

Raising the Interest of Students in Engineering with an Integrated Summer Programme*

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In this paper, we describe how a two year summer programme is conducted for high-school students to stimulate their interest in engineering and allow them to understand how engineering can improve people's living standards and contribute to society. In this programme, thirty-four students participated in a series of activities including lectures, visits to plants, a guided hands-on project, and a four-day voluntary service trip to P. R. China, applying their engineering knowledge. The objective of the programme is to expose high-school students to engineering at an appropriate level. The voluntary service trip can help to instil a sense of compassion in high-school students. In the presentation and reports submitted, most of the students stated that they found the programme meaningful, it can enhance their knowledge of engineering, that they could apply the engineering skills to real-life applications to improve the living standard of people, and that they would like to consider choosing the field of engineering as their future career option in order to contribute to society based on their interest. According to the survey, the integrated summer programme can raise the students' interest in engineering.

Keywords: engineering education; outreach activities; high-school students; P. R. China, Hong Kong

1. Introduction

The enrolments in undergraduate engineering majors rose substantially from 1990s to 2000 [1]. This is because there was a need for more engineers to meet the competition and growing demand of the high-technology industries in those years. Recently, the enrolments have declined in most developed countries and cities [2, 3]. The same phenomenon appears in Asia. For example, in Hong Kong, both the admission results and number of students admitted in engineering majors through the Joint University Programmes Admissions System (JUPAS) have been declining significantly since 2001 [4]. In contrast, the admission results and number of students admitted in business- and finance-related majors has been growing significantly. It is a high priority for engineering schools to attract high quality students and increase the number of students choosing engineering as their majors in order to provide a high quality work force to the engineering field.

There are different reasons for this deficit. Some research works concluded from their investigations that many high-school students are unaware of the career opportunities in engineering [5, 6]. Thus, they are not interested in pursuing technical majors in university [7]. The researchers proposed developing some summer programmes, which included camps and hands-on design projects for high-school students. It can help them to gain some basic knowledge about engineering so that they can be aware of the career opportunities in various engineering

disciplines. One research work [8] found in their investigation that, in their country of study, many high-school students are not proficient in mathematics and sciences. It turns out that the science and engineering subjects are too difficult to them. They proposed that there is a need to improve the university curriculum to resolve this problem. In addition, they proposed a series of outreach programmes including on-campus activities and service learning programmes to increase the interest that K-12 students have for maths, science and engineering. However, service learning is not the main activity of that programme.

Recently, the value of engineers has come into question in a business society. They are supposed to be the most highly valued people, but the prestige and power belong to capitalists in this capitalist society [9]. In addition, the career decision is identified as the most important concern for most high-school students. They would like to have prestige and power in the future. In Hong Kong, the top ten richest people are businessman, while their companies focus on the business of banking, trading, finance and real estate [10]. As a result, a significant proportion of students would like to become businessmen instead of engineers. These students would like to find the path to becoming businessmen and are not interested in choosing an engineering discipline as their future career. According to a survey made in 2011, more than 40% of high-school students would like to choose the university discipline mainly based on career prospect [11]. It is very important to educate high-school students to

appropriately choose their own future careers. The students should understand that their personal achievements should not only rely on prestige and power but also on social contributions. We should let them know the role of an engineer and how engineers can contribute to society. At the same time, we should let them understand their own interests. We should encourage them to develop their own interests through their career, instead of focusing only on fighting for prestige and power. We believe that a portion of high quality high-school students would like to choose engineering as their future career if they aim to contribute to society.

In view of the reasons above, we have organized a two year summer programme for high-school students. In this programme, thirty-four high-school students participated in a series of activities, including lectures, plants visits, a guided hand-on project, and a four-day voluntary service trip applying their engineering knowledge. The goal of the programme is to expose high-school students to engineering at an appropriate level. The voluntary service trip can help instil in the high-school students a sense of compassion through participating in work to help under-privileged children in a backward township in Guangdong. These under-privileged children are living in impoverished conditions and lack formal school education. In this paper, a description of the programme is presented to achieve the goals. An overview of the proposed programme is illustrated in Section 2. The technical details of the lectures and the hand-on project are described in Section 3. The details of the voluntary service trip are discussed in Section 4. Some survey results are collected and they are discussed in Section 5.

2. Overview of the programme

The corresponding youth programme was held in the summers of 2010 and 2011. In this programme, there are thirty-four participants from different top-ranking high schools in Hong Kong. The high-school students have spent around five weeks over

these two years in a series of activities with an engineering project as the prime focus of the programme. They can apply what they have gained in engineering knowledge throughout these two years to real-life application to provide some services to under-privileged children in some backward townships in the province of Guangdong. The programme schedule is shown in Table 1.

Before the start of the programme, an interview was conducted for us to select and invite only students with the proper mindset to participate in this programme. After the selection, an introduction giving an overview of the entire programme is first given to the participants. The introduction allows the participants to understand more about the aims and activities of the programme. In addition, the schools and villages where the voluntary service would later be carried out were introduced. With that, the first summer camp was held. This allowed participants to be familiarized with one another and prepared them to work in co-operation in serving under-privileged children in the service trip in the following year. Some lectures on the fundamental and operating principles of photovoltaic cells and the general types and development of available renewable energy sources were conducted by our professors to the students in the summers of 2010 and 2011.

Since the objective of the lectures is to build up the knowledge base of the participants in the areas of solar cells and renewable energy, the lectures were supplemented by laboratory visits as well as a visit to a solar cell manufacturer (Dupont Apollo, Hong Kong Science and Technology Park) in Hong Kong. Also, in the first summer of the programme, participants were taught the basic operating principles of solar-powered LED lamps. Each participant was also guided into completing the assembly of ten sets of solar-power LED lamps. The solar-powered LED lamps are the desk lamps for household use that would be donated to the students in the relatively backward township in the People's Republic of China (P. R. China) during their voluntary service trip in the second summer of the programme.

Table 1. Programme schedule

Activity	Duration
Programme introduction	1 day (April 2010)
Summer camp for team building	3 days (July 2010)
Lectures on renewable energy	1 day (July 2010)
Laboratory visit	1 day (July 2010)
Lectures on solar cells	1 day (July 2010)
Guided hand-on project (solar-powered LED lamp assembling)	3 days (August 2010)
Plant visit	1 day (December 2010)
Guided hand-on project (solar-powered LED lamp testing)	2 days (April 2011)
Service trip	4 days (July 2011)
Summer camp for reflection	4 days (July 2011)

A few months later, the participants visited an 800 kW wind turbine in Lamma Island in Hong Kong, which is a practical example on how wind energy can be used to benefit our environment as a form of renewable energy. The visit exposes the students to a more in-depth understanding of such a technology and its positive and negative impacts. Here, they will see and learn that wind power is one of the most sustainable ways of generating electricity. After the visit, more detailed lectures on environment protection and the operation of solar cells were given. Following that, the students were introduced to the process of fabricating solar cells, and were given a chance to fabricate some solar cells in our micro-electronics laboratory. During the second summer of the programme, the participants joined the voluntary service trip to visit some backward townships in the province of Guangdong in P. R. China. The participants organized the fairs in two high schools in two different towns. In the schools, each team of participants provided four one-hour lessons to around twenty under-privileged students to raise their awareness of various environmental issues and the importance and benefits of renewable energies. In addition, our solar-powered LED lamps were handed over to the local students in these two schools. The participants also visited some poor families in both the developing township and the backward rural area. They gave their self-assembled solar-powered LED lamps to those families. After the trip, a summer camp was held at our university in Hong Kong. During this camp, the participants shared with one another what they have learnt and their thoughts about the programme.

In general, the entire programme enables the high-school students to learn about more than just engineering, the environment and renewable energy. By combining the engineering project with a voluntary service trip, the participants can have first-hand experience of how technology can be used to improve the living standard of people. They can understand that they can be active and responsible citizens and can make a contribution society with their knowledge. Finally, through the process of giving the lamps in the voluntary service trip, they can gain not only technological knowledge, but also understand their own value and experience the joy of giving. The satisfaction obtained from participating in this programme can help the students to raise their interest in engineering disciplines.

3. Lectures and hands-on project

There are three lectures on two different days in this programme. The first lecture started with the screening of a well-known documentary entitled *An Inconvenient Truth* [12], which storyline centres on our

environment and its detrimental state. This documentary can raise the awareness of high-school students of global warming. This film showed that global warming is real, potentially catastrophic and caused by humans. We can solve the climate crisis by using the knowledge of science and engineering. Hence, the lectures following the film were focused on renewable energy.

Different types of renewable energies were introduced in the lecture with Solar Energy being discussed in greater detail for its promising potential. It gives the students better preparation for the laboratory exercises later. In the second lecture, a preliminary overview on the basics skills of electrical and electronic engineering, including the use of equipment for measurement, circuit construction, soldering, and the properties of basic components such as capacitors, resistors, transistors, LEDs, switches, etc., was presented to the students. In the third lecture, a basic knowledge of quantum mechanics was introduced, so that the students could understand the mechanism of the solar cell.

After the two days of lectures, the students carried out a hands-on project under our guidance. In this project, they were required to solder ten pieces of printed-circuit boards (PCB) for the solar-powered LED lamps. The PCB board is shown in Fig. 1. This PCB board is designed by our academic staff. It is a simple circuit containing a photovoltaic (PV) battery charging regulation system and an LED driving system [13]. In this system, the maximum power point tracking (MPPT) technique was employed, so that there is better harnessing of the available PV energy. The corresponding schematic diagram of the PCB board is shown in Fig. 2. Through the assembling process of the solar-powered LED lamps and various interactive discussions, the participants can have a simple understanding of the basic mechanism of the circuit. More importantly, it allows the students to understand that they can apply the knowledge from the lectures to help them to fabricate these products. After the soldering task, they found that engineers should be careful and precise in their work, otherwise they cannot design and produce a product successfully. They also learnt that the most important thing in engineering is to keep oneself safe from work injury and to ensure that the product is safe for consumer use.

In addition, they had to use the equipment provided in the laboratory to test the functionality of the PCB boards. Hence, after they completed the assembly of the PCB with the package to produce the solar-powered LED lamps, they carried out a final test for both functionality and reliability. The testing procedure is very important, because the lamps were to be donated to some poor families in the P. R. China. Through the project, they have

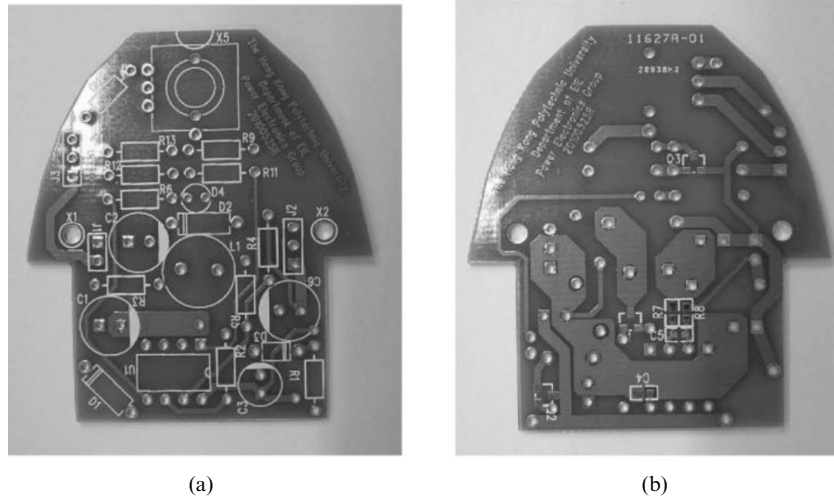


Fig. 1. (a) Top view of PCB. (b) Bottom view of PCB.

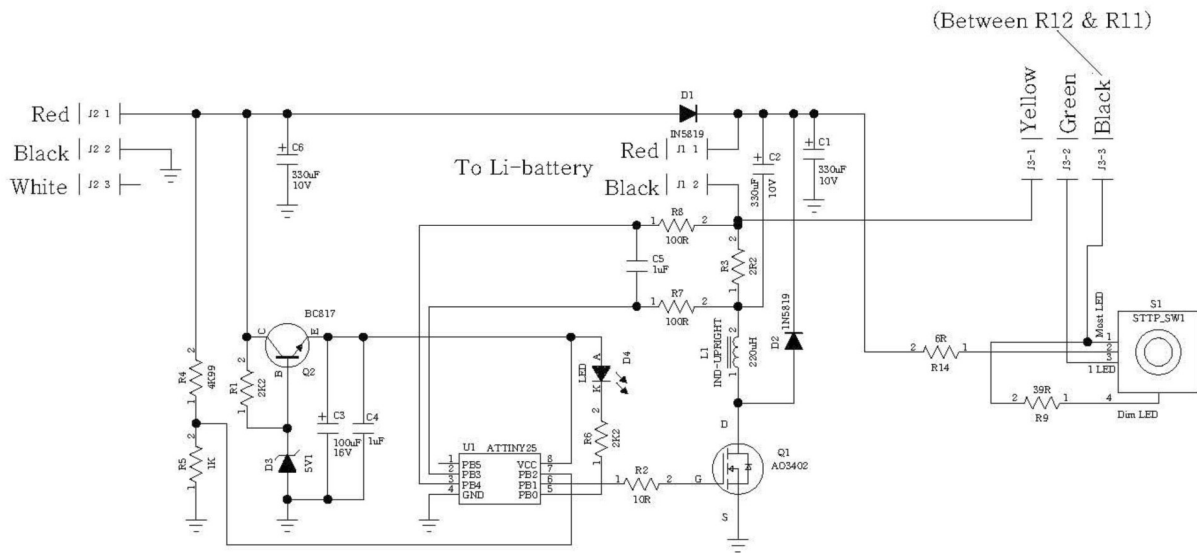


Fig. 2. Schematic of the solar-powered LED lamps.

learnt that reliability is very essential during manufacturing procedure. The lamps should work perfectly and should be safe for use. The end products are depicted in Fig. 3.

Between the lectures and the project, two visits were arranged. First, the students visited a solar cell manufacturer (Dupont Apollo, Hong Kong Science and Technology Park). The visit helps the students to understand the large scale production of solar cells and the manufacturing process of photovoltaic panels. They also had a taste of what it is like to be dressed in laboratory clothing and experience what it is like working in a clean laboratory environment. In the second visit, they were taken to Lamma Island, which is an island located in southwest of Hong Kong Island, to see the operation of a working wind turbine. The intention was for them to see

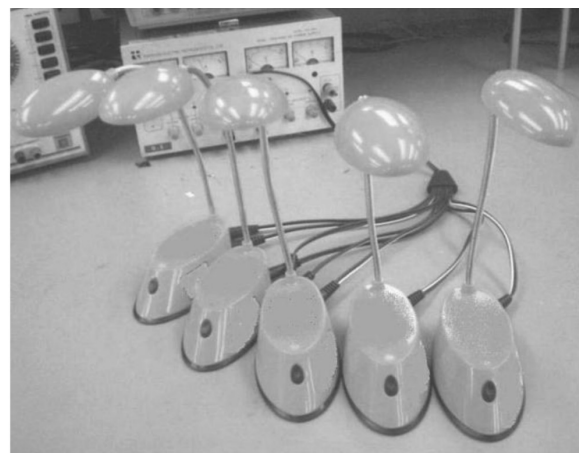


Fig. 3. The end products of the solar-powered LED lamps constructed by the students.

how the wind renewable energy is being harnessed and used in Hong Kong. From these two visits, the students get to see first-hand some of the relevant developments and applications of renewable energy technologies in Hong Kong. They can understand the importance of technology in improving our living standard while protecting the environment. In addition, they had the chance to discuss career development with the employees in the industry. This helps the students find out more about their career choices as engineers.

4. Voluntary service trip

In this programme, the participants have the opportunity to apply the knowledge they have gained from the lessons to contribute to society. A voluntary service trip to Qingyuan was arranged to achieve this goal. Qingyuan is a city in the north-western Guangdong province of Southern P. R. China. It is a developing city that includes many backward villages. During the trip, they visited both the developing township and the backward rural area in Qingyuan. The schedule of the service trip is shown in Table 2.

The high-school-students had three main tasks in this voluntary service trip. The students were divided into ten teams and they had to work in their respective teams to complete the three tasks. First, the high-school students who themselves are aged sixteen, were to play the role of classroom teachers to impart the knowledge they have gained in the programme over the last two years about environment protection and renewable energy to the local Qingyuan students, aged 13 and 14. Each of these teams was responsible for a class of about twenty students. Second, left on their own, they had to organize two fairs in two schools of two different villages. In these fairs, each team is put in charge of

one booth, which offers activities and games that are related to the dissemination of information and knowledge on the environment and renewable energy. It should be mentioned that the activities and games were wholly designed by the high-school students themselves. Third, the teams were taken to visit families living in the backward villages and some poorer families living in the town. Their mission was to pass on the solar-powered LED that they had built to these families as gifts.

4.1 Teaching

The lessons were focused on renewable energy and environment protection. In order to teach the local students, who had not had the chance to learn about environment protection and renewable energy before, our students prepared teaching materials that are closely related to their daily lives by themselves. During the preparation process, our participants actively raised their questions about the mechanism of different renewable energies. They tried to learn as much as they could so as to deliver the topics to the children in a clearer way. They actually learnt more during the preparation than by attending the lectures. Their interests in science and engineering are raised through the teaching process. The participants could understand that by delivering such practical knowledge to the local students, it is possible that the living environment and conditions of the local students might one day be improved.

4.2 The fairs

In the fair, each group of our students is required to prepare one booth game. The theme of the booth game should be related to science and engineering discipline. One of the booth games is shown in Fig. 4. Through the designing and preparation of the booth game, there is a chance that the student might find a particular interest in a science or engineering discipline, and that they can see that doing engineering is interesting and fun. It was a pleasant surprise for us to learn that some of the high-school students could actually come up with quite complicated circuits for the games.

During the fair, some of the components used in the booth game were found to be faulty. The students needed to find the correct methods to repair the electronic components. In addition, they could find some replacements for the mechanic parts. They actually could act like engineers in these situations. In general, it was an interesting and meaningful experience for the students. They were serving and educating the under-privileged children with the science and engineering knowledge they had learnt over the two summers through the games and activities that they had designed.

Table 2. Schedule of the service trip in Qingyuan

Day 1	
Morning	Travelling to Qingyuan
Afternoon	School visit in Qingyuan town
Evening	Final preparation for lessons and fair
Day 2	
Morning	Teaching in a school in a village of Qingyuan
Afternoon	Organizing a fair in the school
	Family visit in the rural area
Evening	Family visit in Qingyuan town
Day 3	
Morning	Teaching in a school in a village of Qingyuan
Afternoon	Organizing a fair in the school
	Visit to hydroelectric power station
Evening	Sightseeing in Qingyuan
Day 4	
Morning	Visit to hydroelectric power station
Afternoon	Travelling back to Hong Kong

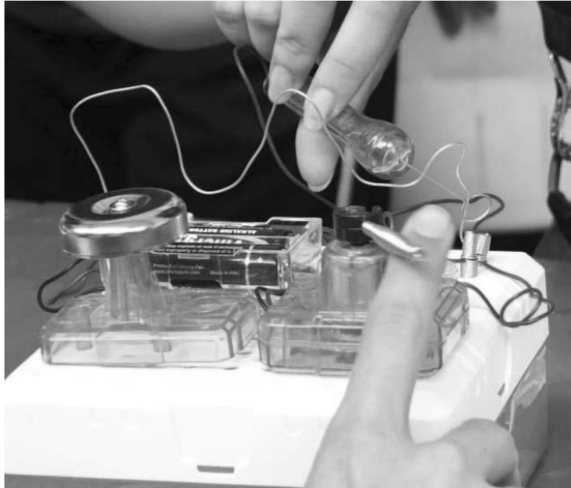


Fig. 4. One of the booth games at the fair.

4.3 Family visits

There is a wide gap between the rich and the poor. This situation is extremely serious in China. When the students visited the families living in the backward villages and the poor families living in town, they could see how limited the resources are that these families have. Most of the families visited living in the rural area are farmers. They earn their living by growing rice, corn, chillies and vegetables on their own small plots of land (around 20 m² in size), which are allocated to them by the government. A small number of wealthier families in these poverty zones keep some chickens and pigs. In most cases, their produce was barely sufficient for their own consumption and there is hardly any excess that could be sold. In these areas, there are inadequate basic services such as education, medical treatment, and applications of modern technologies.

The conditions of the poor families living in the town are no better. Most of them had moved from the rural areas to the town in the hope of finding a job to escape poverty. However, most of them lack education and are unskilled, which make it difficult for them to get a job in the town. They end up living in the slums. These families lack food and basic public services. Even though they receive financial aid from the government, they are living in great hardship. Without the help of charity organizations, they cannot even sustain their basic living in terms of getting sufficient food. Electricity is relatively expensive for them. They use it only for very necessary functions like night-lighting.

During the visit, the students could understand the positive impact of technologies to people living in backward villages and slums. Air pollution due to coal-powered generation is a serious problem in Qingyuan. Clean energy technology can help to

improve the living environment of the people in this area. The students gave the solar-powered LED lamps they made to the families they had visited. Even though they are only small desk lamps, these families can freely use them without being constrained by the cost of electricity, since the lamps are rechargeable in the day by sunlight. Through this gift-giving process, the students realize that they can help to resolve some people's needs through their contribution in engineering the product.

5. Survey results

After the voluntary service trip, we distributed a questionnaire to the students and collected their feedbacks. This survey contains seven closed-ended statements to which the students must respond. The corresponding questions are shown below. The students could choose a score of 1 to 10 for each of these statements. This score represents their level of agreement and disagreement with the statement with a score of 10 being the highest, representing that one strongly agrees with the statement and a score of 1 being the lowest, representing that he/she strongly disagrees with the statement. The survey results are shown in Fig. 5. Below are the seven statements in the questionnaire.

- This programme can help you to understand the life of poor people.
- This programme enhances your knowledge in science and engineering disciplines.
- This programme can show how the technology can be applied to serve the society.
- This programme can raise your interest in science and engineering.
- This programme is meaningful to you.
- You are satisfied with what you have learnt from this programme.
- You would like to join some similar programmes again.

According to the survey results, we can see that most the students have a strong agreement with all the statements. Recall that one of the objectives of the programme is to raise the interest level of the students in science and engineering. In order to achieve this goal, the lectures and the hands-on projects had to be designed to be more intellectually interesting and stimulating for the students. On the other hand, the results of the survey show that the students are willing to participate in voluntary service. They find that it is meaningful and they could apply what they had learnt in the voluntary service. In general, it is a valuable programme for the students and most students would like to participate in such a programme again.

In addition to the survey, a reflection session was

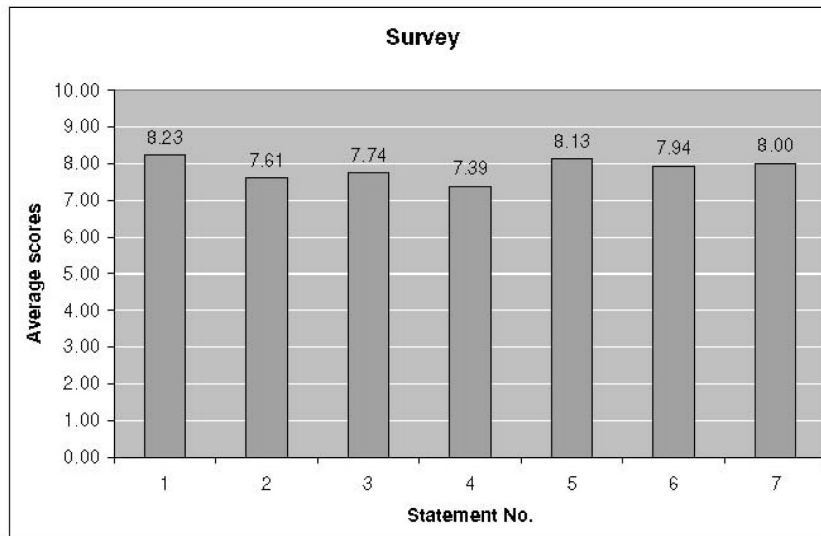


Fig. 5. Survey result of the students' feedback on this programme.

held at the university back in Hong Kong right after the service trip. The students were required to write down their reflection and comments on the report and share them in a presentation. In the presentation, the students had the opportunity to express their views and feelings on the programme to all participants. One of the students commented that before taking part in this programme, he always thought that he would like to work in the financial sector as there is a greater opportunity to get rich, even though he is interested in science and engineering. However, after taking part in this programme, he found that he should not be aiming to work and fight for prestige and monetary gains but, more importantly, he should and can contribute to the society with his knowledge, skills and passion. He shared with us that he would re-consider what he would be studying at university. We observe that this programme can help to trigger students' interests in science and engineering, and also enable them to become more aware of their social responsibility as part of humankind.

6. Conclusions

This programme provides students with an opportunity to gain some basic knowledge in engineering through lectures and their interactions with the engineering professors and tutors. Through the hands-on project, they briefly experienced what it is like to learn and work like an engineer. For most, this is the first time they have been exposed to engineering work. Through the visits, the students would also have some ideas of the career opportunities and job scope of an engineer in a related field. In addition, they also understand that they can take

on the role of a responsible citizen to help the poor as an engineer. The feeling of satisfaction as a teacher and an engineer in this programme can help the students to develop their interest in the field of engineering.

From our interactions with the participants and the consolidated feedbacks of the survey and a reflection section, it was evident that there are some students who have changed their mind, from wanting to take a business major to wanting to take an engineering major after attending the programme. The sample size is limited but we think that the programme succeeded in raising the interest of the students in engineering. If programmes similar to this are widely conducted for high-school students in Hong Kong before they make their choice for university entrance, there is a chance of improving the number and quality of applicants in the enrolment of engineering majors.

Acknowledgements—The authors would like to thank Chun-Kit Cheung, Sitthisak Kiratipongvoot, S. Y. Lam, Ivan Lau, Barry Mok, Nick Ng, Richard Pang and Roger Yau of the department of Electronic and Information Engineering in the Hong Kong Polytechnic University for their help and support in the entire programme and also thank the helpers of the Center for Cross Cultural Service Ltd for their co-ordination of the voluntary service trip.

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