

Figuring the ‘*Making*’ With Indian Teachers: Can We Reimagine STEM Learning?

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Abstract: There is a recent interest among education researchers and a push by policymakers towards making, due to a converging acknowledgement of its potential in improving learning. In India too, there is a push in creating maker spaces in schools. However, there is a limited realisation of the potential possibly due to the limited understanding of this in the teachers. Here, we attempt to engage with the teachers in a meaningful way. This paper captures the initial understanding of making in a cohort of 21 science and 19 mathematics teachers of government schools in India. Further, it highlights the nuances in the understanding of the making culture (developing a framework) and its broader implications after reflecting on the video prompt and collective discussion with the teachers. Using this evidence of teachers eliciting subtleties of learning and making culture, we argue for a greater possibility of and a need for meaningful teacher-researcher engagement for reimagining learning.

Theoretical and contextual background and the motivation of the study

Making as a culture emerged mainly from among the hobbyists, geeks, and hackers (both software and hardware). This caught attention of educators due to an interesting convergence of (1) acknowledgement of the learning potential with almost no negative results and more meaningful learning experiences (Blikstein, 2013; Papavlasopoulou et al., 2017; Peppler & Bender, 2013; Sheridan et al., 2014; Vossoughi & Bevan, 2014) (2) emphasis on the role of bodily actions in cognition from activity theory and enactivism based ideas emerging from 4E cognitive theories (3) fostering of design thinking through engineering courses in schools (Martin, 2015) (4) increasing technological affordability and accessibility with modular and micro-computing devices like Arduino, Raspberry Pi, 3D printing etc (5) equity-related implications (Ryoo et al., 2015) among others. However, there hasn't been enough research on the underlying learning mechanisms and enabling makerspaces within a school setting.

In 2016, NITI Aayog (Indian governments' planning agency) proposed to set up tinkering spaces and it rapidly expanded from 500 to 8000+ schools in a short span of 3 years. However, these spaces were far from reaching their complete potential in creating a spirit of innovation in children. This could partly be due to a fundamental shift between the way the educational system is operationalized in the classrooms currently and in the makerspaces. This shift has posed another challenge to the teachers' community to upskill and meaningfully integrate making and tinkering (M&T) in their teaching practices. In this context, professional development programs also need to be revamped to embrace making in education. It's important to work even more closely with the teachers' community to expose them authentically to M&T culture. Knowing the teachers' perception and identifying their current ideas around making can help maker-educators design programs that are bottom-up and can work on the targeted areas which need the most attention. The study reported in this paper is in this direction to engage in a meaningful dialogue with the teaching community in India.

The study: Methodology, analysis and findings

Here, we engage with 40 middle-school teachers (21-science, 19-mathematics) from central government schools, to capture their current understanding of making. During the workshop (~120 mins), we tried to evoke genuine reflections and conversations (triggered by a worksheet and facilitation) with the teachers collectively figuring out the idea of *making* practice, and also to explore their potential as stakeholders in reimagining STEM learning. We use some contexts like a making video (<https://youtu.be/TjrKl4-5sBI> by projectdefy.org), a making activity and demonstration (paper helicopters and DIY weather station demonstration: details in the poster). We analysed all the written material and video-recordings produced during the workshop using a proposed framework consistent with other literature. The poster gives more details of the framework. Keywords from the data were classified into 10 categories: Actions, Material, Knowledge elements, Real-world context, Knowledge Source, Models, Activities, teaching-learning (TL) processes, Attributes, and No experiences (Details of the categories in the poster). The framework developed above helps in establishing inter-relations between these categories. At the start of the workshop, two-thirds of (68%) teachers were not aware of the making as an idea. However, 90% of them could associate it with some action (like constructing, doing or performing), and 80% with some material

involvement and 78% with TL processes. Very few (less than 40%) could make connections to the knowledge-sources (especially the contexts of real-world and out of formal systems like schools). Besides these, the poster lists some of the interesting patterns among science and math teachers.

Table 1: Patterns in the distribution of teachers using keywords of each category

Percentage answered	Action	Material	Knowledge elements	Real-world context	Knowledge Source	Models	Activities	TL processes	Attributes	No experience
	90%	80%	66%	29%	39%	46%	66%	78%	17%	68%

Qualitatively, one of the first aspects that the teachers reflected about was the students' ability to learn on their own, by using resources like Google, or by seeking help from others, without external support. In relation to this, a second aspect emerged, which is another defining aspect of the making culture, a sense of playfulness and fearlessness [G6T2 - "If the kid is dependent on teachers and they are the only one source of knowledge, kid ... may develop fear]. They concede a sense of fright in students to make mistakes, seek help in the existing system. A third aspect that was debated was the assessment of learning in such contexts. Though the debate was not resolved, it captured their assumptions and reflections about learning and assessments.

The first aspect indicates the teachers identifying the centralised nature of knowledge transfer in the current educational system and the related changes in the contemporary society. In the second aspect, the teachers elaborate on the possibility of positive affective states emerging in relation to the decentralisation of knowledge sources. They reflect on their current practices, and openly acknowledge that the students are afraid to seek help or make mistakes. This indicates the teachers being sensitive to the possible changes in their roles in makerspaces. Also, a reference to being like a coach in the 3rd aspect debating the learning through making indicates possible ways of reimagining their roles (reconfiguring to the contemporary societal context). Another interesting pattern was that unlike in other studies reviewed in the literature, the conversations with the teachers did not confine to using digital technology (3D printing, Arduino, etc), which is a useful development in the process of a wider definition of making and smoother adaptation by the system.

These are the aspects that we could touch upon in the conversation within the limited time of the workshop. This can thus raise the confidence of the system (educational stakeholders including researchers) in the teachers, thereby restoring teachers' intellectual dignity, and strengthening their self-esteem. However, we are careful with our interpretation and in no way suggest that the reflection will easily translate into practice. For that, the educator community needs to focus on building communities of practice of teachers and researchers which embrace making and tinkering approach. Further, many other factors, beyond those in this paper, need to be addressed through more teacher-researcher engagement and the proposed framework (in the poster) could be a very useful starting point in organising the thoughts and conversations in such engagements.

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