# The STEAM Camp
## Introducing Sustainable Development Goals in K-12

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Conference Key Areas: Curriculum Development, Sustainable Development Goals in Engineering Education, Innovative Teaching and Learning

Keywords: STEAM, Project-Based Learning, Teacher Professional Development

## INTRODUCTION

Although MIT's main focus is college level education, both at the administration and at the faculty level there is a great understanding of the importance, and a growing interest towards transforming and enhancing pK-12 level education, both by developing new resources but

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also by attempting to transmit MIT's core values to the pK-12 level system. As a result, MIT already has a long history of pK-12 summer outreach programs, with particular focus in STEAM education.

For one to better understand what MIT inspired pK-12 education would look like, one should first acquire a better understanding of the values the guide the MIT community. Taking a look at the MIT Seal, as presented in *Fig. 1*, the Latin motto *Mens et Manus*— "mind and hand"–and the volumes, Science and Arts, reflect the ideal of cooperation between knowledge and practice [1], and the whole MIT education is designed with these ideas at heart. Today, 150 years later, "MIT has a long history of pedagogical boldness balanced with deep introspection. The Institute's very existence is based on a grand and daring experiment in teaching. It is a hands-on, science- based, problem-focused engineering education that continues to define MIT's educational model to this day" [2].


*Fig. 1.* The MIT Seal

In addition to providing student education, one more core mission to MIT is to form collaborations and partnerships dedicated to solving complex, global scale, real-world, sometimes even what appears to be "unsolvable', problems. Most of the times, solving this type of problems require strong, innovative, interdisciplinary approaches. With this mission in mind, MIT has been working on the UN Sustainable Development Goals through various new campaigns and initiatives, such as the *Campaign for a Better World*; the *MIT Energy Initiative*; the *Jamel Water and Food Security*; and many others.

## 1 THE STEAM CAMP

### 1.1 Camp Design and Implementation

In an effort to bring new learning opportunities and motivate students to explore STEAM related areas, MIT proposed a combined 2-week long summer camp for a subset of pK-12 students (ages 8-12 years old) and teachers in the region during the summers of 2017 and 2018. The STEAM Camp sought to bring MIT's curriculum and learning approach to students and teachers from a diverse number of schools in Hong Kong, and the camp was designed with 3 broad goals in mind: a) to advance the scientific understanding of the participants, b) to support teacher professional developments and STEAM curriculum development, and c) to develop digital resources that promote student growth through experiential, project-based education. The whole effort was placed within the Sustainable Development Goals context, as it provides a great pathway towards real life problem solving. "Energy" was selected as the theme for the 2017 STEAM Camp, while the theme for the upcoming 2018 camp will be "Into The Water". The Camp was offered at the Chinese International School in Hong Kong. The Camp director at the School and her staff handled

registration and logistics for the implementation of the camp and will continue to do so in 2018.

In the summer of 2017, 200 students from schools all over Hong Kong were exposed to a broad range of advanced STEAM content, designed by MIT faculty and staff, and taught the MIT way, with hands-on, immersive learning by doing. As part of the 2-week long summer camp, Hong Kong students engaged in hands-on activities to advance their knowledge, which they could then use in the development of ideas and solutions for a project of their choosing associated with “Energy”. The first week was designed to help students develop their base knowledge through a variety of modules that were not only engaging but, ideally, different from lessons and activities that they had normally experienced in their regular school classrooms. With 200 students attending the program, the campers were split into eight 25-student groups. They were also split up by age, grouping 8-10 years old students separate from the 11-13 years old ones. Throughout the first week, these groups remained together as they attended each module. Progressing into week two, the campers were then tasked with designing and constructing a project that applied (or at least was partially informed and inspired by) the knowledge that they acquired during the first week. Students then formed groups around ideas that they found interesting and used their remaining time to prototype, build, fail, and rebuild their projects. The project-based learning approach is central to the Camp and type of learning we would like to promote among schools in Hong Kong. It has roots in the Constructionism learning theory [3], which states that knowledge is not only built in our brains, but that this learning process happens more effectively in “a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe*”.* The Camp ended with an open house event where students shared their work and projects they had developed over the course of the two-weeks with their parents and other members of the Hong Kong community.

The STEAM summer camp was also designed to provide a vehicle for hands-on teacher professional development as Hong Kong teachers worked alongside MIT instructors to facilitate camp activities. Teacher education workshops happened a few days before the camp began, in afternoon sessions. The MIT instructional staff gave abbreviated versions of the 2.5-hour activities to familiarize them with the lessons the teachers would be attending over the first week. The teacher education component of the Camp included elements of successful professional development [4][5]: allowing teachers to provide input regarding topics for professional development, building on teachers’ experiences, creating a practical and applicable experience, encouraging teachers to facilitate concrete learning activities, and fostering an environment for practical reflection. The 30 attending teachers were also divided up and distributed amongst the student groups. The schedule was set on a rotation basis to make sure that all who attended were able to experience nearly every module. As the camp started, attending teachers were expected to join groups of students *as students* during the daytime, and to stay for an additional period after students had departed to give feedback. These discussions would inform our staff about modifications that could be made to the materials to allow for the lessons to better fit a variety of Hong Kong curriculum standards. During the second week, teachers had the option to join a team of students, become a roving mentor to assist groups, or build projects themselves. Teachers were also invited to attend a reflective conversation at the camp’s end.

## 1.2 The Hong Kong Educational Framework

In planning for the modules that would be implemented during the STEAM Camp, the developers were guided by requests from the leadership at the Chinese International School for activities that followed MIT's "Mens et Manus" approach to learning with strong focus upon activities that were project- and design-based as opposed to those that might be lecture-heavy. Upon implementing them during the program with both the local Hong Kong youth and educators, our team sought to obtain feedback from and create modifications with the educators during the afternoons after students had gone home. While this process yielded some helpful suggestions, we ultimately decided that the modules would need to be co-developed with local educators prior to the program to reap the most benefits. Additionally, teams from MIT will be encouraged to relate their activities directly to Hong Kong's ecosystems and to follow STEM curriculum guides [6] that were referred to our team by last year's educator cohort.

# 2 SUSTAINABILITY MODULES DESIGN

## 2.1 Module Selection Process

Centering on the theme of "Energy" for the 2017 STEAM Camp our group created the MIT pK-12 Learning Grant, a grant opportunity that sought to cull unique activities for the camp from the wealth of knowledgeable individuals and programs at MIT. While there was an initial desire to limit the opportunity to the traditional set of faculty and staff, we decided instead to expand the open call to anyone from the MIT community that was interested in developing programming that would benefit those attending the camp. This meant that MIT students could also develop their own modules and apply for the grant. The Learning Grant opened on February 15$^{th}$ 2017 and ran for four weeks. In that time, we received 7 submissions: three from education-focused groups on campus, one from a laboratory doing work in health technologies, and three from MIT undergraduate students.

## 2.2 Module Design Principles and Evaluation Criteria

Each module proposal submitted for funding through the STEAM Camp Grant should fulfil a number or requirements. Each team submitting a proposal should address in detail the following items.

- **Module description:** a full description of the module including the topic's lesson and activity, how it will differ for the younger and older age groups, and a write-up of learning goals for the students and ways to assess the success of the module.
- **Teacher professional development:** a layout of the module's related session for participating educators along with the intended learning goals for teachers to bring back to their own classrooms.
- **Why is this relevant?:** an explanation to justify both why the proposal is uniquely appropriate for this program and why it is important to sponsor it.
- **Biographical profiles of team:** a list of the staff that are developing the module along with potential travel availability.
- **Itemized budget and narrative:** a spreadsheet of development costs and the materials and supplies needed for the week along with a justification for all listed.

Furthermore, it was made clear to MIT faculty, students, and staff that the leading team would give greater attention to proposals that make connections MIT research, as well as to proposals that make connections to the latest drafts of the *Hong Kong STEM Curriculum Guides* [7]

To evaluate these, we recruited individuals from the MIT pK-12 community to act as grant reviewers and content evaluators to choose which modules would be funded. In the end, six modules were chosen, after deciding to merge two proposals together into a more complete activity. The committee of faculty and staff affiliated with the MIT pK-12 Action Group evaluated and consider the proposals based on the following criteria:

- Potential to significantly improve students' understanding of STEAM-based education
- Considerations for how lessons can be used in classrooms with limited resources
- Originality of ideas and approaches
- Clarity of module design, learning goals, and proposal
- Feasibility: resources are sufficient to implement module
- Measuring success: expectations for outcomes and long-term impact

## 2.3 Camp Modules

Six projects were selected by the group to be implemented during the first week of the 2017 STEAM Camp. Table 1 provides the title and a short description of each module. All modules listed in the table were developed in two versions: one for younger students and the other for older students in the range of the program. In addition to these initially modules, two short modules were included in the program with the specific goal of instilling a level of curiosity among the students, a state of mind known to favour' people's ability to learn [7]. The first one, had camp's younger students create miniature solar cells using conducting glass coated in titanium oxide and deep-hued dyes, and the second had the students play a new participatory simulation game named "Energeo." In this game, students are tasked with finding ways to meet energy needs for the cities they live in while also being aware of consequences their actions have on neighbouring cities and the world at large.

*Table 1.* Modules selected to be implemented in 2017 under the "Energy" theme.

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| Internet of Things for Healthy Plants<br>(MIT App Inventor) | This module introduced students to App Inventor, a block-based programming language, as a means for fostering their digital empowerment while growing their understanding of plant health and different forms of energy. |
| Creative Learning Skills with Scratch and Makey Makey<br>(MIT Media Lab, Lifelong Kindergarten Group) | This module encouraged students to create and code their own projects using the Scratch [8] and Makey Makey [9] platforms. Both of these platforms support creative learning through projects, passion, peers, and play [10]. |
| Electrical Engineering Basics with an IR Controlled Circuit<br>(Natalie Mionis, Undergrad '18) | This module focused on the basic fundamental concepts of electrical engineering, as well power and energy transfer. Students built a small circuit that drove a motor to spin a propeller, controlled via an infrared light remote. |
| Building an Ethanol Biochemical Factory using Ampli Construction Sets<br>(MIT Little Devices Lab) | Using a modular system for biochemical reactions called Ampli, students used discrete plug and play elements to experience the design and biochemical programming of reactions that encourage tuning, tweaking, and real-time analysis via on board sensors. |

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| Food as Fuel!<br>(MIT Teaching Systems Lab) | In this module students looked at how food is processed in the body by tracking caloric intake and measuring metabolic rates. |
| Wind Turbine Design<br>(Emily Tsang and Teresa de Figueiredo, Undergrads '17) | Students designed and constructed wind turbines in teams. Then they had to learn to develop solutions as new problems, associated with their assigned region, were introduced. |

## 3 FEEDBACK AND REDESIGN

We used a design-based research approach to conduct a pilot study and gather information about various aspects of the STEAM Camp, varying from the elements of the Camp itself, to the learning experience of the student and teachers [11]. The data, collected by 10 teachers and 25 students, using pre and post surveys allowed us to conduct a preliminary analysis, reflect and revise the following elements of the Camp:

- Less modules: a smaller number of modules will allow additional time with the content and the MIT instructors and a deeper engagement with content and tools.
- Ownership of materials: the MIT instructors will work closely with the designers and teachers to make the necessary adjustment to the materials.
- Additional opportunities for teachers. As the modules for the camp are chosen and refined, a group of Hong Kong educators will also be paired with the MIT developers to co-develop and ensure strong connections to the local curriculum and context. These teacher fellows will also work together with the MIT educators in the implementation of the modules during the Camp.
- Close alignment to teachers' interests. We are planning to have teachers complete a survey with further inputs regarding their current teacher professional experiences and more concrete expectations for the camp.

## 4 SAMPLE OF STUDENT PROJECTS

Students worked together to create around 40 different projects using the concepts, materials and tools available. The following projects provide an idea of the kinds of projects developed by participant students during the second week of the STEAM Camp.

### 4.1 Solar Energy Project

This solar energy project was created by a team of two girls (see Figure 1). They created both a physical model of the solar energy system, but they also worked created a Scratch project that guests could interact with during the Open House. Their goal was to help people understand how much they could save by using solar energy.

In the physical model, they connected 4 solar panels in series to power a small light bulb. They later thought of the need of a battery to store energy from those solar panels to use at night, but they did not incorporate that to the model. In addition to the physical model, they build a project in the computer using Scratch, the programming environment developed at MIT. Their Scratch project calculated the amount of energy consumed by people, when they provided an average amount of money they paid for electricity in a given month, and the amount of money and electricity saved by installing their Solar Energy System. In order to build these two components of their project, they worked closely with the mentors from MIT

to understand the problem, design a solution, build and test until they were ready to share their project.

### 4.2 Phone Solar Fan Project

This project was developed by two young boys who were inspired by the heat to make something portable that could help them cool down (see Figure 2). Using cardboard, solar panels, a 3V motor, and a 3D printer, the team created an iPhone case that could cool down its user when walking in the sun. After measuring the size of the phone, the boys created a fan using an online modelling tool and printed out a fan blade shape that would fit snugly on the motor's axle.

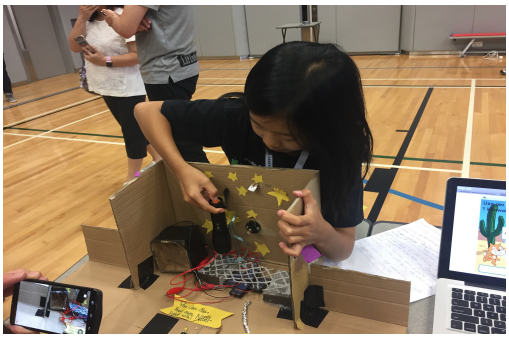

*Fig. 1.* Solar Energy Project

*Fig. 2.* Phone Solar Fan Project

## 5 CONCLUSIONS AND FUTURE WORK

The MIT STEAM Camp in Hong Kong provided a success learning experience for the 200 young students, 30 educators, and 9 MIT facilitators. The Camp ran to conclusion with a large number of personal learning experiences, interesting projects, and along with many lessons learnt for everyone. After evaluating the 2017 STEAM Camp, and as we move into the 2018 summer, we are cognizant of where we can make improvements and taking steps into implementing the feedback we received from all participants in the program. The upcoming theme will be *Into The Water*, again taking direct inspiration both from the educator's suggestions and Hong Kong's plans for STEAM Education but also from the United Nations' Sustainable Development Goals and the MIT research on the topic. A similar process to the 2017 Learning Grant has already been announced for the 2018 pK-12 Learning Grants on January 2018, and accepted proposals include projects for students between 10-12 and 12-14 years old. In addition to the 2018 STEAM Camp preparation, we are also continuing the development of a platform where all modules will be made available to the public for anyone to run.

## 6 ACKNOWLEDGMENTS

Authors would like to thank the founder of the 2017 and 2018 STEAM Camps in Hong Kong, MIT faculty, students and staff for designing the modules, supporting and implementing the program. We must also recognize the large amount of effort and support exhibited by the Chinese International School in Hong Kong.

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