improvement, children build resilience.

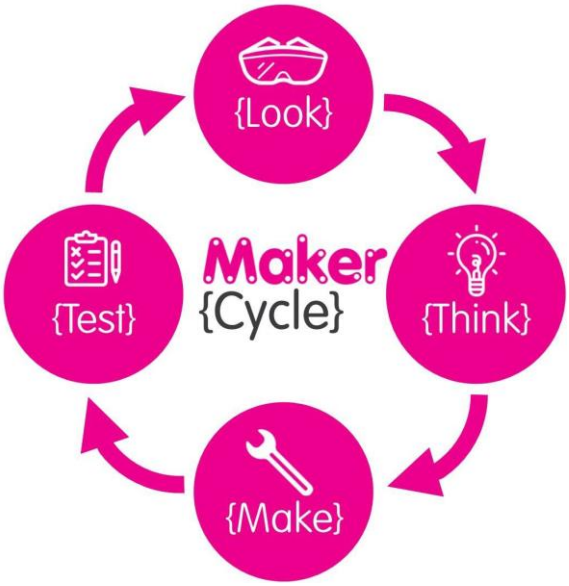

Diagram 2 – the Maker{Cycle}

The Maker{Cycle} is based on similar cyclical models such as the design cycle, or the engineering design process, and provides an approach to making, prompting children to look, think, make and test. Makers work through these four stages of the process regularly, reflecting real world innovation and creative problem solving. Children develop the confidence to try new things and test their ideas little and often and they learn to evaluate their work and make improvements. Through doing this, they discover what works and what does not and where the gaps are in their maker skills and knowledge. In turn, this leads them to pursue further exploration and skill builder sessions. Teachers can help by signposting children to where they can develop their skills further independently or perhaps start a display where children can add their ideas for new skill builder sessions.

Using the Maker{School} Model

The teachers trialled the three phase approach to ensure maker-based lessons gave children the opportunity to be fully engaged and to develop their Maker{Spirit} as well as practical skills. Six classroom maker projects were developed to enable class teachers to run their own activities linked to the English Primary National Curriculum (DfE, 2013). These were developed with a focus on materials and electronics with two activities suitable for Key Stage One children (aged 5 - 7), lower Key Stage Two children (aged 7 - 9) and upper Key Stage Two (aged 9 - 11). Projects were run over a series of classroom sessions with opportunities for teachers to adopt or extend projects to suit their particular needs.

Three projects, Trip Trap about the Three Billy Goats Gruff, Toys, and Simple Machines all focused on cardboard building skills. These included a series of short videos developed to show teachers and children the different types of card available, tools and methods for cutting and effective strategies and tools to join cardboard together for strength and for movement. Three further projects were developed to support skills development in electric circuits. Light and Shadow was a project aimed at KS1 and introduced skills in creating simple circuits to

create the light source for a shadow puppet show. Earthquake Proof explored natural disasters and tasked children with using their new circuit knowledge to design and build a vibrating platform to assess the strength of model buildings in the event of an earthquake. Warning Iceberg! Was a project that introduced a range of electrical outputs and switches where children designed iceberg warning systems.

As teachers' interest in maker-based projects progressed, they were keen to develop further opportunities for making. The project team suggested a whole school approach and ideas around a school Maker{Festival} were born. Using the book If I Built a School by Chris Van Dusen for the Exploration, childrens' interests were captured as they began to imagine a very different setting to their current school. Each class chose different skills to build such as computer aided design using Tinkercad or how to use tools to safely cut and bend wire to help them realise their ideas into models. These were then completed and showcased to other classes and the wider school community during the festival.

Impact on teacher practice and children's learning

The research component of the project sought to address the following question:

- How does the Maker{School} curriculum and teaching resources support the development of children's STEM learning and skills?

Staff reflections on makerspace lessons and interviews with participating teachers provided the data for the research. The discussion that follows will focus on the role of the adult in makerspace lessons and the skills that were observed during these sessions.

Role of the adult

Teachers talked extensively about how important adults were during making sessions. In the early years classroom one teacher spoke extensively of how modelling different skills was “vital” to move children on in their learning. This helped children progress beyond the exploratory phase to using and applying the skills they had learnt. The teacher talked of being “responsive” to children and the need to listen and look at what they want to do and what they are ready to do. Adult intervention also included offering children suggestions without completely “giving them what they need to do” whilst enabling their input, so ideas are collaboratively “moulded together”. Finding a balance between the two was seen to be key so adults did not end up “taking over”. The teacher also spoke of how she would provide stimuli for children so they can “see different things” which was especially helpful for children who found it more difficult to come up with their own ideas. Careful consideration of the environment and the suitability of materials and resources was also seen to be key to successful making. Professional development was also highlighted during the interviews and how “upskilling” was important to ensure teachers had the skills in specific areas of the Maker{School} curriculum.

The Key Stage One Teacher talked of being “open minded”, acknowledging “when you don’t know something” and being prepared to go and find out the information you need. She went on to highlight how learning was broken down into chunks to support learning but then seeing the process as a co-construction of knowledge between the teacher and the children. Working in partnership with the children helped to facilitate ideas, creations and solutions rather than just being the “provider”. Having aspirations for the children was also important. The teacher explained how useful it was to have an understanding of what skills are about and where they can lead you and how makerspaces provided a vehicle for getting children to “aspire beyond what they know”.

The idea of being aspirational was echoed by the Key Stage Two teachers who highlighted Maker{School} has “broadened children’s opportunities” through conversations and shared experiences in the classroom. One teacher talked of the technological environment children

were growing up in and the vital need that children learn the skills that will enable them to access the opportunities that the modern world offers. The development of softer skills such as team-working was seen as particularly important for the children who attended the school. It was stated that makerspaces inspired the children to push themselves to develop their own curiosity into the subjects they had learnt about.

There was positivity about the move away from a prescriptive approach to Design and Technology and how makerspaces “breathed life” into learning. One teacher described the “buzz in the room” the first time they did this type of session. Flexibility and a “willingness to try new things” was also seen to be key to success when carrying out making activities. Having “freedom” was mentioned a number of times and how enjoyable it was to observe the children have “ownership” over what they were engaging in and developing skills in different ways. Another teacher highlighted how taking a step back allowed her to observe children’s “creative flair” and expressed surprise at how the children are able to apply ideas from different subjects into another. Putting trust in children and allowing them to lead projects was seen to be the mark of a “good teacher”. However, the teachers shared initial challenges with this approach as children were not used to the lack of structure, having forgotten “how to play”.

It is pertinent to note that teachers are not the only significant adults in a child’s life. Families play an important role in supporting and encouraging their children at home and schools are ideally placed to help families gain the confidence and inspiration for making and tinkering at home. One teacher told of how proud the children were of what they had made and that they would go home and tell their parents what they had been doing. Makerspace sessions were held after school so parents could get involved which helped to support school/ family partnerships, something that was important to the school. The teacher explained how this helped to raise aspirations and ambition for the parents and children. It was also reported that the makerspaces were effective in engaging fathers. One little girl had made a light up wand as part of a makerspace project and then worked together at home with her father who was

an electrician to make a “new improved version” that reflected the LED lights more brightly. The teacher described it as a “perfect father/daughter project”.

21st Century Skills

Teachers observed attributes across the scope of the Maker{Spirit} framework. Teachers talked of children using problem-solving skills to try out different ways of doing things when they met challenges in their making. It was noted that children had stopped asking for help so readily and were working more independently, trying to solve the problems themselves. Older children in Key Stage two were also doing their own independent research on their Chromebooks and then incorporating this into their making. One teacher highlighted how children were also starting to use their problem-solving skills in other subjects, such as Mathematics and Literacy.

Resilience and perseverance was seen to be a particularly important skill for the children in the school. One teacher believed improving children’s resilience would help them give them the skillset to “climb out of poverty” and become confident lifelong learners. Engaging in the making gave children the freedom to take ownership of their own learning but it was reported that some of the older children struggled with this initially. Children were not used to lessons being unstructured and a teacher told us it took some time to (re)train the children to work independently, without instructions. Maker{School} enabled children to build their confidence as they became secure in the practical skills they had been taught and were then able to use their skills in different contexts. Giving children the opportunity to feel good about themselves beyond Mathematics and Literacy was seen to be vital to show them they can succeed.

Children were observed working collaboratively, learning how to listen to different ideas and arriving at a consensus across the group. They were able to make adjustments and amendments as necessary using the Maker{Cycle} and produce and fine-tune until they had

a product they were happy with. One teacher talked about the “sense of fulfilment” in achieving a quality product they were all proud of.

One final point to make is that makerspaces enabled quieter children to shine. One teacher commented that she had found some pupils demonstrated impressive leadership skills that they may not have been able to show in other subjects like Mathematics and Literacy. Makerspaces also enabled children to showcase previously hidden expertise in areas such as electronics and coding and how this developed confidence as they were able to show other children what to do.

Case study

Y1 - If I built a school (Victoria Ling (teacher), Arbourthorne School, Sheffield)

Brief

To design and make an element to enhance our school.

To use your imagination to create a dream element as inspired by the story ‘If I Build a School’ by Chris Van Dusen.

To create a plan through drawing and labelling the materials required.

Skills builder: cutting skills / using scissors

Resources

hole punch, stapler, glue, pens, sequins, wool, lollipop sticks, matchsticks, pipe cleaners, paper, card, tissue paper, cellophane, tape, boxes, tubes, pots.

Maker{Spirit}

The children loved the story and were inspired to discuss ideas to create their dream school. They spoke about what they would add to enhance our school weaving in their own interests.

For example: Child A said *'I'd make a huge gymnastics studio where I could do gymnastics all the time!'*

Children's ideas were ambitious and vast. This led on to learning about design skills and how to think of design as a process (The Maker{Cycle}). Children need support and guidance to think about how they could turn their ideas into a design while thinking about the materials and methods they will use. For the future, a materials list will support children to choose suitable material and to apply these to their plan.

Children learnt how to make a simple circuit - there was an awe and wonder moment when the LEDs lit up was wonderful - what happened then is that children who developed the skills confidently then became coaches for other children who needed more support. Children developed problem solving skills - some children became frustrated when it didn't work immediately - but then worked out how to troubleshoot and work through the elements to help create a wand which worked - this helped build teamwork, resilience and determination - by the end of the session all children were successful and had created a light up circuit.

<u>Outcomes</u>

During the activity children were engaged, shared resources and tools, and worked collaboratively, mostly without support. Children used tools safely and used their cutting skills previously developed through skills builder, to cut a range of materials.

Children were creative and produced individual projects. Children spent time constructing and then deconstructing. Children gave the explanation of *'it wasn't stuck right*' or *'it didn't work'.* This demonstrates their ability to reflect, evaluate and improve.

Next steps

As part of the University of Sheffield's knowledge exchange, we will continue to work closely with teachers in schools to further develop the programme and measure its impact on the ground. This includes growing the programme and welcoming more schools across the UK. We are also doing work to understand how this programme might be developed in an international context. The Maker{Futures} team are looking forward to understanding more about the ways in which the programme is creating lasting change for teachers, children and the wider school community.

https://makerfutures.sites.sheffield.ac.uk/

References

Department for Education (DfE) (2013) *National curriculum in England: primary curriculum* Retrieved from: https://www.gov.uk/government/publications/national-curriculum-in-england-primary-curriculum