

Investigation of Effect of Curriculum Change on Students' Performance in Knowledge-building and Knowledge-integration Subjects

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Introduction

In order to respond to the fast changing needs of the society, it is a common practice that countries undertake major reforms to their education structures time to time. In Hong Kong, a major educational reform, known as “3+3+4” education structure (6 years of secondary and 4 years of tertiary education) has been implemented in the recent past. The new system replaced the old three-year undergraduate curriculum with a new four-year curriculum. One of the objectives of this change is to provide the students with student-centred and multidisciplinary learning experience that will improve their generic skills preparing them for a complex, mobile and challenging work environment. The curriculum of Mechanical Engineering programme of The Hong Kong Polytechnic University (HKPolyU) has also been changed in alignment with the core requirements of new system and the first cohort of students was admitted to new four-year programme in year 2012. With the graduation of this first cohort in year 2016, this study aims to investigate the effect of curriculum change on the students' performance. The outcome of this study may provide some insight for international academic community planning on similar curriculum reforms. For example, India has started a serious discussion on education reform as the current “10+2+3” system which is 30 years old now is in need of updating to stay relevant with the socio economic changes happening locally and globally. The lessons learnt from Hong Kong education reform may provide a good reference for such new initiatives. Furthermore, as the students graduating from Hong Kong universities are increasingly becoming mobile global citizens looking for educational and employment opportunities around the globe, what is happening in the education sphere in Hong Kong is of relevance to global community too.

The “3+3+4” educational reform was initiated in 2006 to better prepare students for challenging needs of the 21st century. Under the new education system, all students will receive 6 years of secondary education (3 years junior secondary and 3 years senior secondary) to meet the needs of Hong Kong as a knowledge-based economy [1], [2]. The new academic structure principally aims to prepare students for future challenges that demands skills/qualities such as adaptability, creativity, independent thinking and life-long learning capabilities. It is expected that the combination of subjects offered, new teaching methodologies and the assessment methods help students to develop those skills to be competitive in the local and international job markets.

The new senior secondary curriculum which is more diversified and broad, breaks the barrier of traditional arts and science streaming. The subjects suit different students' interest, aptitudes, needs and abilities allowing them to reach their full potential. The new system has eliminated one public examination compared with the old curriculum structure. There will be only one public examination at the end of the six-year secondary schooling leading to the Hong Kong Diploma of Secondary Education (HKDSE). The diversified curriculum has also opened up different pathways for further education and employment [1].

The structural change in the secondary school system has followed by a change in the higher education system from a three-year undergraduate curriculum to four-year curriculum. This change provided greater flexibility/mobility for Hong Kong graduates to pursue further

studies or to work abroad, especially in countries like China, North America and Australia as they have similar educational systems [3]. Overall curriculum change happened across all degree awarding universities had a common set of goals: to provide the students with broader academic experience by putting greater attention to non-academic learning components and extra-curricular experience; to focus on all-round development of students; to promote enhanced linkage to the workplace; to enhance opportunities for further studies abroad; to produce graduates capable of succeeding in the global knowledge economy and able to meet society's rapidly changing needs. With the additional year to the degree programmes, as compared to the previous 3-year undergraduate curriculum, students got more opportunities for generic skill development and engage in more experiential learning components such as internship, student exchange, service-learning, etc.

Curriculum Change in Mechanical Engineering

In 2012, the Department of Mechanical Engineering of The Hong Kong Polytechnic University (HKPolyU – ME) started to offer its new 4-year curriculum for the first cohort of students admitted based on HKDSE results. The first year of the new curriculum mainly consists of subjects aiming at developing student's language skills, basic mathematics, applied science and generic skills. Discipline specific subjects are gradually introduced starting from the second year. Despite the fact that the curriculum has undergone a major structural change, there are some common subjects between the new and the old curriculums. There are 2 common core groups of subjects common across two curriculums; Core mechanical engineering 'knowledge-building subjects' such as mathematics, engineering mechanics, thermodynamics, mechanics of materials and 'Knowledge-integration subjects' such as engineering design, capstone project. The basic objective of knowledge-building subjects is to gradually develop discipline specific knowledge while knowledge-integration subjects focused more on students' all-round abilities and workplace skill development.

The Mechanical Engineering programme in HKPolyU-ME admits students to its BEng(Hons) in Mechanical Engineering programme through 2 major routes; (1) direct admission to year 1 based on Hong Kong Diploma of Secondary Education (HKDSE) results (4 years in the university – HKDSE intake) and (2) the Senior Year (SY) intake admitted in year 3 from those who have completed 2 years of relevant sub-degree programmes (2 years in the university – SY intake). SY intake students failed to get admission to university through HKDSE intake route as their HKDSE results did not meet the cut-off university entry requirements. They therefore sought alternative route of higher education at sub-degree level where HKDSE entry qualification requirements are lower. The SY intake route provides the best performers from relevant sub-degree programmes to gain University admission. They are admitted directly to the 3rd year of the bachelor's degree programme.

Several educational institutes in Hong Kong offer sub-degree level education opportunities (associate degree or higher diploma) for students who didn't test well while taking HKDSE Examination. Most of the SY intake students joining the HKPolyU-ME programme in year 3 have completed an associate degree in engineering. The curriculum structure of associate degree in engineering consists of around 60% general education subjects and around 40% discipline-specific subjects [4], [5]. It is very much similar to that of first 2 years of engineering bachelor's programmes. These associate degrees in engineering provide flexibility for students to decide their specialism based on their interests and capabilities.

Therefore, graduates from associate degrees programmes have strong preference to their chosen field of specialism. On the other hand, HKDSE intake students are directly admitted to the specialised field and do not get a chance to test their capabilities and preferences.

Students' Performance Assessment in Knowledge-building and Knowledge-integration Subjects

As the first cohort of students who has followed the new 4-year curriculum graduated in year 2016, this study is focused on assessing the effect of curriculum change on their academic performance. Since the new educational system emphasizes more on students' overall development, it is expected that the cohort of students that followed the new system perform equally well in both knowledge-building and knowledge-integration subjects. The students' Award Grade Point Average (AGPA) which is the primary grade for their graduation award classification (Table 1) should be a reflection of their all-round abilities. Therefore, in this study, students' AGPAs have been compared with their performance in core knowledge-building and knowledge-integration subjects.

First the performance of 82 Mechanical Engineering graduates from the new system were investigated. This population of students consists of 53 HKDSE intake students and 29 SY intake students. The data is extracted from the University central database. Table 1 shows the award classification for graduating students in academic year 2015/2016.

Table 1 Graduates' Award Classification, 2015/2016

Award Classification	No.
First Class Honours	8
Second Class Honours – Upper Division	35
Second Class Honours – Lower Division	37
Third Class Honours	2

The correlation of students' AGPA and performance in common knowledge-building subjects across new and old curriculums; mathematics, physics and mechanics are shown in Figure 2. Pearson correlation analysis was used to examine the correlation between AGPA and each subject [6]. There is a strong positive correlation between students' AGPA and the knowledge-building subjects; mathematics ($r = 0.82, p < 0.001$), physics ($r = 0.87, p < 0.001$) and mechanics ($r = 0.86, p < 0.001$).

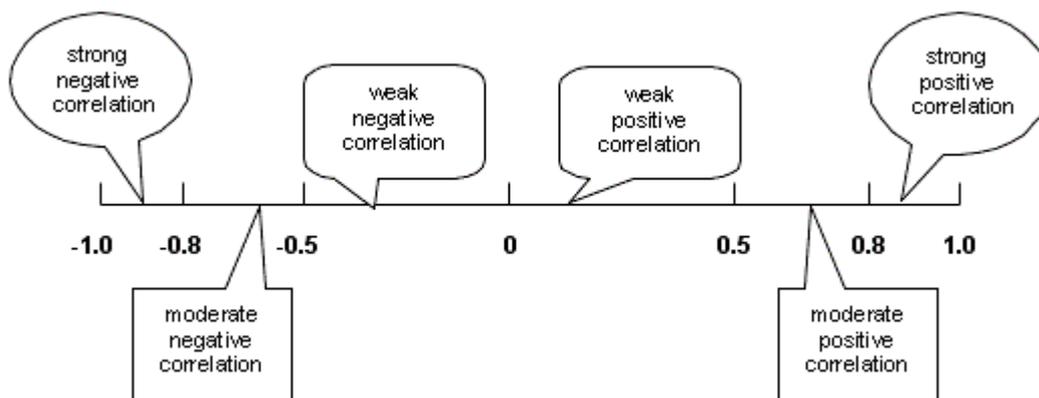


Figure 1 Guide for interpreting correlation coefficient [6]

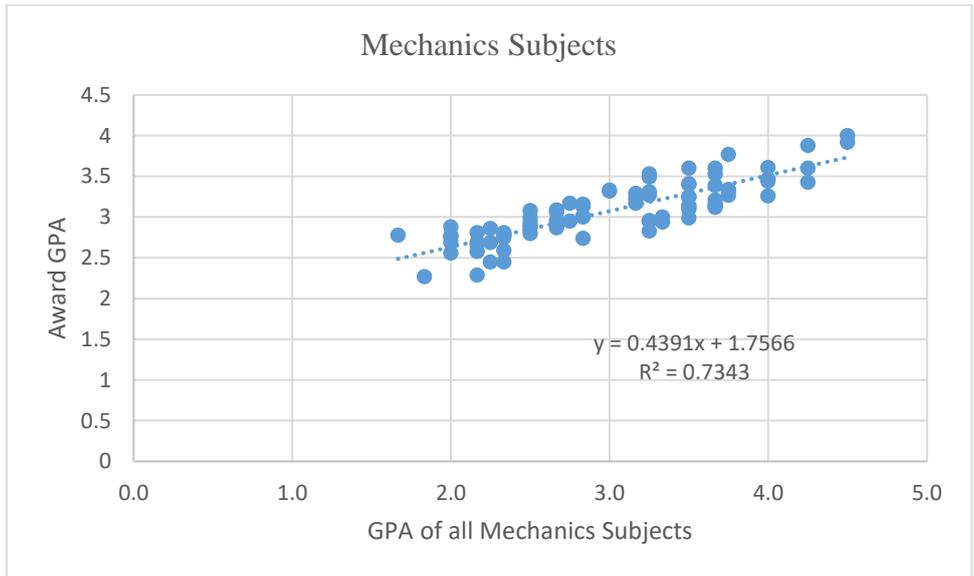
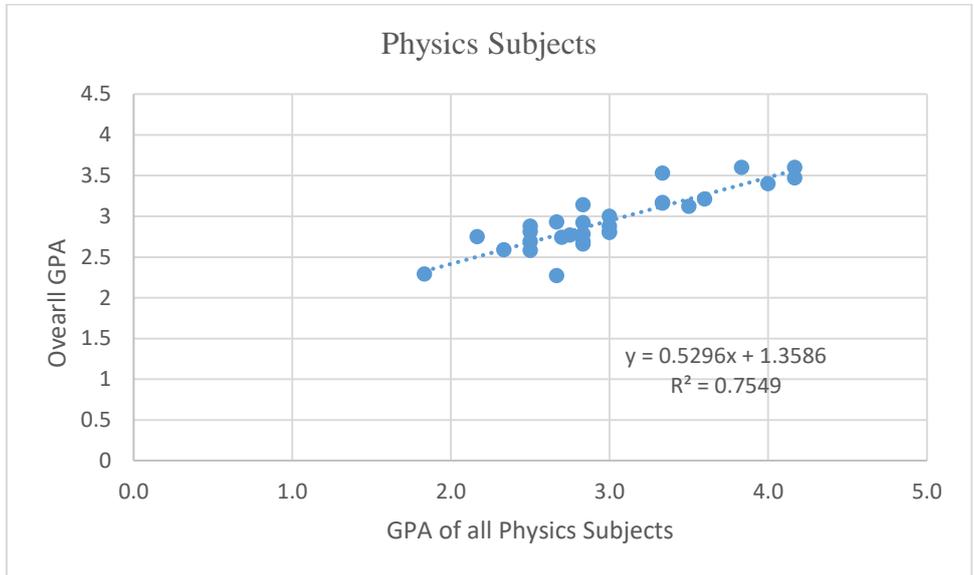
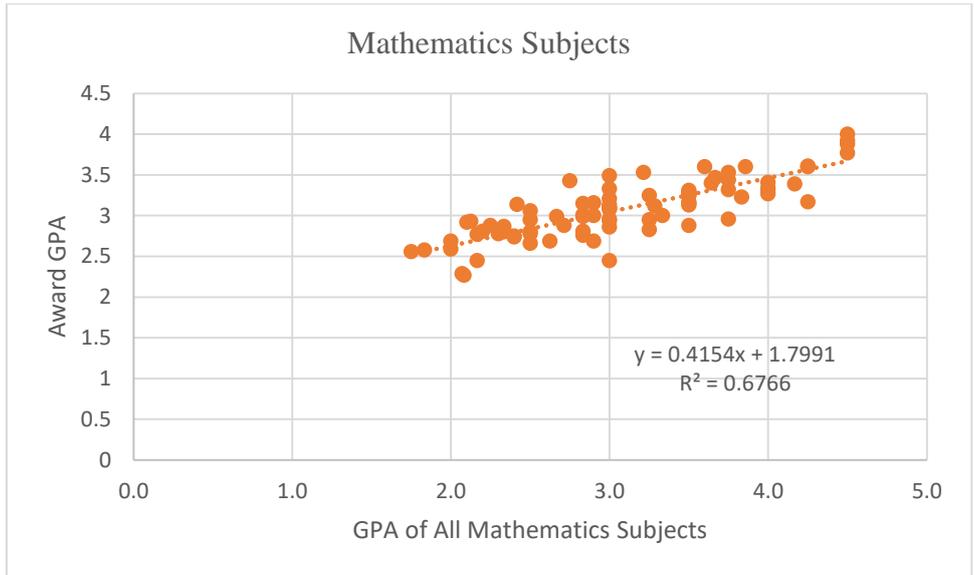


Figure 2 Correlation of Award GPA and Knowledge-building subjects

The main knowledge-integration subject common across both old and new curriculums is the Final Year Capstone project where students undertake a project spreading across 2 semesters in groups of 3 members. Most of the projects are coming from the industry which are challenging real life problems. The capstone project is the platform for students to demonstrate their group working ability, project management skills, communication skills (technical, oral and written communication), knowledge integration skills, creativity, etc. In general, capstone project assessment is a good indicator of students' all-round ability and the workplace readiness. With 10 years of focused training on all-round ability of the students through secondary and tertiary education as planned in the new education structure, it is expected that the students perform much better in the capstone project. All the assessment components of the capstone project are also carefully designed to capture students' all-round abilities and the workplace readiness individually. Figure 3 shows the correlation of graduating students' AGPA in academic year 2015/2016 and their Capstone Project results. The results show that the correlation is relatively weak ($r = 0.24$, $p < 0.05$). It indicates that the AGPA is not a good reflection of students' all-round abilities and workplace skills. The higher AGPA is mainly due to the better performance in the knowledge-building subjects. The same has been analysed for 5 most recent cohorts of graduates from the old curriculum and a similar pattern has been observed, i.e. students' AGPA is weakly related to their performance in capstone project. This comparison shows that the new curriculum change has not made a significant improvement in students' all-round abilities and workplace skills as expected.

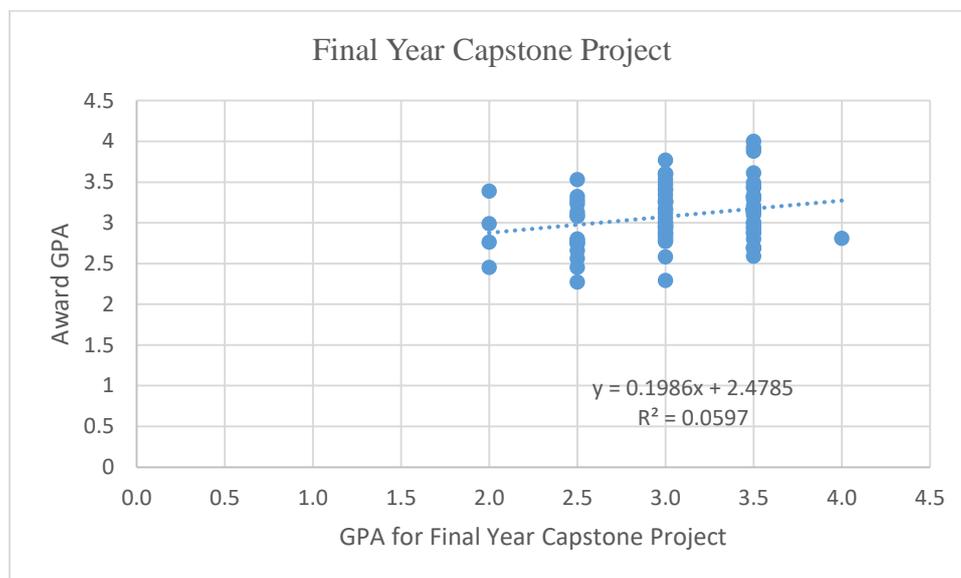


Figure 3 Correlation of Award GPA and Final Year Capstone Project 2015/16

Since the cohort of students investigated in this study consists of 2 distinct group of students; HKDSE direct intake and SY intake, the performance of those two groups were then analysed separately to see if there are any significant differences. Figure 4 shows the award classification distribution for those two groups. It is clear that the overall performance of SY intake students is better than direct HKDSE intake students.

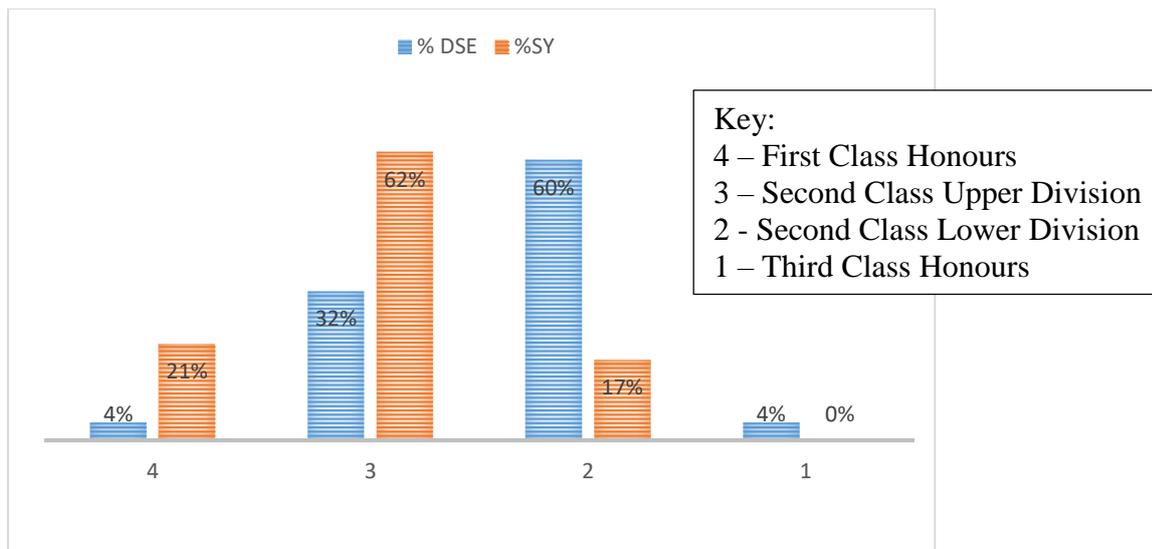


Figure 4 Award Classification Distribution (HKDSE and SY intakes 2015/16)

The performance of the two groups of students were then analysed for knowledge-building and knowledge-integration subjects. No significant difference is observed in the performance of knowledge-building subjects. Both groups' AGPAs showed a strong positive correlation with their performance in knowledge-building subjects which is expected. However, their performance in Final Year Capstone Project showed a significant difference as shown in Figure 5 and Figure 6. SY intake students' capstone project performance showed a moderate positive correlation ($r = 0.47, p < 0.05$) while that of HKDSE intake students showed no correlation ($r = 0.099, p = 0.479$).

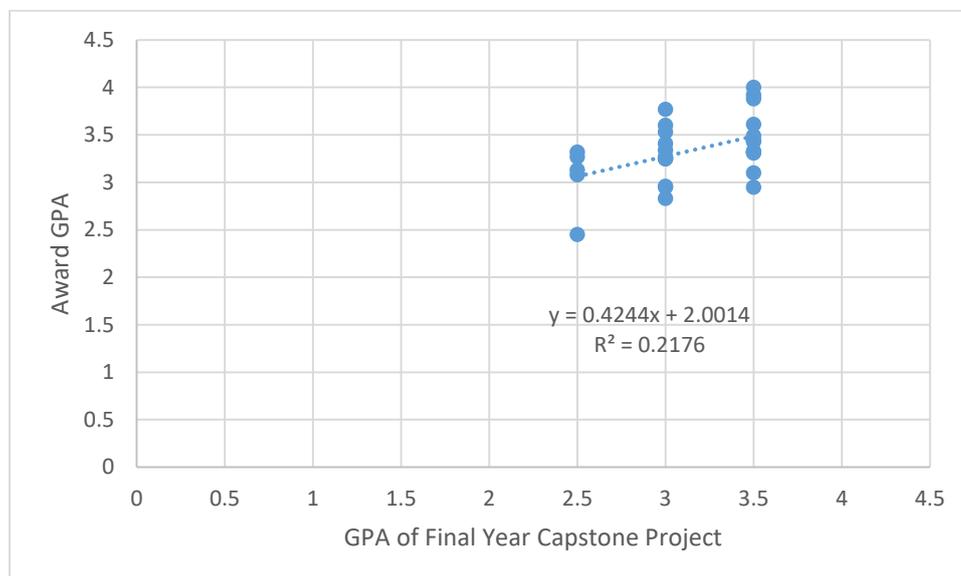


Figure 5 Correlation of Award GPA and Final Year Capstone Project for SY Intake

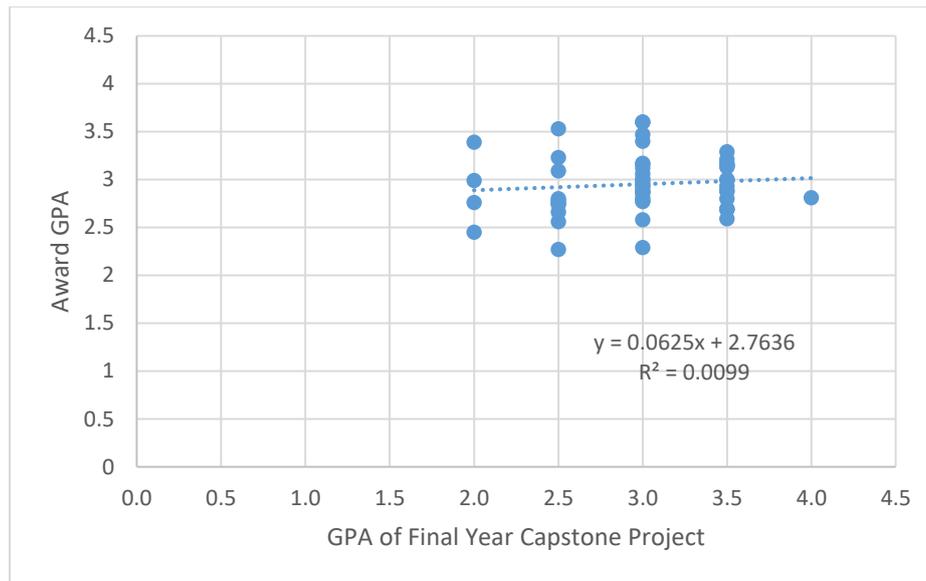


Figure 6 Correlation of Award GPA and Final Year Capstone Project for HKDSE Intake

The results indicate that the SY intake students who have completed a 2-year sub-degree programme prior to university admission have developed all-round abilities and workplace related skills significantly while the direct HKDSE intake students have not managed to develop those skills adequately despite the fact that they have followed the full new curriculum in the university for 4 years. The same has been analysed for 5 most recent cohorts of graduates from the old curriculum and no significant difference in performance has been observed between those two groups.

Discussion and Conclusions

It is premature to make a conclusion about the effectiveness of the newly introduced curriculum based on the data of one cohort of students considered in this study. However, it is significant enough to conduct further investigation to understand the contributing factors for the observed differences of performance. Followings are some of the potential contributing factors:

Reduced student performance filtering of new 3+3+4 system: The new educational reform has reduced the number of public examinations that filter capable and high performing students for higher education from two to one. It has obvious advantages such as creating more space for students to enrich learning experience through extra-curricular activities, enhance learning effectiveness, reduced focus on examination oriented training, etc. [1], [3]. However, the down side is the less filtering of quality students. There may be many first-time-lucky students becoming eligible for university entrance. Some of them may have not developed the skill sets sufficiently to be successful in the university learning environment. On the other hand, the SY intake students have lost the opportunity of getting university admission through direct HKDSE admission route due to their poor performance. They have undergone 2 years of academic training in sub-degree programmes where the learning environment has more similarities to a university than a high school. SY intake route admit the best performers in the sub-degree programme which acts as a second filter. More focused training and the exposure to a second round of competitive environment may have made the SY intake students better prepared to learning challenges in the university environment than

their peers who have got direct admission to university. It must be admitted that the filtering effect speculated above is a simple speculation that needs further investigation.

Parental pressure for higher focus on examination: The previous educational practices in Hong Kong had greater influence from Confucian Heritage Culture (CHC) educational approaches where summative assessment by way of examinations were used to assess the learning achievement of students [7], [8]. Most of the current generation of parents have undergone this CHC influenced educational training. As a result, they value the achievement of their children's in examinations more than the skill and all-round development as planned in the new educational reform. Therefore, students focus more on examination performance to satisfy the parental needs and they tend to perform better in knowledge-building subjects as evident from the historical student performance records. The student performance records show that the parental influence for higher performance in examinations have significant effect than the influence of teachers, the new curriculum and the assessment practices.

Assessment focused teaching and learning: One of the key objectives of recent education reform in Hong Kong is to move from an examination-oriented education to a system that use assessment to support learning [9], [10]. However, the assessment is still deeply influenced by the traditional system of 'assessment of learning' that generally happens at the end of the education process. In Mechanical Engineering curriculum, all the subjects contain a significant portion of continuous assessment components encouraging formative assessment practices that focus on 'assessment for learning (AfL)'. However, both teachers and learners with deep-rooted traditional thinking, still take continuous assessment components as methods to collect marks for the final grades rather than a method to identify students' strength and weaknesses and to provide quality feedback for continuous improvement. There is a strong need for realigning assessment focus from 'Assessment of Learning' to 'Assessment for Learning' as envisioned in Hong Kong government educational reform documents [9].

This cultural shift in assessment focus in fact need to be started in the school level and then implemented with higher intensity at the university level. Once the students get used to the 'assessment of learning' culture it is very hard to reorient them for AfL. Many findings have pointed out that the lack of preparedness of the teacher for the new role of facilitator who facilitates learning to allow students to explore rather than the teacher who knows-it-all as expected by the new education reform is a key contributing factor in this regard [2], [3], [11], [12]. It has been pointed out that most of academics in Hong Kong have been taught through the traditional way of teaching during their own school years and have experienced mainly with Assessment of Learning methods. Only few academics have taken the courses on teaching and learning prior to the curriculum change [3].

Effectiveness of generic skill development: The added focus on the generic skill development in the new educational system should have produced students equipped with considerably high level of generic skills. However, various studies done at different educational institutes have shown that the differences on generic competencies among students who have followed the old and new curriculums are not that significant [13].

The first year of the current Mechanical Engineering curriculum also mainly consists of subjects intended for students' generic skill development [14]. The discipline specific subjects are introduced gradually starting from year 2. There may be a possibility that the

curriculum forces the students to develop generic skills and the discipline specific knowledge separately without providing them with enough opportunities to integrate them. However, this does not explain well why the students joining the programme through SY intake route perform better in knowledge-integration subjects as current sub-degree programmes in Hong Kong also consist of similar curriculum structure.

Lack of rewarding system for mastery of skills: The criticism with the old curriculum is that it focuses more on the knowledge building and less on knowledge integration and generic skill development. With the introduction of 4-year curriculum the generic skill development has been substantially enhanced. However, it still contains most of the discipline specific subjects from the old 3-year curriculum which are taught and assessed in mostly traditional way. For a student who has less knowledge of the skills needed by a professional engineer, there are no clear incentives embedded in the curriculum for extra time investment on mastering discipline specific skills. The SY intake students with 2 years of more hands-on type training at sub-degree level have higher awareness, enthusiasm and aptitude in skill development. They also have the added advantage of preparing for two public examinations to do well in knowledge-building subjects taught and assessed in traditional way. Hence, the HKPolyU-ME Mechanical Engineering curriculum may favour more for the SY intake students. Therefore, it needs some rethinking to enrich the existing curriculum with built in rewarding systems for both mastery of knowledge and skills focussing more on workplace skill development. This can be mostly achieved through more project-based studies and creating continuity across subjects in key knowledge-building areas that act as feeders for knowledge-integration subjects.

Most of the education reforms happening around the globe today, including in Hong Kong, is triggered by the need of the global economy. During the education reforms and curriculum development, it is natural to pay more attention to global needs and look for successful models from other countries. The experience in Hong Kong points out that the local cultural issues also needed to be taken into account in any reforms as success of any new reforms depends on how well all the stakeholders respond to the changes. The societies highly influenced by CHC may need long but sustained continuous improvement to reap the full benefits of educational reforms.

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