

## CHAPTER 12

# Social Learning: Does Cooperation Contribute To The Learning Of The Makers?

Wendy Fox-Turnbull  
University of Waikato  
[Wendy.fox@waikato.ac.nz](mailto:Wendy.fox@waikato.ac.nz)

### Abstract

This chapter explores the scope and nature of social learning evident in the Makerspace movement as identified by the cases studies presented previously. The makerspace movement is clearly situated within a constructionist paradigm, placing the learner centrally in the construction of artefacts. Because of its collaborative nature and the need for learners to become critical thinkers and makers Makerspace is well situated to ensure learners today are equipped with the necessary skills and dispositions essential to life in the 21st century.

This chapter draws on literature on three learning theories particularly relevant to makerspace philosophy. The first, Kolb's Experiencing Learning theory, providing an excellent mechanism for teaching and learning design-based activities while placing learners at the centre of learning. The second, Social Learning Theory, describes the process of collaborative practice in a common activity with the aim of reaching an intended goal. Bandura suggests that Social Learning theory emphasises synthesis of behavioural events and human cognitive processes. This is relevant to makerspaces through the collaborative nature of design and development of artefacts-technological products and systems. The third theory is Social Partication Theory and draws together both learning through experience and learning socially and is therefore most pertinent to the Makerspace movement as it gives equal emphasis to working collaboratively and learning through doing.

To identify and discuss the scope and nature of social interaction, a modified version of Bronfenbrenner's Ecological Systems Theory is applied. This Ecological Systems Model is modified to organise a discussion on the social interaction within the Makerspace case studies. Selected for its layering and spheres of influence the model gives a framework for the types of social interaction evidenced in the cases. In this section the cases presented are organised according to The Ecological Systems Model and categories in relation to their influence on learners.

## **Keywords**

Social learning, Collaboration and Cooperation, Makerspace, Ecological Systems Model

## **Introduction**

This chapter provides reflection on the case studies in the previous section in relation to aspects of social learning. Makerspaces are workshops that facilitate creative and technical endeavour for individual tinkering, social learning and group collaboration on innovative technological projects (Schrock, 2014). They are extremely collaborative environments, modelling the practice of scientist and technologists. Often the true benefit of makerspaces is in the process, rather than the product (Harrington, 2019). The makerspace phenomenon draws on and facilitates a number of aspects critical to success in education in the 21st century (Hatzigianni et al., 2021; Rayna & Striukova, 2021), three of which inform this chapter: learning through participation in concrete experiences- experiential learning (Kolb, 1984), the role social interaction plays in the learning process- social theory (Bandura, 1977) and Social Participation Theory (Zewde, 2010). This last theory draws together learning through experience and learning socially. Thus an explanation of Social Participation Theory and its relevance to the makerspace movement is presented leading onto commentary about role of and aspects of social learning evident in the provided case studies. Due to the collaborative nature of makerspace social interaction plays a significant role in learning.

## **Social Interaction in Educational Activity**

Social interaction is a vital component of participating in collaborative projects. Vygotsky's (1978) Constructivist Learning Theory suggests that students learn through interaction with others and their environment. According to Vygotsky there are two critical but opposing tendencies at work in social interaction- Intersubjectivity and Alterity. Intersubjective dialogue occurs between novice and expert, with the aim to reach a shared definition to assist the novice to a state of independence. In the makerspace context an expert may be an assisting adult or alternatively it may be one of the participants who is particularly knowledgeable and skillful in aspects of the project. It is therefore feasible to imagine the 'expert' role shifting within and across participants and projects.

Alterity occurs when discrepancy or conflict occurs between participants ideas, views and understanding, thus it is concerned with the distinction between one's thoughts and that of others'. In collaborative practice, common in Makerspaces participants, if they are to successfully design and develop outcomes with peers need to share common understandings of their way forward. When there are conflicting ideas, change must occur for some or all participants, thus sparking cognitive development (Babrow & Kuang, 2022; Daniels, 1996b).

Intersubjectivity and Alterity go hand-in hand in the Makerspace context because understanding of others' thinking and knowing during

collaborative practical engagement in developing designed solutions is absolutely necessary. In this space the immediacy of talk and resulting cognitive restructuring is highly desirable.

Interaction between people is a central aspect of cognitive, social and cultural development within a constructivist paradigm. As people interact, they construct their world. Joint problem solving uses debate as a major force in cognitive development (Daniels, 1996a). Constructionism Theory builds on Constructivist Theory by suggesting that deepest learning occurs if learners are constructing something that others will see, critique, and perhaps use (Papert & Harel, 1991). Hence 'doing and talking together' facilitates the potential for powerful learning. Makerspaces are intentionally designed constructionist spaces where young people can design and share projects using 'high tech' and 'low tech' resources and materials while working alongside others (Halverson & Sheridan, 2014; Peppler et al., 2016; Sheridan et al., 2014).

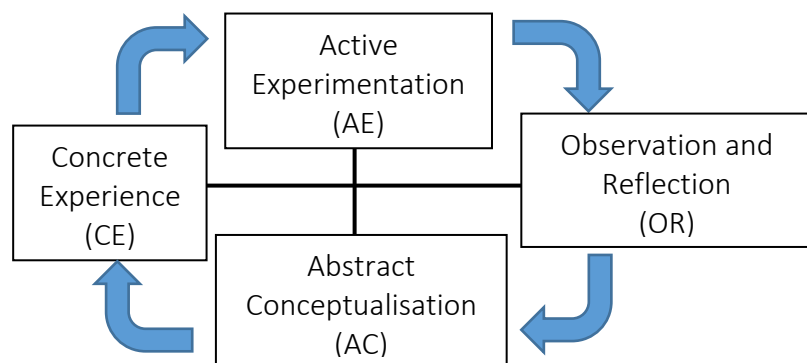
Discussion that takes place during educational activities is dialogue. Dialogue is complex and dynamic, often involves very different cultures, perspectives, ideas and people, and therefore is much more than just talk (Shields & Edwards, 2005). It generally involves the use of words and requires engagement with people (Mercer & Hodgkinson, 2008). During dialogue, the speaker considers the listener's response giving insight into potential variability of meaning. When listener's response aligns with the speaker, understanding in the conversation is enriched (Babrow & Kuang, 2022; Barnes & Todd, 2021). However, when the listener's understanding differs (alterity), the speaker may sense resistance. Beliefs, values and attitudes inform the way people act and interact, however these are not static but change as people read, experience, observe and adapt to new situations. When people collaborate in problem solving situations they 'inter-think' and are able to combine shared understandings, skills and knowledge in creative ways often reaching outcomes well above the capability of each individual (Mercer & Dawes, 2008; Mercer & Littleton, 2007). Problem solving situations involve a dynamic engagement of ideas with dialogue as the principle means to establish shared understanding, testing solutions and reaching agreement or compromise. Dialogue and thinking together are important aspects of life-long learning. Given the collaborative nature of problem solving required to develop technological outcomes designed in makerspaces, the implications are clear. Social dialogue coupled with concrete experiences have a huge potential in assisting people to learn and flourish.

### **Experiential Learning Theory**

The Makerspace movement is practical in nature and is a space and an approach where participants can go to design and make, not always using digital tools (Hatzigianni et al., 2021). Although the makerspace movement is a reasonably recent phenomenon, the idea of learning through doing is not. It has its roots in the understanding that experiences facilitate learning and assists the learner to transform themselves and their environment (Durkheim, 1956, 1984). Abdulwahed and Nagy (2009) suggest that Kolb's experiential learning model provides an excellent mechanism for teaching and learning

design-based activities. Kolb (1984) promoted experiential learning as a successful pedagogical model within which the learner passes through a series of four stages of a learning cycle. Zewde's (2010) modified version of Kolb's experiential learning cycle (Figure 1) begins with the learners' participating in conceptualising and understanding the issues at hand- Abstract Conceptualisation (AC), then subsequently engage in concrete experiences- Concrete Experience (CE). Students move freely into experimentation with new ideas- Active Experimentation (AE) and either accept or reject key ideas. This involves reflection, observation and registration- Observation and Reflection (OR) of the key ideas gleaned from participation in the concrete experience leading to full conceptualisation and accepting- Abstract Conceptualisation (AC) of new ideas developing participants with richer and more advanced knowledge and skills, including the adoption of new materials and technologies. Models are designed to be simple and represent a clean version of reality. In Makerspace as within any technological practice reality is messy as participants revisit and jump forward as their thinking develops. To add to this complexity the cycle may be used multiple times on one or different aspects of a single project.

FIGURE 1 Zewde's modified version of Kolb's Experiential Learning Model



### Social Learning Theory

Social learning is defined as the process of collaborative practice within which participants work and learn together through participation in a common activity or process with the aim of reaching an intended goal (Rosenthal & Zimmerman, 1978). This is hardly surprising; humans are instinctively social beings, and can attribute their success as a species on their ability to work and learn together to achieve common goals such as when hunting for food or building shelter. Collective survival depends on society's ability to learn and adapt to our changing environment (Zewde, 2010). Social Learning Theory emphasises a synthesis of behavioural events and the human cognitive process while paying particular attention to social variables (Bandura, 1977). Dunn (1971) states "social learning is an essential component of the absolute goal of life" (p181). Social learning theory recognises that socioeconomic development is a cumulative evolutionary process that builds on lessons from each

practical experience (Zewde, 2010). Dewey (1951) states that the social process consists of all activities by any of a group's members.

Social participation in projects goes beyond the using of materials, and receiving and following of instructions- this is complying. Participation centers and engages people as learners, thus enabling and empowering them to learn, to conceptualise and undertake a range of related tasks. Bandura (1977) identified that cognitive development and external stimuli operate in a reciprocal relationship within an ever-changing environment. Human behaviour is contingent of individuals' response to their environment and to others. This is constantly changing as a result of the actions of all those involved (Babrow & Kuang, 2022; Rosenthal & Zimmerman, 1978). Experience is a critical part of social learning, thus the two theories are linked. Due to the physical and collaborative nature of makerspace both the above theories go some way to assisting our understanding of the programme's success. However, Participatory Social Learning Development (PSLD) theory appears to combine both the above theories and is also well situated to help us understand the makerspace phenomenon.

### **Participatory Social Learning Development Theory**

PSLD theory emerged in the early 1970s as social learning theory as described above. It views socioeconomic development as a continuous process of experimenting by doing and learning both individually and collectively (Zewde, 2010). Zewde (2010) added 'participatory' to ensure that participants are the agents of their own development. Through experiences, reflecting, absorbing new ideas and technologies, concepts are transformed into purposeful action, providing meaning, which facilitates constructive use of ideas in the interest of individuals and society's social and economic needs (Zewde, 2010). PSLD offers a valuable merging of both experiential learning and social learning theory as it situates learning within social activity.

### **Participatory Social Learning Development in Makerspace Cases**

In makerspaces, Kolb's concrete action would be manifest in designing and making technological outcomes, sometimes digital in nature and working collaboratively with peers and experts. This is evident in each of the cases as identified below.

Westerhof and colleagues in Chapter 6 describe a series of workshops undertaken by elementary students in rural Africa. Although the students worked individually to design and create their own outcomes social interaction and collaboration were particularly obvious in the first and third phases of each workshop. In the first phases the students explored the topic and their ideas through the asking of questions of the workshop facilitator (expert), leading into student discussion about key ideas of the identified context for each workshop. In the third and final phase of each workshop the students presented their designs to each other, thus identifying, and celebrating diversity of ideas.

Gu & Yang in Chapter 8 describe two cases, the first case a makerspace facility situated within a university that caters for primary and secondary school

children as an 'outreach' facility and the second makerspace activity taught in a middle school specialist facility. Both cases aim to focus on social development of the whole child, thus facilitate opportunities for students to be innovative and creative and to solve real-life problems. The role of social interaction is implied both cases. In the university case student teachers are trained to work with students thus developing their interpersonal skills. In the second case set in Tianyi Middle School students again work and are assessed individually, however communication with teachers plays a large role in the activity of designing and developing LED lamps.

In Chapter 5 Nuñez and colleagues' recount of maker education using e-waste to stimulate the maker mindset and circular thinking in a Mexican context provided opportunity for young children to build their technical skills and act on a global issue: electronic waste, thus highlighting the importance of reusing, repairing and repurposing technology and materials. Students aged 10 to 13 worked with a retired engineer (expert) who was the workshop facilitator and undertook series of five activities based on the 5E (Engage, Explore, Explain, Elaborate, and Evaluate) model. The first, second and fifth activities were done individually and focused on grasping the conceptual understanding of what 'Circular Economy' is with the assistance of the expert. Critical thinking and communication skills were practiced in this workshop. The third activity focused on creative and tinkering skills to create an original outcome representing the concept of 'Circular Economy'. The learning goal of the activity series was to practice the 21st century skills of creativity, collaboration, communication, and critical thinking. Throughout the five activities students worked in self-selected sex-based teams of two and with their 'expert' facilitator to meet the session goals. Of particular note in this chapter is the prominence of discussion facilitated by the 'expert'.

Pijls, Van Eijck and Bredeweg in Chapter 4 present a number of vignettes all of which show evidence of collaboration. The first five describe a safe community space in public libraries for children, aged from 8-12, from low socio-economic families to design and make both digital and material outcomes. Although children frequently work on individual projects a number of them talked about sharing ideas and getting assistance from both the makerspace coaches and other children in the programme and sharing their new learning with their families. Pijl et al.'s chapter also reports on the setting up and support of this makerspace movement (Maakplaats021). This involved the development of a training programme for library staff to become the makerspace coaches, mentoring of student teachers to assist the makerspace coaches, developing both technical and pedagogical skills of the coaches and collaboration within the community to establish and maintain this library based programme.

In Chapter 9 Pols and Hut's case is situated in the tertiary space bachelor's programme at Delft University, The Netherlands. Their first-year learning outcomes include student success in the design, realisation and testing a physical apparatus or manufacturing or measuring process and the ability to cooperate and work effectively in groups. In their second year, learning outcomes also indicate collaborative design as successful students will be able

to design and devise an instrument that measures and digitally stores or displays a physical quantity, make 2D (vector) and 3D models, and work effectively in small groups.

Kwon's Chapter 7, situated in South Korea, presents an investigation into the technology teachers' professional learning community for maker education. The four themes drawn from the study clearly illustrate the social and participatory nature of the Makerspace movement from a teachers' perspective. These are:

- *sharing and communication*, technology teachers are makers, and practitioners who share ideas and learn from each other,
- *diffusion and movement*, technology teachers' professional learning community is focused on sharing and communication of ideas,
- *experienced makers and collaboration*, thus presenting a balanced interest and practical ability in both hardware and software parts,
- *active*, teachers are active in practicing and spreading the philosophy and practice of maker education and technology education.

In chapter 3 Kanstrup et al, focus on the participatory aspect of the Makerspace movement. They indicate that participatory design aims to give voice to those affected by the result of the design and that they benefit. This chapter also focuses on empowering technology teachers and principals to set up and sustain a makerspace practice within their school or communities. The study identified six steps to this process within which social participation is obvious.

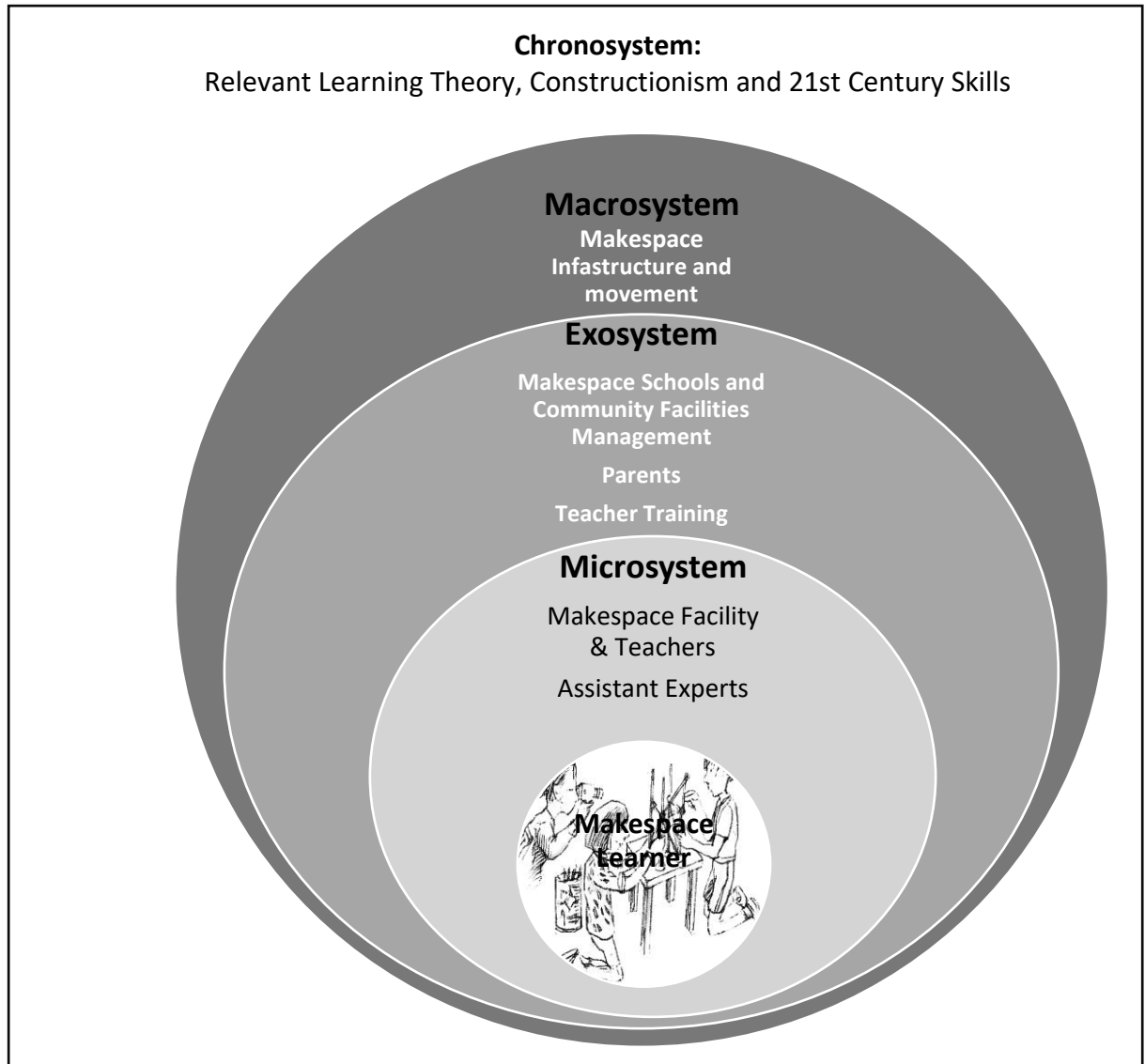
The first involved the participants understanding the complex nature of the makerspace initiative. An existing makerspace manager (expert) outlined ongoing initiatives, facilitated a discussion about makerspace gave a tour of an existing facility enabling participants to talk to existing teachers. This activity culminated in the collaborative design of a community-based training facility shared within and across schools and their local communities. In the second step teachers participated in a collaborative makerspace activity, thus facilitating their undertaking of design process which focused their understanding of the central role collaborative learning plays in this space. This session culminated with a facilitated discussion of the role of teachers in the makerspace movement. The third step presented a state-of-the-art overview of research followed by a facilitated discussion to situate maker education within the broader political landscape from a macro perspective. The fourth step involved school staff and external partners and represented a shift into the micro space within which participants reflected on and design the ideal makerspace, share with colleagues from the same school community collaboratively developed a strategy for implementation. In this session, participants also learned to communicate convincingly their initiatives. The fifth step involved each group presenting the implementation plan to other groups present and a higher ranked education official aimed at local policy and obtaining structural support. The sixth and final stage involved receiving practical insight by the visiting of another makerspace focusing on the practical, such as equipment purchased, safety and maintenance, relevant regulations, challenges and opportunities experienced by the makerspace. This visit

concluded with a few practical activities aimed to help participants' evaluation of resources. The session concluded with a collaborative representation of their implementation plans, with adjustments made and collaboratively identified how their plan could be applied to their initiative.

### **Types and Levels of Social Learning Across the Cases**

The above section identifies the social and collaborative aspects within Makerspace and in each of the cases. Now let's look closely at the nature and scope of social learning evident across the cases. Using Rosenthal and Zimmerman's (1978) definition of social learning as the process of collaborative practice within which participants work and learn together through participation in a common activity with the aim of reaching an intended goal, this section explores specific aspects of social learning evident in the cases. A modified version of Bronfenbrenner's (1979) Ecological Systems Theory (Figure 2) is used to frame this section. This model was originally developed to show how each aspect of a child's environment influences their development and how aspects impact each other. It is modified for this chapter to organise discussion related to social interaction with the makerspace movement. The learner is the central component in both Bronfenbrenner's Ecological Systems Theory and the participatory and social learning theories mentioned previously this chapter.

FIGURE 2: Makerspace through a Modified Bronfenbrenner's Ecological Systems Theory



Four of the cases presented: Chapter 6 *Westerhof et al.*, Chapter 5 *Núñez et al.*, Chapter 4 *Pijls et al.* vignettes 1-4 and *Gu & Yang's* Chapter 8 -second case are situated within classroom or community training programmes for school-aged children. They sit within Bronfenbrenner's microsystem of influence because the children are the primary learners who have numerous layers of influence encompassing them including their teachers, makerspace coaches, community hubs such as libraries and schools and the wider system that educates them including education policy makers. The Chapter 9 *Pols & Hut* is set in a tertiary setting and also occurs in Bronfenbrenner's microsystem of influence with science and engineering students. It is somewhat unusual to apply Bronfenbrenner's Ecological Systems Theory to tertiary students as it usually refers the development of younger child, however the students in this case study are the 'primary learners' who also have other layers of influence on them- their lecturers, the university and the wider tertiary education system, just like their primary and secondary school aged counterparts.

The *Kwon* chapter, Chapter 7 and *Pijls et al.* vignettes 6-8 are set in the makerspace teachers and coaches professional learning community, thus situated in the Exosystem. *Kwon's* chapter describes technology teachers as maker practitioners and *Pijls et al.* discuss the training of their makerspace coaches along with some student teachers who complete a practicum in their makerspaces thus both sitting just beyond the microsystem. *Gu & Yang's* Chapter 8- first case is interesting. On the one hand it is situated within the Exosystem as it provides teacher support to teach students in makerspace activity, thus outside the immediate circle of influence for primary learners. However, students are also present in this case study as they are brought into the facility to participate in makerspace activity, thus situating it in the Microsystem. Thus illustrating that cases may not be situated exclusively in one of Bronfenbrenner's systems, but span across them.

The Chapter 3 *Kanstrup et al* presents a model for establishing and sustaining the makerspace infrastructure and is situated within the macrosystem of influence as it founded on common overarching values and beliefs about makerspace education. Chapter 2 *Gu & Yang* describe the makerspace developments within China and is also situated within Bronfenbrenner's macrosystem as it discussed the movement development in China, however it could also be situated in the Chronosystem. The Chronosystem is defined as life transitions and sociohistorical events, and is relevant as it recognises the need for nations to have all citizens well equipped for life and economic development in the 21st Century and beyond, which drives the makerspace movement. In Chapter 2 *Gu & Yang* link the makerspace movement to China's historical and political ideology, thus straddling between the two outer systems. Another relevant aspect of the Chronosystem is education theory that underpins action and practice of the maker movement, thus discussion and consideration of relevant learning theories discussed earlier in this chapter are also situated within Bronfenbrenner's Chronosystem.

#### Social Interaction in the Makerspace Microsystem

This section draws on the case studies of *Westerhof et al., Pijls et al., Nuñez et al., Gu & Yang* and *Pols & Hut*. The first three involved children in community makerspace facilities. In the cases of *Gu & Yang* Case 1 occurs in community facility situated in a university. Case 2 is situated within a school programme. *Pols & Hut* investigated the maker approach in a university setting for tertiary students.

At the Microsystem the social learning characteristics underpinning teaching and learning occur from the simple transmission of information such as when giving instructions to a higher level thinking and engagement such as when students design, construct, reflect and evaluate their performance and achievement. As Einarsson and Hertzum (2020) suggested makerspace activity starts with the transmission of information, which is usually structured around the giving of detailed instructions. In our cases transmission of information occurred for the giving of instructions. This usually occurred face to-face but in some cases via video, thanks to the COVID-19 global pandemic. Safety instructions were also given via transmission in the *Pols & Hut* case. In their

study Rayna and Striukova (2021) identified the teaching of safety skills were the only skills specifically mentioned by all their participants. Explanations of the status-quo and the setting up of the authentic context to be studied also occurred through direct transmission of information in all five cases within the microsystem. Some of the students in these case studies were also involved in listening to explanations of recognised experts. The transmissive phase of the process assists with Abstract Conceptualisation stage of Zewde's (2010) modified version of Kolb's Experiential Learning Model.

Once underway activity involved collaborative play, tinkering and designing and making for the students some of which was quite structured and others more iterative. This approach saw the participants agents of their own learning in line with PSLD (Zewde, 2010). In both the Gu & Yang cases students are involved in creative problem solving to develop a range of outcomes. In the Nunéz case students were encouraged to become agents of change through consideration of Circular Economy thinking. Their groups consisted of people with varied skills. Aligned with constructionist theory (Papert & Harel, 1991), students collaboratively designed, explored and developed artefacts to meet the identified issue or problem. In Pols & Hut case time was spent developing a collaborative culture to ensure students were able to work successfully together. In Pijls et al. case vignettes 1-4 students worked individually however they also interacted with their peers for assistance and feedback. Rayna and Striukova (2021) state that a range of collaborative and cooperative skills are developed through the makerspaces, however conscious effort is needed to do so. In this phase the Concrete Experience and Active Experimentation stages of Kolb's experiential learning model were met.

Continuing the Active Experimentation stage, another key aspect to students' social learning in the makerspace in the microsystem involves a higher level of thinking through teacher questioning, critical debate between students and with their teachers to facilitate critical problems solving and developing empathy of those who are impacted on the issue in hand. In the Pols & Hut case teachers took a Socratic approach to their questioning, encouraging students' critical thinking about their own and other's ideas. In Nunéz et al. students explored circular thinking in relation to environmental issues. Snape and Fox-Turnbull (2013) and Fox-Turnbull (2003) identified the importance of authentic contexts within technology education to enhance students' learning.

Aligning with Kolb's Observation and Reflection stage, the final phase identified in each of the cases at this level involved the students presenting their outcomes and reflecting on their process and practice. In PSLD reflection is considered a critical component of social learning (Zewde, 2010). Even when students work as individuals as in this phase, there is a social element to it. The very nature of presenting design ideas and outcomes to others is social. When working collaboratively this is obvious. Teams need to work together to identify what and how to present their outcomes. They may well share the task. When working individually aspects of social learning are less obvious, however as in Gu & Yang's cases presenting to others needs consideration of audience. Individuals also need to be aware of and acknowledge those who have assisted

them and or are impacted by their designed outcomes, such as stakeholders. In constructionism the sharing of designs and design ideas plays a pivotal role in students' learning. The sharing and talking about designed artefacts that are personally meaningful facilitates a deeper understanding of materials, ideas and construction possibilities (Keune et al., 2019).

#### Social Interaction in the Makerspace Exosystem

This section draws of the case studies of *Kwon*, aspects of *Gu & Yang's* first case and *Pijls et al.'s* vignettes 6-8 as they are situated in the teacher professional space, one level removed from the individual students' learning. In *Kwon's* case cooperation and sharing are two foundational beliefs that underpin maker education in South Korea. Teachers in the learning community at the focus of this study played a leading role in the field of maker education in Korea. The case is situated in a movement aimed at spreading the making culture. In the initial stages this group held regular meetings, seminars, and lectures. This involved transmission of knowledge as in the microsystem above and also situated the Abstract Conceptualisation stage in *Zewde's* (2010) version of Kolb's Experiential Learning Model. Participants were assisted in the identification of a common understanding and purpose for makerspace education.

In these meetings teachers were given opportunities to talk about issues and difficulties encountered and explore and develop solutions together. This provided opportunity for learning not available at universities or teacher education institutions and illustrates a shift to Kolb's Concrete Experience stage as teachers explored concrete ideas and solutions to their issues and difficulties. The open sharing in this phase motivated participants to reciprocate the assistance received. Teachers reported that they became makers themselves in their communities by designing, developing and conducting workshops and voluntary professional development sessions for others, thus moving through to Active Experimentation of learning shared and gained at the seminar series. Subsequent meetings also provided teachers opportunities to reflect on and share their experiences both from classroom teaching and their assistance of others (Observation and Reflection phase). Aspects of *Gu & Yang's* first case are also situated in the Exosystem as it describes a team of people who provide a platform for training tertiary students in makerspace education. At this level the team at the Tsinghua makerspace facility worked collaboratively to design and develop skills training, plan and implement 'creator marathons', develop tools for brainstorming and facilitate the use of expert guests to share their ideas to broaden their students' horizons. In addition they have incubated many projects for students. In providing this range of activities and tools they facilitate a journey through Kolb's Abstract Conceptualisation, Concrete Experience and Active Experimentation stages for the school and tertiary students who come into their centre. They also engaged in observation and reflection when evaluating and critiquing their programme for future improvements. The *Pijls et al.'s* latter vignettes have an underlying theme of pedagogy as they focus on developing professional skills and knowledge of the maker coaches and student teachers. Coaches used

reflection and experimentation to consider and develop effective strategies for facilitating their workshops, thus they were also situated across Kolb's Abstract Conceptualisation, Concrete Experience and Active Experimentation stages. Harrington (2019) suggests that when some people participate in maker communities their main motivation is to be and for others just to make. In these cases collaboration and the formation of learning community are emphasised. Collaboration and communication amongst participants leads to improved outcomes and increased capability.

### **Social Interaction in the Makerspace Macrosystem**

This section draws on the case studies reported by Kanstrup et al. Chapter 3, and Gu & Yang's Chapter 2. Both are situated in Bronfenbrenner's macrosystem. Kanstrup et al. propose a framework for the development of a sustained robust makerspace infrastructure in Denmark with a focus on the sustainability of makerspace infrastructure. This case used the Scandinavian PD approach to makerspace development which emphasises direct and continuous involvement and voice to stakeholders. The case describes a six step framework leading towards sustainability of the makerspace initiative used in eleven workshops in eleven municipalities. Gu & Yang's chapter explores and describes the makerspace movement in China and its underpinning philosophy and purpose.

The paragraphs below use the Kanstrup chapter to illustrate Kolb's steps within the Macrosystem. Unlike the preceding two systems, where transmission of information in the early stage played a critical role in establishing a context, activity in the Kanstrup et al. case began with a brief explanation of vision and objectives, followed by discussion. The Abstract Conceptualisation stage continued with a sharing of knowledge and experiences within and between makerspaces and other infrastructural levels such as makerspace managers, school principals, municipal and government personnel. Movement into the Concrete Experience stage began with a tour of existing makerspaces where they interacted with teachers and students. The makerspace manager also shared meaningful student experiences along with technical and organisation requirements of running a space. After the tour participants collaboratively planned and shared a community-based training programme for their local makerspaces (Active Experimentation stage). This activity was situated within the constructionist paradigm as participants drew on their experiences to construct their plans. Keune et al. (2019) and Papert (1993) state that projects within a constructivist paradigm must be meaningful and present evidence of learning. The makerspace plans were both. The Active Experimentation stage continued through the second step presented in this case. Staff from participating schools who were not at the first workshop and from a range of disciplines experienced collaborative hands-on makerspace activity with the aim to developing their understanding makerspace's educational potential.

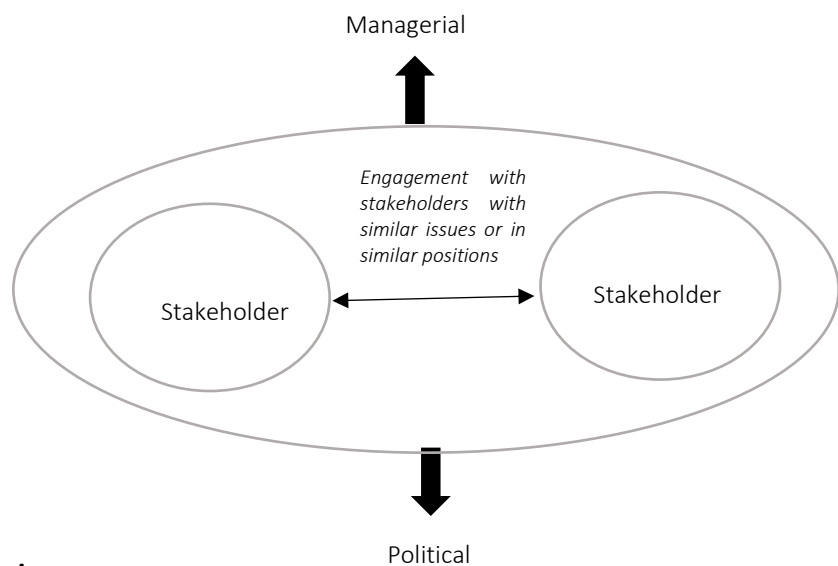
The third step in the framework moved into Kolb's Observation and Reflection phase as participants were presented with 'state-of-the art' overview of international research on maker education' followed by discussion aimed at

situating maker education with a political, economic and social context and developing shared understanding of makerspaces.

Step Four took all participants except the director of education through an activity asking individuals to reflect on their dream facility as individuals and then in small school/community based groups share, identifying, and discuss ideas. This included identifying existing and required resources, exploration of avenues of assistance and ultimately visually presenting ideas to other groups and their Director of Education. The fourth to sixth steps ensured participants were able to implement their planned makerspace within managerial, political, local, practical and physical constraints of each situation.

As we know PSLD states that participants must be agents of their own development (Zewde, 2010). Participants in this case study were agents of change within the macrosystem as each was assisted to action their planned makerspaces. There is little doubt that learning undertaken in this case was social in nature. Learning occurred within and across varied groups and levels of people as illustrated in Figure 3. Groups of stakeholders shared with each other, but also they were able to understand the political and managerial possibilities and constraints, thus ensuring a deeper understanding of developing and sustaining the maker movement.

FIGURE 3: A Macrosystem for Makerspaces



### Conclusion

All cases illustrated were examples of PSLD and involved learning aligned to experiential learning theory following Zewde's (2010) modified version of Kolb's Experiential Learning Model. The cases presented in this book clearly illustrate that cooperation and collaboration contribute to participant's learning and sense of ownership, not just within Bronfenbrenner's microsystem, at the classroom or makerspace level, but also across the exo and macrosystems. Learners at all levels were agents of their own learning. Working collaboratively, sharing ideas with others, presenting developed artefacts and reflecting on their own and others' outcomes.

All cases involved participants in designing, making and modifying outcomes, most collaboratively starting with Abstract Conceptualisation. It was interesting to find that most cases involved some direct transmission of information. Although not commonly associated with constructionist principles knowledge transmission played an important role in these cases. This is a timely reminder that constructionist learning does not occur organically without preparation and planning in makerspace facilities. Initial stages of any project within all systems requires transmission of instructions to assist the setting of the scene and has an important role in keeping participants safe. However it is clear from the cases that early transmission of information and instructions did not diminish participants agency or sense of empowerment; in fact it possibly enhanced it as transmission of information ensured all participants had the necessary information to be empowered learners and agents of change.

When undertaking makerspace activities participants were also engaged in the Concrete Experience and/or Active Experimentation stages, however the nature of activity differed across Bronfenbrenner's systems. In the Microsystem children and tertiary students designed and made artefacts. The Exosystem saw teachers engaged in makerspace activity with the aim of developing a shared understanding of, planning and implementing the makerspaces in their school or develop opportunity for professional development. Finally in the Macrosystem concrete experiences and active experimentation occurred to ensure the design and development of sustainable maker movement infrastructure and policy.

Sharing outcomes and reflecting on outcome success and failure was common to all cases, across all levels. In most cases aspects of observation and reflection were undertaken orally, through discussion and sharing, however in one case it was in the form of a written report. Observation and reflection enables participants to engage in dialogue through articulating their processes, artefacts and learning, thus talking together facilitates the potential for powerful learning.

In conclusion the cases presented in this book strongly indicate the important role social interaction has in the makerspace movement at all levels of participation and structural organisation. The nature and purpose of the social interaction changed across Bronfenbrenner's systems of influence on the learners central to the movement- our children. However what did not change is the impact social engagement had on motivation, empowerment and engagement for participants. This acts as a timely reminder of the value of social interaction has on practical learning and reminds us that rich opportunities for social interaction must be embedded in the foundations of all makerspace facilities, programmes and the movement as a whole.

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