Introduction

Theory, experiment and computation form the three huge pillars of science and engineering. In education, there has been a gradual but steady shift toward inquiry-based, learner-centered and open-ended problem solving.

This shift has been facilitated by the convergence of emerging and affordable technologies such as 3D printers and laser cutting machines, open-source electronics platforms and accessible programming languages such as Arduino and Python.

Imagination to Reality

These tools have catalysed the movements of Making-and-Tinkering (MT) and Computational Thinking (CT). Students and educators alike are utilising these tools to engage in creative activities that allow imagination to become reality.

Making, Tinkering and Computational Thinking

Making-and-Tinkering is a necessarily creative enterprise. It has been described as "creative production in art, science, and engineering" (Sheridan et al., 2014.). Jennifer Wing (2008) describes Computational Thinking as involving the abstraction and decomposition of a complex problem into simpler parts, with the design and implementation of a series of procedures to solve a problem. These elements are critical in any Science and Engineering related course, from primary school to junior college and to university.

Although the learning goals of MT and CT activities may not have been explicitly spelt out in the current MOE school curriculum, the skills and dispositions nurtured through such activities are essential for an innovative mindset in the education of our next generation of scientists and engineers.

Opportunities for Innovation

At NTU, the School of Physical and Mathematical Sciences’ Making-and-Tinkering as well as programming courses have been embraced by innovative science students as one of the most inspiring courses in their undergraduate career. In their words, the courses allow them to understand, communicate and apply science creatively and towards goals and visions that are set and owned by students themselves.

For example, in our MT course, students created a solar-powered, mechanical, flapping bird or "ornithoptor" (photo, right), based on designs by Leonard da Vinci. While imagination and a strong vision were essential ingredients in their success, they could not have achieved it without strong computational thinking and scientific problem solving skills, such as optimizing the performance of the bird given structural and electrical circuitry constraints.

Relevance and Teachers’ Role

We are now able to expose and teach students at the confluence of theory, experiment and computation, rather than the traditional theoretical “formalisms-first” approach. It is, therefore, important that as educators, we re-examine our approach to the teaching and learning of science and related subjects, so as to inspire our students and remain relevant in the face of new technology and innovation.

Invitation to Physics Teachers

We, at NTU, will like to invite all A level and IB Physics Teachers to a series of professional development workshops and classroom studies. The workshops are aimed at teaching the tools of the MT and CT, with a co-designed lesson package for your A level / IB students as the outcome. The classroom study is intended to evaluate the success of the packages.

We hope to welcome you on board this exciting pedagogical journey with us!
Workshop Objectives and Deliverables

Objectives and Deliverables

We aim to enhance the professional capacity of teachers in utilising Making-and-Tinkering and Computational Thinking elements in their delivery of Physics lessons. There will be a series of two workshops, each accompanied by a classroom study.

As part of the workshop deliverables, participants will co-design with us, a classroom package comprising MT and CT elements for authentic science learning. This package will be implemented in schools, where a study of its effectiveness will be conducted.

Timeline

There will be a series of two workshops and two classroom studies in a complete professional learning cycle. Each workshop is anticipated to comprise approximately 24 contact hours. The schedule is given in the table below.

Depending on the teachers’ school schedules, we will work out a schedule that best suits all participants. Tentatively, we expect that the sessions of Workshop 1, running during term time, will be held on weekday afternoons. A part of Workshop 2 will be held during the June holidays, so we can expect to have some full day sessions.

Commitment

We hope to negotiate the best schedule for participating schools. If possible, we may hold the sessions at one of the participating schools. In return we hope that participants will be able to commit to both workshops and classroom studies listed in the schedule.

Workshop Approach

The workshops will utilise a “learning by doing” approach, where participants may be expected to work their way through a series of experiential “making” tasks, by the provision of nested design prompts. There will also be reflective dialogue pieces to scaffold participants’ learning. As John Dewey said, “We do not learn from experience; we learn from reflecting on experience”.

We will use examples and topics from the A level and IB Physics syllabus to encourage in-depth thinking and greater understanding of Physics. This is so that the workshops and classroom studies can be customised to the needs of teaching and learning at that level.

Classroom Study

Participants will co-design instruction for implementing in small test samples of students within their school, observed by the development team.

Registration Deadline

Register by dropping any of us an email, before 27 Oct 2017 (Friday). Places are limited so preference will be given to schools with teams of 2 - 3 teachers.

SCHEDULE

- Jan – Mar 2018: Workshop 1 (Approx. 24 hr)
- Apr – May 2018: Classroom Study 1
- June – July 2018: Workshop 2 (Approx. 24 hr)
- Aug – Sep 2018: Classroom Study 2

Limited places only. Teams of 2-3 teachers from each school will be given preference.

Register by 27 Oct 2017 by contacting any one of us!

REFERENCES

