Positioning educational makerspaces within schools serving low socioeconomic status students

Lou Lahana

Columbia University
Teachers College,
525 W. 120th St.,
New York, NY 10027
and
The Island School,
442 E. Houston St.,
New York, NY 10002
Email: Lou.Lahana@gmail.com

Abstract: Educational makerspaces are fertile grounds for students to develop innovative products infused with science, technology, engineering, art and math (STEAM) principles, and practice social action. Yet, rarely do these makerspaces prioritise such outcomes. Rather, they tend to revolve around the creation of novel artefacts using low and high technology. Drawing on field observations, interviews, and artefact analysis, this qualitative study explored the experiences of low socioeconomic students participating in a social action themed school makerspace. Based on a transformative research perspective, the teacher-researcher sought not only to infuse STEAM and social studies into student work, but to also address the 'participation divide', a term suggesting that students of higher socio-economic status have more opportunity to produce media creatively than their low-SES counterparts. Qualitative results indicated that students reported increased agency in effecting positive change in their world. Their creation process required extensive research and brought about social action within their communities. Their products included a cigarette smoke-detecting shirt, an edible bug stand, and handcrafted wallets and jewellery for the homeless. The study concludes with recommendations for the implementation of educational makerspaces in schools.

Keywords: educational makerspace; participation divide; social action; educational technology; middle school.

Reference to this paper should be made as follows: Lahana, L. (xxxx) 'Positioning educational makerspaces within schools serving low socioeconomic status students', *Int. J. Innovation in Education*, Vol. X, No. Y, pp.xxx–xxx.

Biographical notes: Lou Lahana has been a Library/Media Specialist and Technology Educator for nearly 20 years. He received his Doctorate in Education from the Teachers College, Columbia University with a specialisation in Instructional Technology and Media. He currently runs a social action-themed makerspace in New York City. As an active Teach for America alumnus, his work has always been located within low socioeconomic status schools. Therefore, issues of equity and access continue to be at the forefront of his approach. Students' social action products are viewable at http://Vimeo.com/channels/socialaction and http://twitter.com/TheTechbrarian.

1 Research problem

The maker movement within schools holds great potential for increasing youth engagement in science, technology, engineering, art and mathematics (STEAM), and social activism. Yet, much of the literature on educational makerspaces pertains to out-of-school-time (OST) programs (Sheridan et al., 2014). Studies involving school makerspaces remain limited and, in some instances, appear to prioritise short-term student engagement over content-area expertise, passion-based learning, and social action (Barton et al., 2017).

This work seeks to contribute to the limited body of research wherein students commit to long-term acts of Making that are academically rigorous and contribute to the betterment of their communities. It does so within the context of a low socioeconomic status (SES) student population that often lacks the technological resources seen in schools serving high socioeconomic students. To this end, the guiding research questions are:

1 What are the distinguishing characteristics of a school makerspace?

2 How do students perceive their work within this study's school makerspace?

3 In what ways can school makerspaces be further incorporated into the school day?

2 School makerspaces

School makerspaces differ from traditional makerspaces. Kurti et al. (2014, p.9) distinguished the former as harnessing "the same intellectual playground concept for the purpose of inspiring deeper learning through deep questioning." School makerspaces offer an alternative environment to those typically found in middle and high schools. Gershenfeld (2012) characterised them as a safe space for students *not* to follow directions, but to question assumptions – essential qualities of innovators. Unlike the discrete topics covered in standard 50-minute middle school class periods, School Makerspaces allow for iterations of a project over many class periods. They provide what Gee (2004, p.67) called an 'affinity space', where common interests and skills transcend age, class, and ethnicity, often leading to peer-to-peer teaching. Martinez and Stager (2013) noted that unlike the 'drill and skill' usage of computers commonly seen in elementary and secondary classrooms, educational makerspaces use computers as 'material' with which students can ponder, experiment, take risks, and satisfy their curiosity. Along with computers, students can 'tinker' with various high- and low-tech materials that may appear 'wildly mismatched', yet work in harmony to create meaningful STEAM-infused products (Banzi, 2011).

Yet the potential for makerspaces to transform learning in schools remains largely unfulfilled. Rather than serving to deepen the content knowledge of core subjects, school makerspaces often veer off into novel activities that provide STEAM-*related* activities. These activities rarely involve long-term projects that directly address the scope and sequence covered in a given subject area. Further, they tend not to be differentiated according to student preference for materials, themes, and approaches to creation. Finally, products created in school makerspaces seldom reach real-world audiences and

provide access to what Havlerson and Sheridan (2014, p.500) describe as 'empowerment and consciousness raising' opportunities.

Schools that commit to using makerspaces to forward these goals are particularly important when working with students of low-SES. Innovative learning environments that use technology as a means for students to solve problems and develop original work occur disproportionately in high- SES schools (Gomez et al., 2014).

Indeed, students in low-SES schools often use technology for repetitive tasks and simple memorisation, whereas their high-SES counterparts use information and communication technologies in education (ICTE) for simulations and deep research (Barron et al., 2010). Hargittai and Walejko (2008) described the disparity in opportunities for the creative production of media by low- and high-SES students as a 'participation divide', in which high-SES male students are statistically more active in creating and posting digital content than low-SES students. Compounding this disparity, low-SES students often lack home and community resources that provide the creative production experiences that do not occur in their schools. The result is students with profoundly different skills, knowledge, and habits of mind related to meaningful content creation at a time when those who wish to impact social issues must possess such qualities in abundance (Warschauer and Matuchniak, 2010).

3 Research context

3.1 Site and sample

Located on Manhattan's Lower East Side, The Island School serves approximately 450 children from pre-kindergarten through Grade 8. Students are primarily local project residents, with 100% eligibility for a free lunch. As of 2017, 47% of the students were considered homeless.

As a teacher-researcher within the school, my schedule included six middle school classes. It was not feasible to maintain detailed notes and conduct interviews with all classes. Therefore, I did a purposive sample of two sixth-grade classes. Sixth grade classes were chosen because they held the possibility for an additional two years of follow-up studies. Through critical case sampling (Patton, 2002), three projects were chosen for their capacity to explore the challenges and opportunities of school makerspaces. In choosing these cases, there were clear threats to both internal and external validities. Excluding less successful students' projects may have ignored important weaknesses in the learning environment and could hinder other practitioners from implementing a highly functioning classroom makerspace. However, given the limited number of studies involving classroom makerspaces, such challenges to validity were deemed acceptable given the benefits of studying the unique projects that were generated.

3.2 Researcher

Acting in the role of teacher researcher (Brindley, 2009; MacLean and Mohr, 1999) I have been a teacher at The Island School since 2001. First a librarian, I now run their educational makerspace. As a Teach for America alumnus, I am not only interested in the

potential of educational makerspaces to transform student learning, but also issues of equity in education.

4 Classroom structure`

Guided by a *social action* theme, this classroom makerspace employed a critical pedagogical approach to working with students (Blikstein, 2008; Duncan-Andrade and Morrell, 2008; Freire, 1970; Giroux, 2004). Such an approach regards students as protagonists whose mission is to identify social injustices in their world. Under a critical pedagogy, students and teachers work side-by-side to explore possible solutions. In many cases their roles are reversed, as students gain expertise in tools and content areas.

4.1 Research

Research played an essential role in my classroom makerspace. It added academic rigor to students' pursuits and guided their social action. My website, http://www.techbrarian.com, was constructed over several years and anchored their research. The site contained links to media such as videos, infographics, and serious games. Linked media were selected based on their ability to engage students, stimulate empathy for those affected by their chosen issue, and provide statistical data detailing the impact of the problem. No issues were 'off-limits' as long as students were well-informed and created products that did not violate the school's student code of conduct.

4.2 The role of technology

The role of technology in this classroom makerspace was as a 'tool' in service of creative media production and social action rather than as an end unto itself. Technology tools included low-tech equipment and materials like hammers, blenders, sheet metal, and rotary saws, while high-tech tools included Arduino microcontrollers, video cameras, and 3D printers. High-tech and low-tech tools were freely available and combined with one another as long as proper safety precautions were implemented.

5 Methods

Qualitative data collection methods included field notes, formal observations, formal and informal interviews, and a project rubric.

The section below details three case studies. Following the studies, prominent themes are discussed as well as recommendations for the implementation of makerspaces in schools.

6 Maddie and Meera: wallets and rings for the homeless

Both Maddie and Meera began their work in our classroom makerspace with a keen interest in the plight of homeless within their neighbourhood. Meera explained this interest as follows:

> "The reason I chose this social issue was because ... there's a lot of people in the streets and some people just walk by them and like giving them a dirty look; and I feel bad. So when I came to this class I'm like, oh, the first project I'm gonna do is the homeless project."

Figure 1 Meera handing a homeless man a wallet (see online version for colours)

Using techbrarian.com, Maddie and Meera researched the underlying causes of poverty and homelessness. Serious games such as http://PlaySpent.org allowed them to learn first-hand the hard decisions that can determine whether a person becomes homeless. At the same time, organisations like Lava Mae that provide showers for the homeless and Soul4Souls that donate shoes to the impoverished, inspired them to find solutions.

As a result of their research, Maddie and Meera decided to create a project that benefited the homeless in their neighbourhood. Maddie explained their project in this way:

> "Well, I [Maddie] made wallets and my friend Meera made rings. So we decided to make them for homeless people. We had a bake sale for the homeless people; which we raised enough money so we could put in the wallets."

Using a series of online tutorials, Meera had learned to create wire-wrapped rings the prior year and had become quite proficient. Through grant money, our school had funded the purchase of jewellery crafting materials such as wire, beads, and mandrels. Thus, Meera confidently reported:

> "I learned how to make the rings last year so I brought it into this year and I can make them really fast and make like one of them in five minutes if I have all the stuff.… [they are] one of a kind, you'll never see anywhere else. Not even from a professional person."

In contrast, Maddie did not possess the expertise or materials (e.g., sewing machine, cloth, buttons, etc.) to create the wallets. Fortunately, our afterschool program funded several teaching artists to work during regular school hours, one of whom was a tailor. I coordinated with the afterschool organisation to have the tailor visit the makerspace twice a week during the time Meera's class was scheduled. Occasionally, it was necessary to coordinate with Meera's other teachers to keep her extra periods to finish tutorial sessions. As a result of her work with the tailor, Maddie's sewing skills steadily improved. She became more independent and often worked with minimal guidance. Meera recounted:

> "In the sewing, I had to know how to make a straight stitch, and turn it inside out, sew the buttons and stuff like that."

Approximately two months after their project began, Maddie and Meera were granted time away from their other classes and held a school bake sale. Their goal was to earn money to place alongside the rings in the hand-crafted wallets. The bake sale was successful, bringing in nearly one-hundred dollars. Two days later, Maddie and Meera were ready to hand out their wallets. Parents and the administration granted permission and we weaved through the neighbourhood streets and parks. We encountered four homeless men on the street willing to receive the wallets and handed out the remaining wallets to a group of homeless men sitting on park benches. Maddie recounted the incident:

> "I feel so, so touched by the issue because when we were giving the stuff out one of the guys said, "Finally somebody really cares about the homeless." Then me and Meera were about to cry when he said that."

During a formal interview following the conclusion of the project, I asked Meera what challenges she faced while making the project. She responded:

> "Getting our teacher, our homeroom teacher, getting her to let us come downstairs. Because they wouldn't want us to be missing class work and stuff like that."

In the same interview, I asked Maddie to reflect on why she chose this project. She explained:

> "Because it makes me sad that I see a lot of homeless people on the floor. And a lot of people don't really care that they're there, but yet they're in your community. They're like your family; you should at least try and help. And most adults think that kids can't make a difference. Well, I believe and Mr. Lahana believes that kids can make a difference."

I then asked Meera how she would describe the makerspace to a friend:

> "I would describe it as a way you can express your emotions and be who you are and try to help save the world and prove grown-ups wrong that we can change the world. Because what they say is wrong. Some say that we can't change but we can make a big, big difference."

7 Sid and Walt: L.E.S. bug stand

Maddie and Meera's project was completely student generated. In contrast, Sid and Walt's bug stand project was the result of a more purposeful series of learning experiences that I coordinated. The prior year, I presented a short unit on entomophagy (the eating of insects). I explained that the eating of insects was practiced throughout the world and that entomophagy held great nutritional and environmental benefits.

To facilitate student learning in this area, I brought in various food-grade edible insects the prior school year for students to sample and cook with. Nearly all of the middle school students were greatly interested in practicing entomophagy, however two students in particular, Sid and Walt, demonstrated particular zeal for experimenting and filming their adventures.

To scale up their involvement and activism at the time of this study, I purchased a mealworm farm so that they could raise their own food. My field notes reflect:

> "Sid seemed a little lost at the end of the year and beginning of this one. But I remember how he liked eating bugs. So I did a speech about how we'll be using the mealworms for a bug stand, farming, and Styrofoam experiments [insects can consume styrofoam]. I said Samuel would be group leader. It worked. They spent the period weeding out and transporting the beetles with an apple slice, doing the Styrofoam experiment, and toasting the mealworms at varying wellness ... sprinkling them with salt. LOTS of kids tried it. Organic research occurred when I asked him what the black husks were. He looked up the lifecycle and told me it was part of the molting."

Figure 2 Sid and Walt and the L.E.S. bug stand (see online version for colours)

As recipes were refined and farming practices grew routine, I beefed up the entomophagy group's understanding of the social issue. My field notes reported:

> "Sid and Walt stayed for several periods doing solid research in order to make helpful info for the bug stand sign. I showed them the solutions page on [my website] techbrarian.com – under the category 'ending world hunger'. They perused the links for quite some time and Walt said, "I should take some notes …" which I thought was a great example of organic outcomes of passion-based research."

Sid appeared to have taken away a few lessons from his research. During a formal interview he revealed his grasp on the social issues surrounding the creation of his bug stand:

> LL: So tell me, why did you choose this project? Why this one with the mealworms?
>
> Sid: I chose this because many people in the world think that bugs are disgusting, and years and years ago many people was eating bugs, it was like the main thing. But say when farming first came to the world, it started spreading and spreading and now people thought bugs was gonna eat their farms and everything, and people started killing bugs. And also because it helps with global warming. I want to solve global warming because let's say cows; cows takes a lot of space, takes a lot of water, which we'll one day gonna run out of water. And like a mealworm, it doesn't even take that long for them to grow. Like a cow, the farms have like toxics in it that goes up through to the atmosphere, and that messes up for us. And so ice, the ice in the polars are melting and now the water's getting higher, and by the time we think of it the world will be flooded.

On a December morning, we prepared the food for the bug stand. I informally interviewed Walt:

> "So right now what we're doing is actually preparing to go outside […] and see the reaction of people who try the mealworms, and we have, so far we have egg that has mealworms and salami in it. Samuel tried it, he thought it was really good. We have Reese's and we're gonna put some mealworms, and then we got plantains, and smoothies."

We set up the bug stand next to the entrance of a subway station to catch the foot traffic in that area. Indeed, many people walked by. At first, the students' sales pitch fell on deaf ears. My informal interview captured a couple of the unsuccessful attempts:

> Sid: Free food everybody, free food!
>
> Ryan: Would you like to try our all-purpose edible insects?

Yet, before long, numerous samplers came and went. Below are two interactions students had with 'customers' (all the food was free):

> Sid: We've got smoothies, brownies ...
>
> Customer 1: This is a brownie, and this is a smoothie. Let's see. Hmm …
>
> Ryan: That's mealworm smoothie.
>
> Customer 1: All right, great. So you're from a school around here?
>
> Walt: Public school 188, if you go straight down, you'll see our school.
>
> Ryan: Oh, the reason why we're doing this is for a project of ours. Which we think is that some people are not daring enough to eat insects, which makes them pass by. So we want them to think that they're not gross because they're helpful for the environment and you.
>
> Customer 2: I'll definitely do it <eats brownie>.
>
> Walt: It's a very good thing for your digestive system, because it has lots of proteins also.
>
> Customer 2: I'll have a chicken. [Eats it and says to companion] It's so good, you should try them.
>
> Walt: Those are weaver ants and the small grasshoppers.
>
> Customer 2: Small? That's a small one?
>
> Rae: The big ones are like this, look [spreads fingers wide] ... this is the small cricket.
>
> Customer 2: All right, we're gonna make it happen. Oh boy. Oh boy. [Eats the weaver ants and crickets at the same time]
>
> Sid: Yeah!
>
> Customer 2: Oh, it tastes good.
>
> Sid: It tastes like sesame seeds, right?
>
> Customer 2: Tastes like sesame or sunflower seeds.
>
> Sid: Yes!
>
> Rae: He's the only one that ate everything, that tasted everything.
>
> Customer 2: I'm dedicated.

Two weeks later, in a formal interview, Walt reflected on how running the bug stand had impact him:

> "The reason why I feel different is because I actually helped people. That's like a good thing, because if you're just sitting around doing nothing, it's like, you're just doing nothing. Well, we're actually trying to make a change in the world."

During the same interview, Sid revealed what working on the bug stand had meant to him:

> Sid: Well, I faced people calling me disgusting and saying that I'm a loob ...
>
> LL: You're a what?
>
> Sid: Loob.
>
> LL: Loob? What does that mean?
>
> Sid: Like, a nobody in life, like you're nothing.
>
> LL: Okay. Because you eat bugs?
>
> Sid: Yep.
>
> LL: And what's your response? How do you get through a challenge like that?
>
> Sid: Well, I really don't pay attention to them. And I see a lot of people like me who's eating them, eating bugs, so it doesn't come to mind. So I really don't care what they say because it's not them who's changing the world.

8 Sander: wearable cigarette smoke detector

Sander described his project in the following way:

> "What I made was a portable smoke detector that could be wearable on a shirt. And made that because a lot of people like smoking, and it's bad for the environment, and both ways, it just doesn't smell good."

Sander began the year not knowing what project to take on. After researching a number of social issues, cigarette smoking seemed to resonate. During an informal interview, I asked him why he had selected this issue. He responded, "because my step-father smokes and I want him to stop."

Sander used techbrarian.com to access sites such as http://TheRealCost.BeTobaccoFree.hhs.gov and http://TheTruth.com to learn facts about smoking. He also spent a period enjoying parody cigarette advertisements from http://AdBusters.com.

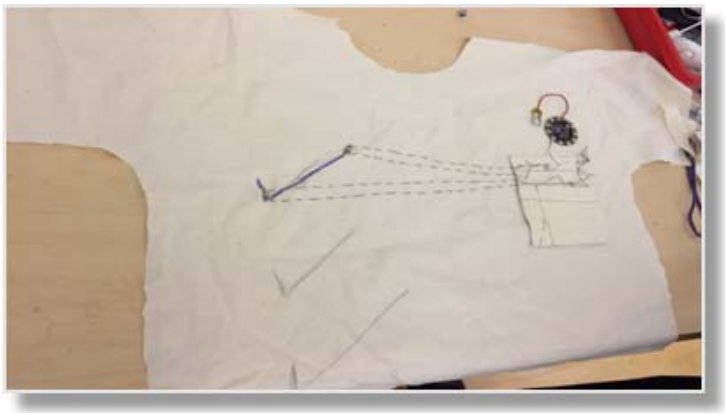
Sander's idea for the smoke detecting shirt originated during a brainstorming session with me and his partner Ryan. My field notes reported:

> "Sander and Ryan came up with the idea of a shirt that flashed a 'no smoking' symbol. I said why not have it triggered by a smoke sensor? I said it could even flash 'stinky breath'. Ryan said, and 'lung cancer'!"

In order to create such a shirt, I knew that sewable electronics would provide the best result. In this case, sewable electronics involved using electrically conductive thread to sew together a smoke sensor, a programmable microprocessor called a LilyPad Arduino, and LED lights on a shirt. As with Maddie and Meera's Wallets for the Homeless project,

Sander's work required the sewing expertise of the after-school tailor, Pizarro. However, unlike the wallet project where Pizarro was the expert, here, Pizarro and Sander co-learned the fundamentals of sewable electronics through a series of online tutorials and my direct instruction. Notwithstanding my knowledge of electronics, there was also a great deal that all three of us had to learn in order to program the shirt to perform as desired.

Figure 3 Working prototype of Sander's cigarette smoke detecting shirt (see online version for colours)



Two weeks into the project, Sander and his partner Ryan were having difficulty trying to get the LilyPad to light an LED when it sensed smoke. Sander was trying to figure how to code this action from scratch using YouTube tutorials. However, such a script was proving relatively complex for a beginner. I helped him locate code Online that had been written for a similar purpose. My field notes reported:

> "I had a good moment with Sander where I explained that all coders take other people's code and then remix them."

Around the same time, my notes recounted how the tailor's involvement in the project grew:

> "After the boys left, Pizarro and I talked at length about the design of the t-shirt prototype. I showed him how the wiring should be and he caught on quickly. He spent time designing the pocket for the t-shirt so that it would hold the sensor, LilyPad, and battery in separate compartments. He took home a sewable battery conductive thread, and LEDs to practice."

Six weeks into the project, Ryan seemed to have lost interest and abandoned the endeavour. Meanwhile, Sander was fascinated by how the carbon monoxide sensor could be connected to the LilyPad Arduino in order to register changes in smoke levels. He learned how 'conditional statements' in the coding could trigger the LED's to light up. Yet, despite our efforts, we were unable to get the shirt fully functional. My field notes recounted:

> "Kept Sander to work with Pizarro. Lots of effort to get the LilyPad up and running. In the end, everything worked but the LED didn't light up enough. So still working on that element. Tried to hook up a separate 9V to it and that

> didn't work. I explained the concept to Pizarro and he said, 'wow, I'm really learning a lot too!'"

By the close of the study, our working prototype was sewn into the shirt, but the LED's did not light up as brightly as intended. During a formal interview, I asked Sander if his tech skills had changed because of this class. He responded:

> "Yes, because before, like I didn't really care about, like, the social action or whatever, but now that I'm starting to do it, it's just getting more interesting."

9 Data analysis

9.1 Content driven school makerspaces

The goals of this study included an exploration of the distinguishing characteristics of school makerspaces and how students perceive their work within them. Qualitative data was collected in order to assess student understanding of their self-selected social issue as well as the personal impact product creation had on them. While the personal impact was quite evident in student interviews, their understanding of the underlying causes and prevalence of their issue was not. This lack of understanding speaks to the importance of deep research in school makerspaces.

For example, while Sander's smoke detecting shirt was remarkable in its originality, complexity, and ambition, it displayed only a surface understanding of the issues associated with smoking. Supported by a learning environment that placed an even greater emphasis on understanding what causes people to smoke and the statistics on its health effects, Sander might have created a more effective product. Similarly, neither Maddie nor Meera was given the scaffolds they needed to understand the scale of the homelessness problem in their community, or why current solutions were insufficient.

9.2 Recommendation 1: research-backed products

Thus, one distinguishing characteristic of school makerspaces should be the inclusion of research throughout the design process and accountability practices that ensure students' deep understanding of their chosen topic.

9.3 Tool and issue permutations

In this study, students chose from a variety of social issues and used a wide-range of tools in order to create their projects. Providing access to a plethora of content and tools allowed creativity to flourish and anchored their work in passion. However, meeting the needs of each student in a learning environment with so many permutations of social issues and tools was extremely challenging. By contrast, in a more traditional classroom where students are confined to a small set of themes and materials, teachers can efficiently address questions common to the whole group.

9.4 Recommendation 2: strike the right balance between freedom and overextension

School makerspaces should be chock-full of tools and materials to build content-driven projects. However, proper scaffolds should be in place to guide students in their creation process. This includes the recruitment of community members with diverse Maker skills and content-area expertise.

Makerspace coordinators are advised to collaborate with content-area teachers in advance in order to determine an appropriate range of themes. Likewise, makerspaces should offer only a limited set of tools and materials that are unfamiliar to the learning community. That said, in keeping with the ethos of the maker culture, makerspace teachers should continually challenge themselves to acquire new skills and knowledge. To this end, a curated set of resources should be created to facilitate the independent learning of tools and materials by members of the makerspace community.

9.5 Incorporating makerspaces into the school day

Product development in this study's makerspaces often took weeks, if not months, to complete. This presented scheduling challenges during the regular school day. For instance, Sander's project required enormous intellectual rigor and time-consuming wiring. To support Sander with these tasks, I needed to be fully present – something not always possible when coordinating a classroom full of projects. Thus, it was essential to pull him out of several regularly scheduled classes during my preparatory periods so we could focus on his work. Similar constraints concerned products whose development and implementation needed to occur outside of school. Both Sid and Walt's bug stand and Maddie and Meera's wallets for the homeless required leaving the school to develop the project and serve the public.

9.6 Recommendation 3: flexible scheduling for school makerspaces

To provide students with the opportunity for extended learning experiences, educational makerspaces can adopt the 'flexible scheduling' model seen in school library media centres. Using this model, the educational makerspace would be 'open access' and unencumbered by rigid time schedules (McGregor, 2006). In this way, students could travel with their teacher, in groups, or individually, to use the space in a project-driven way rather than arbitrarily based on the administration's scheduling needs.

9.7 Equity in school makerspaces

As noted, the educational makerspace analysed in this study took place within a school serving low-SES students. Through the lens of three projects, we saw how students explored social issues grounded in research and constructed social action projects using low- and high-tech tools. However, projects such as Wallets for the Homeless and the L.E.S. bug stand do not fit squarely into the pedagogical practices and materials often associated with makerspaces. Indeed, using cooking, traditional sewing, and jewellery crafting differs from the robotics, 3D printing, and 'making kits' that typically form the basis of the white middle class Maker pursuits (Vossoughi et al., 2016). Yet, by building upon tools and practices that are embedded in the everyday lives of students and their

families, this makerspace might be viewed as far more inclusive than those claiming to be scrappy and anti-establishment, but often serve corporate agendas.

9.8 Recommendation 4: embrace ingenuity within the community

Rather than viewing makerspaces through the deficit model (i.e., bringing STEAM to the underprivileged), consider the ingenuity already present within the school's community. Many students and their families will have untapped skills used outside the school context such as fixing cars, making clothes, and repairing broken appliances. Honouring these skills as belonging in the classroom makerspace can help create a more inclusive environment.

10 Conclusions

Needless to say, no two school makerspaces will look alike. Still, as the maker model increasingly finds its way into the school day, it is important to put forth a set of expectations beyond short-term student engagement in STEAM exercises. This study explored a social action-themed school makerspace in order to codify these expectations into a set of practices. Results of this study suggest that school makerspaces should: promote academic rigor through student research prior and during product creation; create a balanced approach to the number of themes and tools offered to maximise freedom of choice while maintaining sufficient scaffolds for students' work to progress; find a scheduling model that allows for teacher collaboration as well as extended learning time for time and skill-intensive projects; and create an equitable learning environment by honouring a broad range of maker skills. Combined, such an approach opens up the possibility that school makerspaces can be a true hub of innovation for students to be academically engaged and practice deep-felt social activism.

References

Banzi, M. (2011) *Getting Started with Arduino*, 2nd ed., O'Reilly, Sebastopol, California.

Barron, B., Walter, S.E., Martin, C.K. and Schatz, C. (2010) 'Predictors of creative computing participation and profiles of experience in two Silicon Valley middle schools', *Computers & Education*, Vol. 54, No. 1, pp.178–189.

Barton, A.C., Tan, C. and Greenberg, D. (2017) 'The makerspace movement: sites of possibilities for equitable opportunities to engage underrepresented youth in STEM', *Teachers College Record*, Vol. 119, No. 6, pp.1–44.

Blikstein, P. (2008) 'Travels in Troy with Freire', in Torres, A.C. and Noguera, P. (Eds.): *Social Justice Education for Teachers: Paulo Freire and the Possible Dream*, pp.205–244, Sense Publishers, Rotterdam, Netherlands.

Brindley, R. (2009) 'Demystifying action research', in Brindley, R. and Crocco, C. (Eds.): *Empowering the Voice of the Teacher Researcher*, pp.18–31, Rowman & Littlefield Publishers, Plymouth.

Duncan-Andrade, J.M.R. and Morrell, E. (2008) *The Art if Critical Pedagogy*, Peter Lang, New York.

Freire, P. (1970) *Pedagogy of the oppressed (30th Anniv.)*, Continuum International Publishing Group Inc., New York.

Gee, J.P. (2004) 'Situated language and learning: a critique of traditional schooling', Routledge, New York, NY.

Gershenfeld, N. (2012) 'How to make almost anything', *Foreign Affairs*, Vol. 91, No. 6.

Giroux, H.A. (2004) 'Critical pedagogy and the postmodern/modern divide: towards a pedagogy of democratization', *Teacher Education Quarterly*, Vol. 31, No. 1, pp.31–47.

Gomez, K., Barron, B., Pinkard, N., Austin, K., Martin, C.K., Richards, K.A. and Matthews, J. (2014) *The Digital Youth Network: Cultivating Digital Media Citizenship in Urban Communities (The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning)*, MIT Press, Cambridge, MA.

Halverson, E. and Sheridan, K. (2014) 'The maker movement in education', *Harvard Educational Review*, Vol. 84, No. 4, pp.495–504.

Hargittai, E. and Walejko, G. (2008) 'The participation divide: content creation and sharing in the digital age', *Information, Communication & Society*, Vol. 11, No. 2, pp.239–256.

Kurti, R.S., Kurti, D.L. and Fleming, L. (2014) 'The philosophy of educational makerspacesakerspaces', *Teacher Librarian*, Vol. 41, No. 5, pp.8–11.

MacLean, M. and Mohr, M. (1999) *Teacher-Researchers at Work*, National Writing Project, Berkely, CA.

Martinez, S.L. and Stager, G. (2013) *Invent to Learn*, Constructing Modern Knowledge Press, Torrance, CA.

McGregor, J. (2006) 'Flexible scheduling: implementing an innovation', *School Library Media Research*, Vol. 9, pp.1–24.

Patton, M.Q. (2002) *Qualitative Research and Evaluation Methods*, 3rd ed., Sage Publications, Thousand Oaks.

Sheridan, K., Halverson, E.R., Litts, B., Brahms, L., Jacobs-Priebe, L. and Owens, T. (2014) 'Learning in the making: a comparative case study of three makerspaces', *Harvard Educational Review*, Vol. 84, No. 4, pp.505–531.

Vossoughi, S., Hooper, P. and Escudé, M. (2016) 'Making through the lens of culture and power: toward transformative visions for educational equity', *Harvard Educational Review*, Vol. 86, No. 2, pp.206–232.

Warschauer, M. and Matuchniak, T. (2010) 'New technology and digital worlds: analyzing evidence of equity in access, use, and outcomes', *Review of Research in Education*, Vol. 34, No. 1, pp.179–225.