Book Review

Remke M. Klapwijk, Jianjun Gu, Qiuyue Yang and Marc J. de Vries (Eds.) (2003). Maker Education meets Technology Education: Reflections on Good Practice. Brill Academic Publishers

Reviewed by Marion Rutland, UK

This book brings together Maker Education and Technology Education through the reflections and presentations of good practice by a range of authors from around the world.

Part 1: The rise of Maker Education across the world

1 Introduction

Remke M. Klapwijk and Marc J. de Vries

This very interesting and thoughtful book begins by noting that *learning by making* has 'swung like a pendulum back and forth through history but argues that recently it has gained momentum through the Maker Movement. This has re-evaluated 'making' so that it enables the learning of a variety of skills, as well as scientific concepts in informal formal concepts contexts. Signature pedagogies, including 'playful pedagogies' focusing on collaboration and the celebration of learning through productive mistakes provide new opportunities and inspiration. The book including case studies from around the world that outline different themes associated with Maker Education in relation with Technology Education with reflections and thematic comparisons of actual practice by a number of authors.

2 The Development and Evolution of Maker Education in China

Jian Gu and Qiuyue

This chapter considers that Maker Education is an increasingly important aspect of a universal education. It is an effective way of cultivating students' communication, cooperation, innovative ability and crucial thinking in the 21st century. The chapter describes the emergence, evolution and development of Maker education in China. Chinese Maker education has a long history from Xingzhi Tao, the pioneer of modern Chinese education in the early 20th century. In 1927 he gave a speech in Shanghai called 'Creative education', arguing that 'doing' is the beginning and 'creation' and completion of Chinese education.

The chapter traces developments in the Chinese educational system to the national education reforms of the 1990s when Maker education took root and gradually developed in the 21st century and a move from factor and investment to innovation-driven, innovative education. Maker education became the source of economic development. The chapter goes on to describe reforms in 2013 and 2014 to the curriculum reforms for senior high schools and

various disciples that resulted in *The General Technology Curriculum Standards for Senior High schools* (2017) and further developments through to the present day.

Reference: Ministry of Education China (2017) *General Senior High School Curriculum Program and Standards* 1st Edition.

3 A Participatory Design Approach to Sustaining Makerspace Initiatives

Katrine Holm Kanstrup, Ole Sejer Iversen, Maarten Van Mechelen, Christian Dindler and Marie-Louise Wagner

The chapter outlines a six-step framework developed by eleven Danish municipalities and a private foundation for sustaining makerspace initiatives by means of a participatory process. The aim was to create sustainable infrastructures the initiatives that provided makerspaces with a shared vision, considering the individual ambitions and circumstances of the municipality.

A six-step framework was developed based on research into Participatory Design (PD). The infrastructure included the technical structures, organisational, political and personal structures needed for long term success. All eleven initiatives makerspace initiatives were in formal educational settings and included schools, municipality libraries and educational institutions. The PD design tradition, originating in Scandinavia emphasises the direct and continuous involvement of future users and stakeholder in the design process and integrates concerns for designing physical and digital spaces, educating and creating organisational commitment. The participatory approach for sustaining maker initiatives derives from Danish research from 2019 to 2021.

Funding was provided from a private foundation for a period of three to five years, with two-to-three-day workshops of 12-30 participants run in the eleven municipalities. There was a director of education, project lead, makerspace manager, school principal, teachers, project partners, funding agency and university researcher. Six steps towards Sustaining Makerspace Initiatives were identified from the eleven makerspace workshops. These were understanding the complexity of the initiative; hands-on introductions to makerspace education; establishing a grand narrative for a makerspace initiative; developing a makerspace initiative within an existing municipality landscape; confirming and articulating management support and then choosing and purchasing technologies for the makerspace.

As a result, the funding agencies decided that six new municipalities would follow the steps in 2021, and 2022. It was emphasised that school systems, funding agencies have different approaches and requirements, and the willingness and culture of collaboration would be different across countries. Finally, that the six-stage framework requires substantial funding in relation to planning time, stakeholders' participation, expert engagement and access to existing makerspace initiatives.

Part 2 Case studies on Maker Education

4 Informal Learning in a Public Library Makerspace for Youth in the Netherlands

Monique Pijls, Tom van Eijck and Bert Bredeweg

This chapter focused on how informal learning spaces create opportunities for children to develop their talents, experience new social roles and where former librarians or other professionals provided informal learning of children in makerspaces for children aged 8-12 years. In recent years, museums and libraries in the Netherlands have established makerspaces in various urban areas to enable young people, sometimes from lower socio-economic status and little access to technology or creative resources at home, to develop their digital skills in conjunction with their creativity. The Amsterdam Public Library created a network of ten makerspaces where children could attend school and after-school programmes and provided training for the makerspace coaches.

The project Maakplaats2 was monitored through a formal research project and 123,826 children visited the after-school programme between 2017 -2020 with a gender balance of 50/50. 27 interviews with children and 12 makerspace coaches were analysed. All after-school activities took place on weekday-afternoons for 15 children guided by two to three makerspace coaches, often recruited from library staff and sometimes student teachers. The programmes consisted of ten weekly classes comprising digital fabrication and tinkering, designing, community art programming/coding often based on a theme.

Eight examples described typical examples of learning in the public library makerspace. In *Developing Skills by creating Creatures* nine children learnt to work with a laser-cutter and sewing machine, Tinkercad software for the 3D printer, Inkscape and a sticker cutter. They designed their own animal, cutting the fabric with a laser cutter and designing small accessories such as eyes. The children were motivated, developed technical skills and creativity, were in a safe place and the activities were structured and focused on individual development.

Another example 'Codeteam', was an activity for eight children working in groups of two or three and called *Making a Robot to help Granma*'. It was a ten-week programme about coding and programming. In 'The Beach' there was collaborative community programme led by the cultural foundation. Some clothing and accessories made by the children were sold at the local market. The tasks were open, and the children had the freedom to come up with ideas and multiple solutions instead of only one *correct* answer.

Essentially, the maker space provided opportunities for children to learn and get acquainted with creativity and technology. The after-school programmes helped motivate, improve confidence and stimulate the children. The makerspace was embedded in the community and needed continuous professional development and cooperation with local organisations, institutions and universities. After-school programmes fulfilled an important role in motivation and the development of talents. It was acknowledged that after school makerspaces put high demands on staff and require time, training and support. Challenges included continuity, finances, keeping children in contact with the makerspace as they grow older and maintaining the service free to children.

5 Using 'EcoMakerKits' to stimulate Maker Mindset and Circular Thinking in Mexico

Alvaro Nunez-Solis, Suneel Madahar, Nathan Eskue and Miroslava Silva-Ordaz

In this chapter Maker Education focused on using e-waste to stimulate the Maker Mindset and Circular Thinking of primary children in a Mexican context. The use of 'Eco-Maker Kits' was explored to see if they enabled or hindered the learning concept of Circular Thinking and Maker Mindset through basic electronics hands-on experiences with waste materials. 'The EcoMakerKits' helped expand the Maker Mindset of the children through assembling artefacts and electronic circuits. They built on their technical skills and motivation to tackle global issues such as electronics waste and the importance of reusing, repairing and repurposing.

The Circular Economy thinking was based on the principles of design, repair and reuse to keep products and materials in use. In recent years there had been a rise in the purchase and waste of electronic and Circular Thinking and Maker aimed to address this issue by developing more sustainable products. The Maker Education mindset was based on the skills, attitudes and knowledge that fosters active learning, curiosity, engagement, playfulness and resourcefulness to transfer their ideas into tangible artefacts.

How sustainability and especially Circular Thinking approach, can be added to STEAM renamed as STEAMS was explored. STEAMS is a project-based approach to create artefacts made from reused, repurposed or repaired objects. Young children were given the opportunity to wonder and explore technological skills such as electric circuits, multimedia, tinkering and engineering computational thinking, creativity, communication, collaboration and critical skills. The aim was to make the new generation in Mexico curious about Circular Thinking by using Maker Mindset and e-waste to recycle and turn it into profitable products. An 'Innovation Lab', a team of engineers and mechatronic based on the maker principles, worked collaboratively to reuse different parts of the e-waste. The Eco-Maker store developed 'EcoMakerKits' from e-waste parts to build a range of products. These were shared with the educational community through donations campaigns, students, teachers and the extended community. Fan Maker Kits' were donated to teachers interested in STEAMS education and have been used for activities in 147 schools with 219 kits in 24 of the 32 states across Mexico. The focus was on a range of hands-on learning activities and workshops, where children fostered their curiosity and expanded their Maker Mindset through hands-on learning based on the concept of reusing e-waste materials and Circular Thinking.

6 Playful Learning by Design in Kenya: Remote Development of Design Education for Rural Kenya

Marten B. Westerhof, Mathieu Gielen, Annemiek G. C. van Boeijen and James Otieno Jowi

The chapter recounts the development of design-related skills for primary children in in non-formal contexts of community centres in Rural Kenya. This was in collaboration with the Dutch Design School (IDE) at Delf University and a local Kenyan non-profit organisation. It required rethinking design education in specific cultural and economic contexts. Travel restrictions due to the Covid-19 pandemic enforced a remote development process. In West Kenya, a local community centre run by Sustainable Rural Initiatives (SRI) developed the programme.

The community centre had workshop facilities for craft for woodworking and tailoring and a facilitator was available to support the children's learning. Workshop instruction guides and supporting videos were developed the initiative and a Masters student was available to develop

a design education format, focusing on creative problem solving and communication. Designing and making toys their own toys would motivate the children to replace their current imported toys with ones that reflected their own cultural identity and individual play preferences. Plastic was replaced by more sustainable locally sourced materials and the project ran for five months.

A rather different approach was taken later, and the workshops were divided into three distinct phases of exploring, building and presenting. In the first a topic was introduced and explored through questioning to develop conversation between the children. In the second phase the children gathered the materials they wanted to use to build their final product by testing and iterating their ideas. In the final stage the children presented their designs to each other and explored the diversity of the possible solutions. A further sequence of several workshops was developed where the children expanded their activities to explore different approaches, tools and materials that they could use in different contexts and circumstances.

7 Connecting Maker Education in Secondary School Technology Education in Korea: A case of the Technology Teachers' Learning Community in Republic of Korea

Hyuksoo Kwon

The chapter described trends and examples for maker education in South Korean technology education with specific reference to technology teachers' professional learning communities. Four themes were drawn from the qualitative analysis of interviews with four technology teachers, sharing and communication; being makers; technology teachers as practitioners for maker education and diffusion and movement. MAKERS, a technology teachers' professional community focused on sharing and communicating to share experiences in both hardware and software.

The core idea of the innovation was learner centred participation. The Korean government had introduced the philosophy of maker education into the school curriculum and teachers had shown great interest in a problem-solving approach centred on hands-on activities. Technology education was one of the national curriculum subjects in elementary and middle school and each provincial office of education had various types of school maker spaces with student-centred activities. 3D printers and software were introduced.

Case studies of maker education included a professional learning community (MAKERS) run by technology teachers in Seoul, the capital of South Korea. Teacher community meetings helped spread the making culture though research, workshops, seminars and MAKER websites. Four themes evolved *Sharing and communicating* through regular sharing meetings and workshops; *We are makers* where technology teachers have developed community meeting and workshops with project-based activities such as a Maker-A-Thon; *Teachnology Teachers as Practitioners of Maker Education* where technology teachers base their activities on design thinking and problem solving from real life and *Diffusion and Movement* based on the concept that Maker education is a good opportunity to promote the value of technology education in schools.

8 Case Studies of Maker Education in China

Jianjun and Qiuyue Yang

Maker Education and the promotion of lifelong learning for all people in China had recent extended and developed due to the vision of the government, society and educational reform. A new educational model that integrated the spirit of creativity into teaching practice had been

developed by the Tsinghua University iCentre. The chapter described the implementation of maker education at the higher educational level and at the basic education level. It explored and formed a new teaching model based on 'student-orientated, creator-driven, project guided teamwork and cross fertilisation'. The 'Manufacturer + Internet +Creative Space had built an open service platform and teaching system for creative, providing support in terms of incubation sites, technical training, product development, processing and production and management consultancy. It provided a more creative learning space for teachers, students and domestic and international entrepreneurs.

It was argued that Maker education is a life-long, whole person development that fosters individual DIY, sharing spirt and creativity to promote the cultivation of innovative talents. It is the ability to use creatively various technical and non-technical means to identify problems, deconstruct then, find solutions through teamwork and form creative artefacts. Inspired by the iCentre activities students at Tsinghua University, Tsinghua Makerspace launched club activities and DIY assemble kits suitable for children education's maker education. In this programme the children's practical imagination, co-operation and communication and other aspects of innovative qualities were fully practiced and improved.

9 Maker Education in the Applied Physics Bachelor Programme at Delft University of Technology

Freek Pols and Rolf Hut

Two mandatory courses based on Make Education as learning activities were included in the applied physics bachelor programme at Delf University of Technology. This chapter included a rationale for their inclusion, the associated learning goals and the need for a makerspace with readily available makertools. The design of the makerspaces was outlined, how this affected education and become part of the final project.

Creating Engineers was an objective at Delft University of Technology. Students may become scientist or engineers, but design skills are essential for physicists as though they may not build instruments themselves, they need to need to understand and know about what will be needed and how the final design or outcome will be evolved. The first- and second-year courses in Design Engineering for Physics Students (DEPS) aimed at teaching students the skills to combine and apply their content knowledge in designing solutions.

In the first-year course students gained experience in design approaches and in the second year the focus was on designing and building an instrument that measures a physical quality. The gained insights and learning were applied in a final project. It was discovered that there was an urgent need for dedicated rooms or makerspaces with tools and equipment for the students to develop their designs. One room, the Maker room was used for quick production of prototypes, another to the use of more conventional and heavy machinery such as CNC's and drills. The Assemble room was equipped with a single60W laser cutter, two tables with three workstations for soldering and general tools and equipment such as electronic test equipment. The introduction of a Makerspace offered chances to streamline design assignments before handling them in. Students were introduced to the final project, expected to pick one of their ideas and present it to a physics teacher and make any changes before finally beginning work on their project. They also have meetings with a teaching assistant. This clarified that *they* are working towards and building a project *they* choose themselves. Working in the Makerspace

had allowed students to work with proper tools throughout and develop a greater sense of ownership. The students presented their demonstrations during a science fair to former physics teachers and university staff.

Part 3 Thematic Reflections

In the following chapters Maker Education was viewed from a range of perceptions by authors from around the world.

10 Maker Pedagogy

P. John Williams

This chapter examined and discussed the pedagogy of the makerspace case studies though a framework of rationale, aims, content activities, resources, teachers' role, collaboration, where and when and assessment. It concluded that there was significant diversity, and it is 'concrete action learning' that fundamentally unities them.

11 Dynamitic Roles of Materiality in Maker Education

Varpu Mehto and Kaiju Kangas

The perspective of materiality was explored in this chapter. It was believed that the maker not only learns about the material world but is also taught by it and that material perspectives enrich what matters in learning and how to live well within the world.

12 Social Learning: Does Cooperation Contribute to the Learning of Makers?

Wendy Fox-Turnbull

This chapter explored the scope and nature of social learning found in the case studies and Makerspace learning, where the learner is central in constructing artefacts. It argued that its collaborative nature and the need for learners to become critical thinkers and makers, ensures that learners today are equipped with the necessary skills and dispositions essential for life in the 21st Century.

13 Reflections on Maker Education as a Potential Context for the Development of Spatial Ability

Jeffrey Buckley

In this chapter the case studies were reflected upon through the lens of their ability to increase learners' level of spatial ability. It was argued that shared discourse between maker education stakeholders, can lead to significantly improved practice in terms of individual learner's spatial and societal outcomes.

14 Making in Informal and Formal Settings

Gerald van Dijk and Elwin Savelsbergh

This chapter welcomed the fact that maker education is increasingly finding its way into informal and formal educational settings. It reflected on the case studies through five lenses, the development of maker identity; what is being learnt; what drives learners, what is motivating; the value of working with tangible objects and different materials and ways of sustaining making in education. The crucial role of the teacher as a maker in creating and inspiring high-quality learning experiences was noted across all the settings.

15 Sustainability of the Case Study Maker Education Initiatives

HildaRuth Beaumont (formerly known as David Barlex)

The chapter began by providing examples of educational reform in the UK that were used as a framework to examine and explore the sustainability of the case studies. Following a scrutiny of each of the case studies, it identified three requirements that need to be meet if these and future initiatives were to become sustainable. These requirements were continued perceptions of worth by key stakeholders, continued funding and professional development for those responsible for implementation.

16 Conclusions

Marc de Vries and Remke Klapwijk

This final chapter drew together the insights from all the previous chapters. It discussed how the appreciation of making is related to a worldview in which the materiality of reality and a certain view on mature and human features. It was concluded that there was a need for further research into maker Pedagogical Content Knowledge with teachers. With teachers being well equipped to do making activities, there is lasting value of Maker Education, both in schools and elsewhere.