Makerspaces in Singapore: Pedagogical Principles for Innovation

By *Michael Tan*

MAKERSPACES IN SINGAPORE have been closely associated with the movement to enhance design skills and innovativeness. In schools, this movement has been nascent, with only a handful of schools with actual physical makerspaces, and a slightly larger number with the intentions to develop one or are currently considering maker-type educational initiatives in informal settings. While these initiatives are to be commended, makerspaces need to be thought of as (cultural) technology that can be used or abused. If innovativeness as a core disposition is desired as an outcome for participation in makerspaces, three pedagogical principles are proposed, focussing on: (i) invention; (ii) people-centeredness; and (iii) just in time knowledge provision. I present supporting arguments for these principles and elaborate on their relationship to making in makerspaces.

Introduction

Makerspaces can be thought of as re-imagined engineering workshops, with equipment that supports digital fabrication and rapid prototyping technologies that represent the future for manufacturing processes. Among machines that have captured the public imagination are 3D printers and to a lesser extent, laser cutters and CNC (Computer Numerical Control) routers. These machines work by being fed a digitally created design, and perform manufacturing tasks to a high degree of precision without much human supervision. At the same time, integrated electronics components and computer processing power have become widely accessible, with open-sourced [1]Arduino boards providing easy ways to create objects with programmable interactivity and intelligence. With all these new technologies and numerous stories of apparently innovative uses in student projects, it can be easy to believe that innovation will inevitably occur as a result of participation in makerspace activity. This is not necessarily the case, however, as technologies in general have open affordances and didactic instructions can result in lower instructional outcomes. To circumvent this, it is important that educators have general principles to guide their instructions in makerspaces. If innovativeness is a prime goal of makerspace activity, it is important to understand the processes of innovation and to consider their pedagogical implications.

What Is Innovation?

Innovation, quite simply, shares much of its knowledge base with that of creativity. However, innovation has a particularly practical aspect to it.

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[1]Arduino is an open-source electronics platform based on easy-to-use hardware and software. It is intended for anyone making interactive projects. https://www.arduino.cc/

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While creativity can be associated with, for example, works of visual art that are simply appreciated by others, innovativeness is also concerned with the practical applicability of ideas, especially by others who will make use of these creative ideas. As such, design knowledge provides much insight into the processes of innovation as the core concern of design is user-centric creative problem-solving. If we were to consider the design process, we see broadly the following steps: (a) a user needs an analysis phase; (b) an ideation phase; and (c) a prototyping and testing phase before final acceptance. While most of these steps are fairly straightforward, the "magic" happens when designers decide which of their numerous ideas is most appropriate for the problem. This process is termed abductive reasoning, and is identical to the process physicians use to determine the medical condition their patients are suffering from. Distinct from deductive reasoning whereby the deductive rule is absolute, in abductive reasoning uncertainty is tolerated. For instance, while a deductive rule could be phrased as "darkness is the absence of light", for which the occurrence of "darkness" *must* mean that "light is absent", an abductive rule could be phrased as "when the ground is wet, it usually means that it has rained". In the latter, with an observation of "wet ground", we cannot rule out "the gardener wet the ground". Therein lies the key challenge to innovativeness—the element of risk that accompanies the epistemic leap from perceived reality to the intended design intent. Innovators and creators can never be completely certain about the fit for purpose of their inventions, and this uncertainty is especially high for novices.

Pedagogical Implications

As a result of the epistemic risk-taking associated with innovation, it is important in instructional scenarios that learners are given opportunities to develop their abductive reasoning abilities, and that the psycho-social environment is designed to encourage risk-taking. In studies of design work, researchers have shown that collaborative efforts usually produce results of higher quality. In sum, if we wish to nurture innovativeness in learners, the following principles are to be advocated:

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Invent, Not Manufacture

The emphasis on makerspaces should be on getting learners to suggest solutions for design prompts. Here, instructors need to resist the temptation to deem their students' work as not "up to standard" of canonical solutions. A way to address this is through the principle of iterated prototyping—a

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standard practice for designers, whereby shortened cycles of development (sprints) are privileged over a single, effortful march through the typical time it would take to complete a unit. By privileging action and prototyping, instructors can lower the costs of failure and mistakes, and allow multiple chances for learners to improve their ideas.

People, Not Things

In makerspaces, the plethora of fanciful new objects, machines and tools means that it is highly tempting for instructors to focus their instruction on equipment use and expertise development. Instead, instructors should treat these objects as what they are—tools that are a means to an end—the more important end being the development of student learning and dispositions. Due to the interdisciplinary nature of design work, it will be useful to appoint disciplinary "experts" within teams to make sure they cover each other's blind spots. Instructors need to design classroom activity that nurtures interpersonal relationships too.

Just In Time, Not Just In Case

The conventional curriculum is provided as a means to ensure continuity of culture—students need to know these things so that we can continue our current way of life. However, this does not mean that the pedagogical approach needs to take on a similarly directed stance. Learning theories suggest that it is often more useful to get students to struggle through with material contexts first, in order to gain some grounded experience of phenomena, before introducing the formalisms that are part of the curriculum. This requires instructors to be aware of serendipitous moments when it would be especially timely to introduce pieces of knowledge relevant to the problem-solving process, and this can be hard to orchestrate. Nonetheless, this approach is superior to one where direct instruction is provided from the outset, and 'practical work' is done subsequently.

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Conclusion

Innovativeness is most likely an innate disposition, which we learn to internalise from school that we do not. Along with the lack of opportunities to develop these dispositions while schools are too busy imparting wisdom, it is hardly surprising that innovative outcomes from schooling are rather poor. Steps must be taken in order to change this state of affairs. For one, acknowledging that

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innovation will definitely be accompanied by literal and metaphorical messes will be important. The process of innovation will often *appear* inefficient, with many failures, mistakes and missteps. However, these missteps are highly essential and will ultimately contribute to the eventual success. It is also important to consider deeply the end points of innovativeness as answers to the question "What is innovation for?" Considerable tension will be encountered between allowing open-ended innovation and innovation geared towards desired ends which needs to be carefully managed. Innovation remains the grand challenge of our times, and our schools need to rise up to meet it. With makerspaces and thoughtful implementation of instructional strategies, we will be better equipped to address these challenges.

About the Speaker

Michael Tan is a Research Scientist in the Office of Education Research at the National Institute of Education, Singapore. His research interests include curriculum studies, embodied embedded extended and enacted cognition, science education, and sociology of school knowledge