



Capstone Experiences

Introduction

Capstone experience has become an important component within the new four-year undergraduate curriculum at the University of Hong Kong (HKU). Capstone experience may be in the form of a research project, research paper, thesis, practicum, or an internship. The purpose of capstone experience is to allow students integrate and apply knowledge that they have learnt throughout the course of their study into the different forms of capstone experience that the student engage in. Capstone experience broadens student's perspective. Students can explore knowledge beyond their studies and learn to work individually or collaboratively with or without faculty supervision. Depending on the individual faculty or department, each major programme can decide the form of experience to be adopted, the number of credits to be awarded on the basis of the specific aims of the programme or curriculum, and student's needs. Capstone experiences are great assessment grounds in providing the faculty or department information on the strengths and weaknesses of their curricula because students' performance are being observed and assessed holistically, and it provides a true method of direct evidence of student learning.

In *Reinventing Undergraduate Education* (Boyer Commission, 1998), capstone experience is defined as a project organized based on all the research skills that a student has developed during the course of his/her studies, which demands the formulation of a significant question, the creative exploration or research to find answers, and the communication skills to express the results to both expertise and non-expertise. Although in this definition the focus emphasizes on "research skills", however we would like to encompass the definition of capstone experience to cover a wider range of skills that includes interpersonal and generic skills. Recently, university capstone experiences have begun to comprise elements of authentic nature to allow students to be better prepared for the real world of engineering.

Capstone experience is student-centered. It requires students to take responsibility and ownership for their own experience. At HKU, the Faculty of Engineering has organized some form of capstone experience as part of their curriculum component such as internship and design projects (capstone projects). Many other local and overseas universities have also incorporated some form of capstone experience within their engineering programme curriculum.



Accredited engineering bodies such as Accreditation Board for Engineering and Technology (ABET) and Hong Kong Institute of Engineers (HKIE) have recognized and emphasized the importance for engineering students to be able to “design a system” and to “work in teams”. Therefore capstone experience is adopted among universities with accredited engineering programmes as a popular mean in demonstrating students’ knowledge of creating and implementing a real design, where students work in teams and gather their knowledge from prior learning experience throughout their studies in the design process. As engineering bodies acknowledges the importance of a design component within engineering programmes, capstone experience has been offered to senior year students and has become an integral part of engineering students’ graduate requirement within the 4-year curriculum in HKU and among many overseas universities.

References:

- Boyer Commission. (1998). Reinventing undergraduate education: A blueprint for America’s research universities. Retrieved from http://www.niu.edu/engagedlearning/research/pdfs/Boyer_Report.pdf



Credit Bearing

Depending on the university's department or faculty, capstone courses or project may be credit-bearing or non-credit bearing. Some examples of overseas and local universities offering credit-bearing capstone courses or projects include Northwestern University, HKU, Polytechnic University of Hong Kong (PolyU HK), and University of California, Berkeley. At Swinburne University of Technology, engineering students take a non-credit bearing capstone course. Students enrolled in the course can gain practical experience in conducting projects in engineering firms, participate in industry visits and inspections, and conduct research for feasibility studies (Swinburne University of Technology, n.d.).

References:

- Swinburne University of Technology. (n.d.). Professional Experience in Engineering. Retrieved from <http://www.future.swinburne.edu.au/units/Professional-Experience-in-Engineering-HED400/local>

Length of Capstone Experiences

Capstone experiences, depending on the individual university's department or faculty decisions, may be offered for one semester or longer. At HKU's Department of Electrical and Electronic Engineering, the senior design project (capstone project) lasts for two semesters, and their internship lasts for one semester; whereas at the University of Melbourne, the Electrical Engineering Capstone Project may be carried out for one semester or two semesters.

Goals of Capstone Experiences

1. Encourage students to demonstrate that they are able to master and synthesize their knowledge and skills gained through their previous learning experiences in relation to the important concepts from their related disciplines. [Integration]
2. Allow students to reflect on their academic, personal, and social development before they graduate, and to further enhance their meta-cognitive skills. [Reflection]
3. Bring to conclusion culminating experience (curricular and co-curricular) of overall university life. [Closure]
4. Facilitate transition from undergraduate studies to life beyond. [Transition]

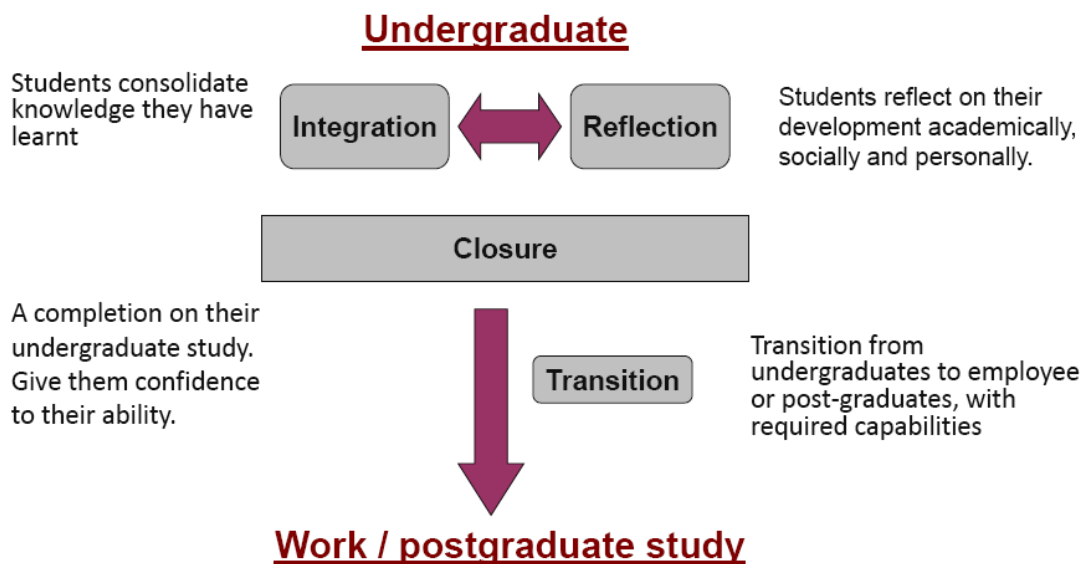


Figure 1: Conceptualizing the goals of capstone experiences (Accessed from Thomas, n.d.)

References:

- Thomas, K. (n.d.). Understanding capstone, examining the final year learning experience. Retrieved from http://www.cuhk.edu.hk/clear/tnl/Capstone_Presentation.pdf



Frameworks for a Capstone Experience (Rowles, Koch, Hundley, & Hamilton, 2004)

Capstone experiences can be organized with respect to these four frameworks that target the capstone programs' needs. Although, one framework is generally adopted, other frameworks may also be incorporated or acknowledged **where appropriate**.

1. Mountaintop: Interdisciplinary or multidisciplinary capstone experience, in which students from two or more disciplines work collaboratively on the same project. Such capstone projects mirror the real-world setting, whereby students are required to work with people from diverse background. For instance, at Georgia Institute of Technology, students from mechanical engineering and industrial design (architecture) collaborated on a multidisciplinary capstone project (see <http://www-old.me.gatech.edu/jonathan.colton/detm/detmbrochure.pdf>).
2. Magnet: Discipline-specific capstone experience which requires students to draw upon concepts learnt from various courses in the discipline. Such capstone projects act as a 'magnet' that pulls together knowledge in a summative manner, requiring students to produce a final product to demonstrate their learning.
3. Mandate: Students enroll into the capstone courses that are organized to meet the standards and requirements set out by external industry or professional bodies (e.g. ASCE, ABET, and HKIE). For instance civil engineering students who are enrolled in a capstone course in the US gather evidence that demonstrate they have achieved the outcomes set forth by American Society of Civil Engineers (ASCE).
4. Mirror: Capstone courses which requires students to reflect on their experiences and metacognitive skills in relation to program objectives and goals. Through reflective writing, students may describe what they have learnt and how their assignments and experiences have helped them achieve each of the expected learning outcomes.

References:

- Rowles, C. J., Koch, D. C., Hundley, S. P., & Hamilton, S. J. (2004). Toward a model for capstone experiences: Mountaintops, magnets, and mandates. *Assessment Update*, 16(1), 1–2.
- University of Hawaii at Manoa. (2013). Assessment how-to: Capstone experiences. Retrieved from <http://manoa.hawaii.edu/assessment/howto/capstone.htm>



Guidelines for a Capstone Experience

1. The developed capstone experience should emphasize the importance of integrating and applying knowledge and skills instead of acquiring only new knowledge and skills.
2. The developed capstone experience should focus on the “student-centered” aspect, where students have to be responsible for their own learning within the capstone.
3. Capstone experience should be organized in the final or senior year(s) of the students’ studies as students are generally better equipped since they already have the solid foundation necessary for conducting the complex tasks within the capstone.
4. Ensure that the learning outcomes of the capstone courses are in parallel with the engineering programme and the learning outcomes set forth by the institution and accreditation bodies. That includes hard core and soft skills.
5. The teaching faculty of the programme should be involved in the responsibilities in structuring, coordinating, and/or supervising a capstone experience.
6. The department and faculty offering the degree programme should be responsible in the decision making of a capstone experience such as deciding the form and credits offered for the capstone based on the aims of the degree programme and students’ needs.
7. Students should be given a wider selection of capstone experiences that targets their needs (e.g. for engineering students it might be in the form of a design project; for social science students it might be in the form of field work projects).
8. Authentic experience should be integrated into the capstone experience to allow students to experience real-world contexts. Multi- and inter-disciplinary experience should also be encouraged.
9. Clear assessment guidelines and proper supervision of the capstone experience should be established.

Examples of Capstone Experiences in Local Universities

Institution	Type of Capstone Experience	Description
University of Hong Kong (HKU)	Internship and Senior Design Project	<p>Students studying BEng in Computer Engineering or BEng in Electrical Engineering are required to do an internship worth 6 credits during summer in their third year of study and to do a design project worth 12 credits prior leaving the university.</p> <p>Supplementary Information http://elink.eee.hku.hk/enrolment/doc/BEng%20Syllabuses-2012-13-Four%20year-Overall-August%202012-revised-20120822%20_EEE_.pdf on page 8.</p>
Polytechnic University of Hong Kong (PolyU HK)	Capstone Project	<p>Students majoring in the following programme need to complete a capstone project:</p> <ul style="list-style-type: none"> (a) BEng (Hons) in Product Analysis and Engineering Design (PAED) (b) BEng (Hons) in Product Engineering in Marketing (PEM) <p>The capstone project allows students to integrate the knowledge and skills they have acquired by putting them into application. The PAED Capstone Project is a group project whereas the PEM Capstone Project is an individual project.</p> <p>Supplementary Information http://www.polyu.edu.hk/me/img/upload/IPD_DPD_2010-11.pdf on page 33</p>
Hong Kong University of Science and Technology (HKUST)	Capstone Course	<p>Students studying Civil Engineering do a capstone course, “Integrated Civil Engineering Design Project” worth 2 credits. It is a group project where students integrate prior knowledge in designing and from course work into a real-life project. Project topics may include project planning, feasibility studies, environmental impact assessments, site development, foundation design, structural design, water resources engineering, transportation engineering, cost estimating, contract document preparation, and construction project management.</p> <p>Supplementary Information http://www.ce.ust.hk/web/CourseDescription.aspx?CourseId=1 section on CIVL 4950 Integrated Civil Engineering Design Project</p>



Examples of Capstone Experiences in North American Universities

Institution	Type of Capstone Experience	Description
Princeton University	Senior Thesis	<p>Students studying Chemical Engineering, Biological Engineering, Mechanical Engineering, or Aerospace Engineering at the undergraduate level need to write a senior thesis, which is a year-long independent research project that allows students to demonstrate skills that are necessary to think, analyze and write coherently and maturely. It gives students an opportunity to work with a faculty member and choose a subject of their own choice.</p> <p>Supplementary Information</p> <p>(a) http://www.princeton.edu/mae/undergraduate/handbook/UG-HANDBOOK-2012-2013-FALL-2012-WEB-Edition-two.pdf on page 17 and 19</p> <p>(b) http://www.princeton.edu/cbe/undergrad/independent_work/</p>
University of California, Berkeley	Capstone Project	<p>The Master of Engineering students are to complete a capstone project worth 5 units over two semesters. The capstone project is a group project with three to five students as a team. The project serves the purpose of letting students apply their knowledge and skills to actual industry problems identified by industry partners in which students will be guided and mentored by a faculty member.</p> <p>Supplementary Information</p> <p>(a) http://funginstitute.berkeley.edu/programs/capstone-projects</p> <p>(b) http://www.eecs.berkeley.edu/Gradadm/MEngprogram.htm "Curriculum" section</p>
Johns Hopkins University	Senior Design Project	<p>It is a two semester course for undergraduate Mechanical Engineering students. Students are to work in small groups to solve specific design challenges presented by industry, government, and non-profit organizations. Sponsors will provide the individual teams funding. The project lets students draw upon the skills and knowledge they have acquired throughout the course of their study.</p> <p>Supplementary Information</p> <p>http://www.me.jhu.edu/design.html</p>



Examples of Capstone Experiences in North American Universities (cont'd)

Institution	Type of Capstone Experience	Description
University of Michigan	<p>(1) Capstone Project (with the following focus areas):</p> <ul style="list-style-type: none"> (a) Research (b) Entrepreneurship (c) Design (d) Global Operations/Business (e) Public Service <p>(2) Honors Thesis</p> <p>(3) Capstone Design Project (for ME Students)</p>	<p>(1)(2) For their Honors Program, engineering students will need to complete a capstone project or an honors thesis. The choice between doing a capstone project or an honors thesis depends on the student's educational or career goals.</p> <p>(3) The capstone design project gives Mechanical Engineering student an understanding regarding design principles. It lets student(s) experience the process of integrating and applying those engineering knowledge they have acquired into the design and manufacturing of mechanical systems.</p> <p>Supplementary Information</p> <p>(a)http://www.engin.umich.edu/academics/honors/requirements/honors-capstone-experience</p> <p>(b)http://www.engin.umich.edu/class/me450/objectives.shtml</p>
University of Toronto	Capstone Course	<p>For students majoring in Mineral Engineering, a capstone course called "Mineral Project Design" is required. The course addresses all global outcomes of the Mineral Engineering curriculum. The course is divided into two parts. Part 1 of the course is where students perform individual detailed case history analyses. Part 2 focuses on the design of a mining or civil rock engineering project, in which students are organized into groups and are given one or more data sets and a design problem to solve.</p> <p>Supplementary Information</p> <p>http://www.mineralengineering.utoronto.ca/current/curriculum/capstone.htm</p>
University of British Columbia (UBC)	Capstone Course	<p>Prior graduating from UBC, Mechanical Engineering students need to complete a capstone course called "45X Capstone Design Project". The project challenges students to apply the knowledge and skills acquired and learnt throughout their studies into real world problems. Students are to work in groups under the supervision of a faculty member. As well as to build a model of their designs and if given the necessary funding by industry partners, to build a working prototype too.</p> <p>Supplementary Information</p> <p>http://mech.ubc.ca/industry-and-alumni/45x-capstone-design/</p>



Examples of Capstone Experiences in North American Universities (cont'd)

Institution	Type of Capstone Experience	Description
University of Washington	Capstone Project	<p>Both Computer Science and Engineering students and senior Mechanical Engineering students gain capstone experience by completing a capstone project. The capstone project is a group project, in the case for ME students, the group consists of three to five students, where supervision of the project is under a faculty member. The capstone project allows students to explore the challenges of designing and to learn to fully define a design problem.</p> <p>Supplementary Information</p> <p>(a)http://www.cs.washington.edu/students/ugrad/capstone</p> <p>(b)http://www.me.washington.edu/students/undergraduate/capstone/</p>
Northwestern University	Capstone Design Project	<p>The capstone design project is for Civil or Environmental Engineering senior students. It is a group project, which develops student's all-round skills such as communication skills, data gathering skills, and designing skills.</p> <p>Supplementary Information</p> <p>http://www.civil.northwestern.edu/docs/course_outlines/course_382.pdf</p>



Examples of Capstone Experiences in Australian Universities

Institution	Type of Capstone Experience	Description
University of Melbourne	Capstone Course	<p>The capstone course, “Electrical Engineering Capstone Project”, is taken by undergraduates and postgraduates of electrical engineering streams. Students enrolled in this course will need to integrate technical knowledge and generic skills they have acquired into the project. Under the supervision of a faculty member or industry partner, the project will involve groups of two to three students.</p> <p>Supplementary Information https://handbook.unimelb.edu.au/view/2012/ELEN90067</p>
University of Queensland	Capstone Course	<p>The capstone course, “Chemical Engineering ME Design Project”, will provide capstone experience for Master of Engineering (ME) students. Students will work in groups and decide on a project of their choice. The project will allow students to cover more specific and in-depth aspects on designing/modeling through the application of skills gained in ME level courses. Aspects of entrepreneurship, building a business case and funding mechanisms for engineering projects will be covered and applied in the project too.</p> <p>Supplementary Information http://www.uq.edu.au/study/course.html?course_code=CHEE7103</p>
University of South Australia	Capstone Course	<p>The capstone course, “System Integration Project 2”, is for MEng (Military Systems Integration) students to gain capstone experience. Students are to work closely with their group members over a period of nine months. They will learn to identify resource requirements (i.e. hardware, software, and data) for generating and synthesizing a complex military/engineering system-of-systems problem by coming up with a competitive and integrated solution and put systems engineering principles into application.</p> <p>Supplementary Information http://programs.unisa.edu.au/public/pcms/course.aspx?pageid=105694</p>



Examples of Capstone Experiences in UK Universities

Institution	Type of Capstone Experience	Description
University of Oxford	Design Project	<p>A design project “The Engineering Science Third Year Design Project” is opened to engineering science students and engineering, economics and management students in their third year of study. The design project is a group project with 4 to 5 students. It aims to give students an opportunity to gain insights and experience in engineering design. Students will be involved in the process of designing, making economic decisions, and allocating work load among group members. Visiting Professors of Engineering Design will participate and provide guidance and technical advice drawn from their industrial experience.</p> <p>Supplementary Information</p> <p>(a)http://www.eng.ox.ac.uk/admissions/undergraduate/engineering-at-oxford/engineering-science</p> <p>(b)http://www.eng.ox.ac.uk/admissions/undergraduate/engineering-at-oxford/engineering-economics-and-management</p>
University of Cambridge	Design Project	<p>A design project “Integrated Design Project (IDP)” is taken by all second year engineering students (Electrical, Mechanical, and Software Engineering). Students are to work in teams (normally 6) to design, build, test and demonstrate an autonomous guided vehicle which has to perform a number of operations similar to those found in an automated factory.</p> <p>Supplementary Information</p> <p>(a)http://www.eng.cam.ac.uk/DesignOffice/idp/index.html</p> <p>(b)http://www.eng.cam.ac.uk/DesignOffice/idp/resources/current/idp_manual.pdf</p>
Imperial College London	Design Project	<p>MEng Civil Engineering students in their final term and third year of study will undertake a five week intensive group design project. The scope of the project spans across a wide range of civil engineering fields.</p> <p>Supplementary Information</p> <p>http://www.groupdesignprojects.org.uk/</p>