REFLECTIONS ON PRACTICE

Reflection On Maker-centred Learning In An Undergraduate Elective Course

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ABSTRACT

This paper provides a reflection on the designing and enacting of an inclusive curriculum for a diverse group of students using a maker-centred learning approach, where students are empowered to have greater autonomy in the decision-making process and given accessibility to prototyping tools in their learning process for an undergraduate general elective course. Based on the student feedback, the finding suggests that students' interest in learning was fostered when they were given greater autonomy in their learning. We recommend giving students more autonomy in choosing their project focus and exercising greater flexibility during the enactment of the curriculum, where students' voices and decisions are considered.

Keywords: Maker culture, learner agency, the Internet of Things, STEM curriculum

BACKGROUND

Maker-centred learning (Clapp et al., 2016) is widely considered to be an emerging approach characterised by its "do-it-yourself" (DIY) culture, knowledge-sharing communities and accessibility to spaces and tools for making. With this backdrop, the course featured in this Reflection was conceptualised to gain a greater insight into the affordances and challenges of running a maker-centred learning instead of a typical lectured-based one. The design of the course's learning environment is underpinned by characteristics of maker-centred learning where students can move around freely and there is no clear physical demarcation of space for figures of authority to facilitate knowledge sharing. A typical lesson is shown in Figure 1.

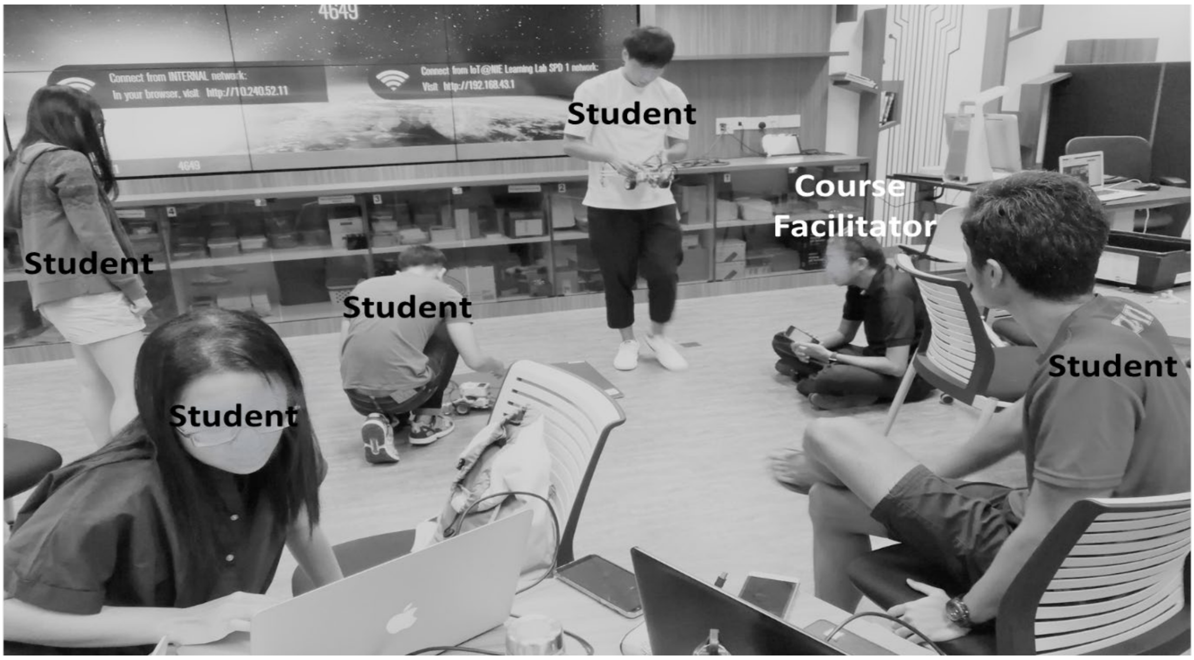

Figure 1. Depiction of a typical lesson during a maker-centred course.

INTERVENTION DESIGN

The course was offered as a general elective and saw an enrolment of undergraduate students from different academic disciplines. They were taken through a scaffolded curriculum which introduced them to the Internet of Things (IoT) as well as the foundational principles of open-source hardware, software, networking, and coding. As this course is offered in a teacher-education institute and also intended to expose students to aspects of teacher training, a foundation in curriculum design from the perspective of the team's work in Disciplinary Intuitions (Lim, 2015) was given.

The course introduces the concept of IoT and students had to demonstrate their appreciation of IoT in their curriculum design assignment and hands-on project. In addition, the classroom where the course was conducted was intentionally designed and equipped with IoT-related equipment to facilitate course-related learning with regular hands-on activities.

Students were assessed based on both individual- and group-based criteria. For individual tasks, they had to write a report on a topic of their choice. For group-based tasks, each group had to come up with an IoT-related project of their choice. Although the minimum requirement for the project was to show the conceptual use of open-source sensors networked in such a way so as to gather data to support the student-led inquiry design, the students often went on to produce physical prototypes for their projects. Students were provided kits of open-source hardware and the required sensors for their projects.

As they built their physical prototypes, students were encouraged to do coding for the components. Along the way, they received guidance and supplementary help from the course facilitators. It is important to note that the emphasis of the course was not on coding competency, but on the design and utilisation of the contextual settings, especially in terms of aligning the technological affordances with the course learning goals.

REFLECTIONS

Lessons learned from the study

During the enactment of the curriculum, the students could choose the focus for their projects. Elements characterising the maker-centred approach, such as ensuring diversity in students' interests and student ownership in the form of collaborative designed projects, were observed. A student shared his experience of participating in the course, and his comments are indicative that these elements were present:

> "I definitely find myself more interested and I think the reason for that was because […] when we have a choice, not just to learn or not, but which direction we want to go. […] you can sort of take IoT and bring it down to your own discipline or to your own interest and then from there you ready[*sic*] see what you can use it for and then that's how the interest came about for me, because I'm not so much interested in IoT. I'm interested in IoT because of what it can do for either my discipline or my (hobby in) fish."

Another student shared similar sentiments regarding his experience of participating in the course:

> "In a way, I feel like our ideas, they reach out easily with ease to the lecturers or the educators. So, another thing is that it seems like it's a very open-minded classroom, in a way. […] it's less of a top-down approach as compared to my other academic settings where it's more rigid. In this case, I could decide on the kind of topic I would want to do, or the kind of idea with the teammates, and then approach the educator accordingly, and then see whether it's viable. And it's fun, it's also safe at the same time."

From the comments given, it suggests that students' interest and ownership play a part in fostering learning.

In one of the projects, which involves using open-source sensors to measure the temperature and noise level of potential study locations on campus to help students find suitable study spaces, the group members had diverse ideas and interests in the beginning. However, they were able to come to a consensus on the project after exploring various possibilities and consulting the course facilitators. Even though they were not familiar with technical aspects of the project, such as coding, the collective interest and social relationships cultivated spurred the group on to completing the project. They went through a few iterations of the prototype design, using sensors for variables such as light, humidity, motion and sound.

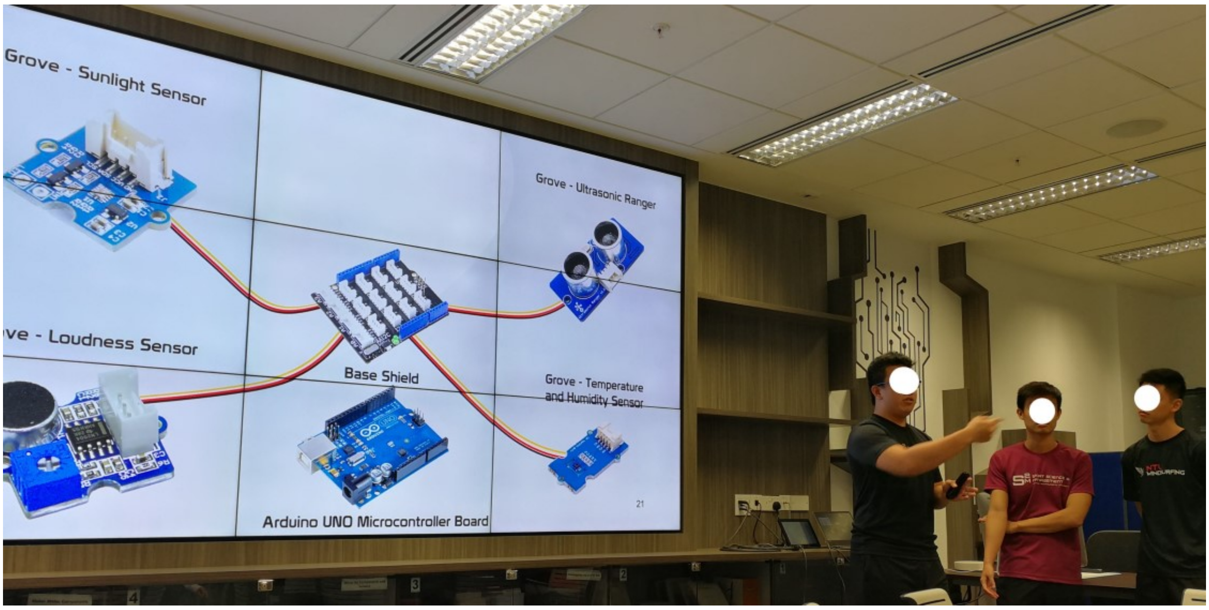

Figure 2. Different project groups present iterations of their prototype design to their peers.

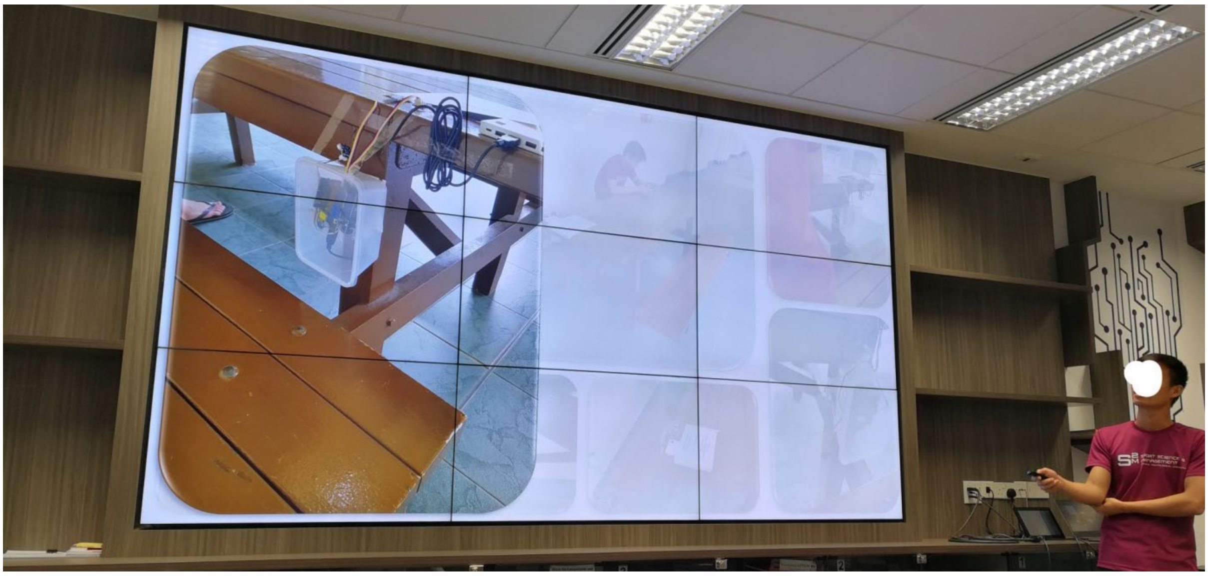

Figure 3. A student explains his group's prototype design to the rest of the class.

The open and adaptive nature of the course gave students a greater sense of ownership towards their work, particularly since they had the opportunity to conceptualise and do iterations of their collaboratively designed projects. This was reflected in the different application of projects, the roles and responsibilities assigned to group members in the project, and the different tools and resources they used. For example, the choice of projects and resources used were often related to students' personal experiences or issues close to their hearts, such as concerns regarding food wastage which led to one student deciding to do a food science project; and another deciding to do a sensor-trigger fan ventilation project stemming from their interest in energy conservation. Other examples include students showing initiative when it came to taking various roles and responsibilities in their projects, from gathering resources, leading or mediating discussions, identifying problems, gathering the technical requirements, coding, preparing for and leading the presentations.

Evaluation of the curriculum was done by administering the form "Student Feedback on Teaching" issued by the Institute. The positive student feedback the teaching team received on the course gave the team some assurance that the course might be moving in a positive direction. Comments such as "I truly enjoyed what

I have learnt in class", and "I would like to thank you for conducting this course, I have definitely learnt something different and new through the lessons" were typical of the feedback received. This was reflected further in comments such as this one:

> "During this course, I have managed to learn about IoT as well as the applications that came along with it. This course has shown me that IoT is something that even ordinary folks like us are able to make use of! If I had not taken this course, I would still have the idea that IoT is something for the "experts". This misconception, I feel, is something most people would have. Hence, in my essay, I touched a little on it stating how IoT is actually something that everyone can include in their daily life and is not something that is really difficult or something we should be afraid of."

These preceding sentiments are akin to those reported in similar studies. For example, Fields and King (2014) have described how "college age and adult women changed the way they viewed themselves as well as how they took up new practices that integrated computational media with existing interests through connected learning in the craft technologies course" (p. 7).

Diversity of disciplinary backgrounds as a strength of the course

The diversity of disciplinary backgrounds among students was a little surprising as the course involved coding and we had expected it to be more appealing to students from an engineering background. This diversity was both a strength and a challenge when it came to conducting the course. This is especially so given the traditionally silo-ed nature of the way learning is structured in formal systems of education, particularly at the post-secondary level. One of the ways to deal with this diversity was to have more course facilitators equipped with different skillsets and from diverse disciplinary backgrounds. Typically, the course would have three course facilitators, one guest speaker and one PhD/student intern. Another way of dealing with diversity and making it more inclusive was that we empowered students to take the lead in being a domain knowledge 'expert', an opportunity to be a source of knowledge which other students, including the facilitators can tap into. A student shared his experience of the course in the following way:

> "Okay, so for me, when I actually do group project in my school since we all come from same course, we have same knowledge background, then we usually have like, same ideas here and there. But I think this (course) is quite interesting because we all come from different courses, and like, we have different views on things. So like for example, like we came with the bunch of ideas to decide on the project, I think, that had a lot of varieties because we came from like, different courses and we have different knowledge… yah. So that was interesting for me."

This was echoed by another student who shared her experience in the following way:

> "I think… I already mentioned it before, there's different cross fraternity so you can see beyond things and can interact and in fact I feel that, the people, the teachers here are all really helpful and willing to help another."

A key learning point is that the diversity of disciplinary backgrounds could be considered a strength for a robust maker-centred curriculum. However, it was also a challenge to enact a course which caters to students with diverse disciplines and interests. In our enactment, there were three course facilitators, with a 1:4 facilitator-to-student ratio. The strength or expertise of the facilitators were different too. For example, one focused on the technical aspects such as coding, another focused on IoT content, and the third facilitator focused on the pedagogical aspect. We suggest a rethinking of course design, the facilitator-to-student ratio, and the composition of facilitators and skillsets will be important when enacting a maker-centred curriculum.

The iterative nature of a maker-centred learning approach

The maker-centred learning approach has its fair share of challenges. From the course facilitators' perspective, there are bound to be shortcomings in effectively meeting all the students' diverse interests. The course might also appear unstructured at times, as part for the course could change along the way according to emerging learning needs and opportunities. For the former, leveraging on a myriad of resources, expertise and tools both within and beyond the classroom is essential. For the latter, it would be useful to conduct early dialogue with students regarding the nature of the course and more importantly, identify students' interests and learning needs at an early stage of the course.

Although implicit, the continuous adaptation of the lessons during the course implies the need to implement a high degree of formative assessment. This could be made more explicit by the facilitators. For example, students could share and discuss their work on a more frequent basis throughout the course, and both the course facilitators and students could take up the role of the assessors.

CONCLUDING REMARKS

This paper provides a reflection on conducting a maker-centred curriculum for a general undergraduate elective on the affordances of learning the Internet of Things. While students who took the elective gave positive feedback about its conduct and curriculum, with some expressing their wish to continue participating should any extension activities be planned, challenges still remain, such as the facilitator-to-student ratio and assessment of learning. Student-initiated projects arising from the course suggested that students' interest could play an important role not just in the diversity of projects pursued, but also in the depth of consideration of the application of the project.

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