IEET
中華工程教育學會

Sharing of Capstone Project Experience

Prof. Liang-Jenq Leu

CEO, IEET

Chair, Canberra Accord

Professor, Civil Engineering Dept., National Taiwan University

President, Taiwan Construction Research Institute

President, Taiwan Society for Construction Safety

Immediate Past President, Taiwan Society for Circular Economy

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What might a Future Engineer Look Like

- Preparing students for the new normal post-COVID19 uncertain world includes developing new skills and re-vitalizing current skills and mental capacity for active learning, synthesis of broad and multi-disciplinary knowledge bridging natural and engineering science with social science and arts and, co-creation of sustainability solutions, curiosity, growth mind-set, and mental stress tolerance. In other words, the future ready graduates to be akin to Leonardo da Vinci (Simon Worrall, 2017).

Leonardo da Vinci

He was curious about everything and all sorts of different disciplines, and was many things: a painter, an architect, an engineer, a thinker, and a scientist. He chose to proactively interact with diverse domain experts and specialists who were mathematicians, architects, playwrights, engineers, and poets. He spent a lifetime absorbing the best of art, science, optics and the universe, which shaped his mind, abilities, and personality. He was a lively character, creative, and inquisitive just for curiosity's sake, not simply because it's useful.

Time for Sustainability Curriculum

- **Embracing sustainability is about enabling graduates future ready and giving a deeper sense of real world and life**.
- Their careers and future involve transitioning from the ‘point of use/consumption thinking’ to ‘life cycle thinking’ of products & services. Progressive and timely efforts by all stakeholders of university education would help to promote the well-being of humans as well as planet Earth. **Sustainability in curriculum will transform the minds of students, and thus enabling transition to healthy individuals, society and Earth**.

Note: https://sustainabilitycommunity.springernature.com/posts/incorporating-sustainability-into-the-university-curriculum

Key Features of Sustainability Curriculum

- Designing a sustainable curriculum is not simply adding some content knowledge into a unit or course but rather it is integrating these principles of sustainability throughout the whole unit or course and delivering the course in sustainable ways.
- Sustainable curriculum would be transformative rather than transmissive as its goal to “equip all people with the knowledge, skills and understanding necessary to make decisions based upon their full environmental, social, cultural and economic implications” (DEWHA, 2009) rather than transmissive with a goal to provide students with knowledge. It would not be specialised, content-driven units of study on sustainability but integrated across courses and units.
- Pedagogies for sustainability curriculum: cooperative, problem-based and experiential learning
- In a sustainable curriculum, connecting with the local, regional or global community is important to find relevance to the topics of interest and problems being solved

Note: https://core.ac.uk/download/pdf/41527966.pdf

7 Principles of Sustainability Curriculum

1. transformation and change (not just knowledge)
2. education for all and lifelong learning
3. systems thinking (highlighting connections between environmental, economic, social and political systems)
4. envisioning a better future (problem solving)
5. critical thinking and reflection
6. participation (engaging groups and individuals)
7. partnerships for change

Note: https://core.ac.uk/download/pdf/41527966.pdf

IEET SSR Template on Mapping SDGs Course Outcomes

A. Course Mapping

Yr	Semester	Course	Credit	Required/Elective	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16	SDG 17
2	1st	…	3	R	■																
3	1st	…	3	E	■			■													
…																					
…																					
4	2nd	…	3	E	■			■													
Total Number					3			2													

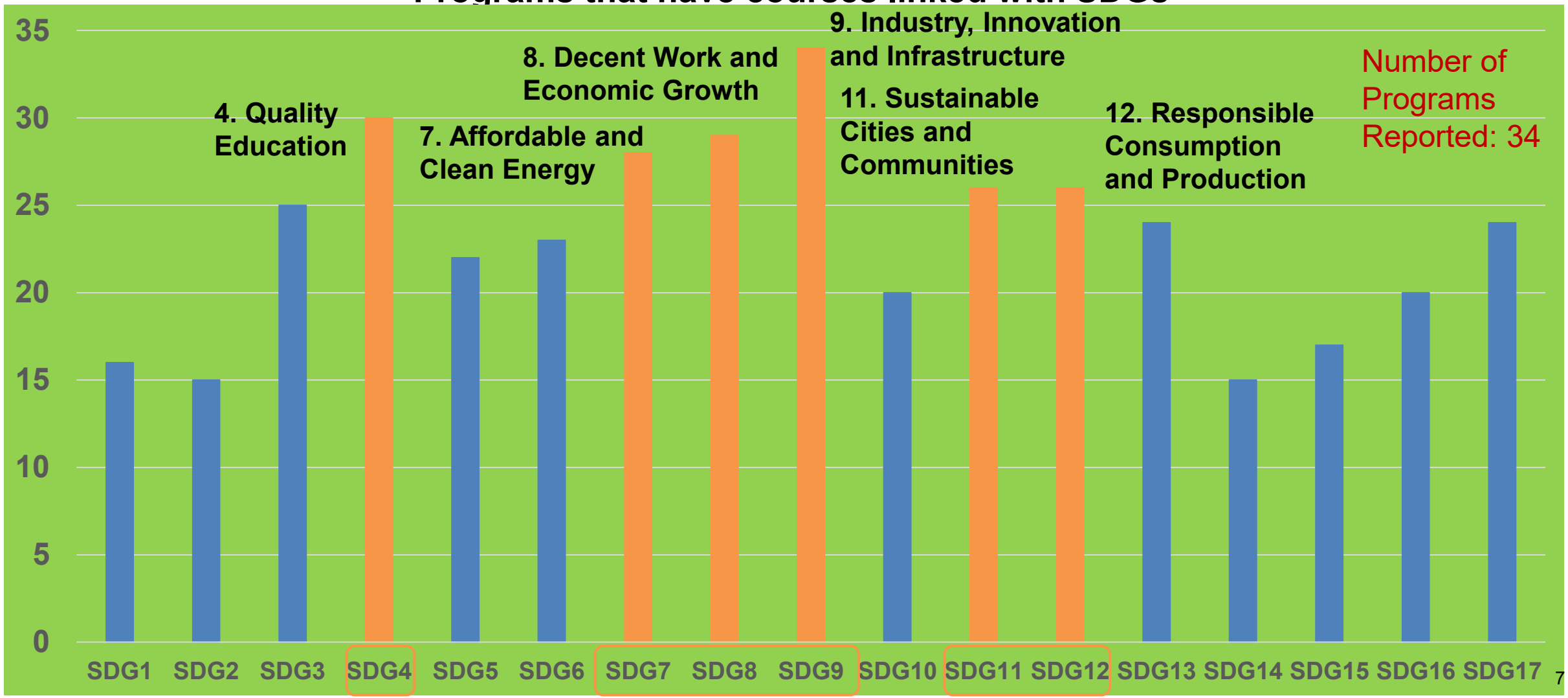
This template is to:
1. Guide programs to demonstrate SDGs-related training
2. Understand what outcomes could be mapped with what courses
3. The extend to which students of the programs are trained in SDGs

IEET:
1. Understands that not all SDGs need to/could be mapped
2. Does not require all courses to be mapped with SDGs-related outcomes
3. Some SDGs are trained in general education or extracurricular activities

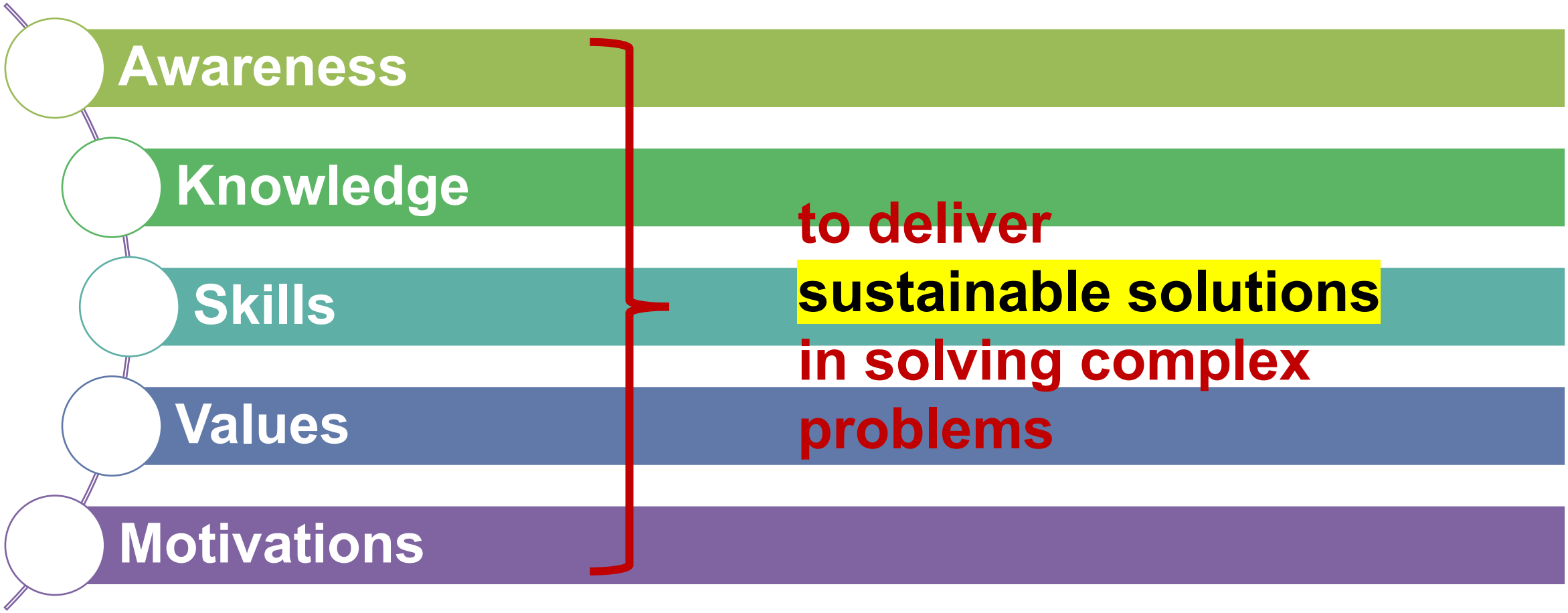
B. Intent of curriculum design/ sample of course

Reporting from IEET's Program Under Review in 2023

Programs that have courses linked with SDGs



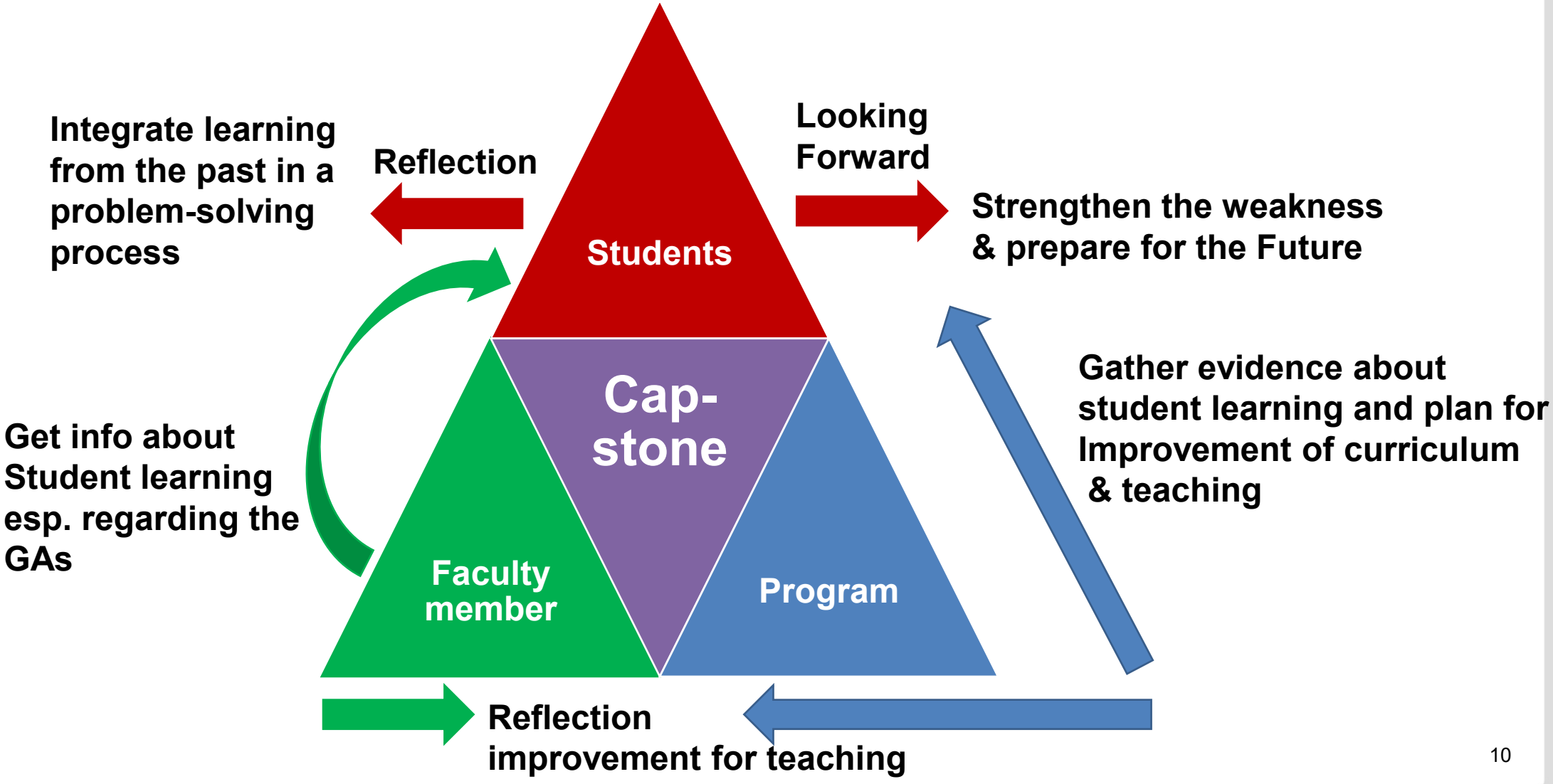
IEET Encourages Programs to Design Capstone Courses Allowing Students to Deliver SDGs Solutions



Capstone Course Trains Students to Ask Questions

- Ask the right questions (frame problems)
- Ask who they serve (putting them in a social, technical, operational context)
- Ask why they are doing it (purpose)

Capstone is the Realization of OBE



Capstone Could Assess GAs in Technical as well as Contextual Skills

Technical (Hard)

- Complex Problem Solving
- Ability to Design

Contextual (Soft)

- Teamwork, Interdisciplinary
- Communication
- Project Management (Finance)
- Life-long Learning

Capstone Should Correspond to All or Most GAs

GAs	1 ability to apply knowledge of mathematics, science, and engineering	2 ability to design and conduct experiments, as well as to analyze and interpret data	3 ability to apply techniques, skills, and modern tools necessary for engineering practice	4 ability to design an engineering system, component, or process	5 ability to manage project, communicate effectively, work in multi-disciplinary environment, and function on teams	6 ability to identify, formulate, research literature, analyze and solve complex engineering problems reaching substantial conclusions	7 knowledge of contemporary issues; an understanding of the impact of engineering solutions in the environmental sustainability, social good, and global contexts; and the ability and habit to engage in life-long learning	8 apply ethical principles and commit to professional and information ethics and responsibilities and norms of engineering practice, and a sense of respect for diversity
Core course 1	X		X					
Core course 2	X	X		X	X			
Core course 3		X	X			X		
Core course 4			X			X	X	
Core course 5				X			X	X
Core course 6					X	X		X
Capstone	X	X	X	X	X	X	X	X

Capstone is Actually an integration of 4-6 Core Courses

Freshman		Junior		Sophomore		Senior	
Required	Elective	Required	Elective	Required	Elective	Required	Elective
Required	Required	Required	Required	Required	Elective	Requ	
Required	Required	Required	Required	Required	Elective	Required	Elective
Required	Required	Required	Required	Required	Elective	Required	Elective
Required	Required	Required	Required	Required	Elective	Required	Elective
Required	Required	Required	Required	Required	Elective	Required	Elective
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Required	Required	Required	Required	Required	Elective	Required	Elective
Required	Required	Required	Rec		ve	Required	Elective
Required	Required	Required	Required	Required	Elective	Required	Elective
…	…	…	…	…	…	…	…

GA 1 2 3 4 5 6 7 8

GA 1 2 3 4 5 6 7 8

GA 1 2 3 4 5 6 7 8

GA 1 2 3 4 5 6 7 8

GA 1 2 3 4 5 6 7 8

Each of these core courses correspond to different Gas, and taken together, they should cover all of the GAs

Demonstration of Evidence: Capstone

(Student Work for Each Team Must be Kept for Evidence)

Student works could be in diverse forms

- Finished Product
- Prototype
- Simulations or other form (Design diagram)

Must require students to produce project report in paper/electronic form for assessment

Must require students to make oral presentation as part of the assessment plan

Could encourage students to participate in competitions

Capstone Assessment (Student Teams)

Course：Civil Engineering Capstone Project **Year：Junior (2nd Semester)**
Student：Team A/ Smart、Smith、Springfield **Topic：Design of Tamkang Bridge**

#	Graduate Attribute	Weight	Score	Total
1	ability to apply knowledge of mathematics, science, and engineering	10%	90	9
2	ability to design and conduct experiments, as well as to analyze and interpret data	15%	80	12
3	ability to apply techniques, skills, and modern tools necessary for engineering practice	20%	70	14
4	ability to design an engineering system, component, or process	20%	90	18
5	ability to manage project, communicate effectively, work in multi-disciplinary environment, and function on teams	10%	80	8
6	ability to identify, formulate, research literature, analyze and solve complex engineering problems reaching substantial conclusions	8%	80	6
7	knowledge of contemporary issues; an understanding of the impact of engineering solutions in the environmental sustainability, social good, and global contexts; and the ability and habit to engage in life-long learning; and	10%	87	9
8	apply ethical principles and commit to professional and information ethics and responsibilities and norms of engineering practice, and a sense of respect for diversity	7%	85	6
			Total	82

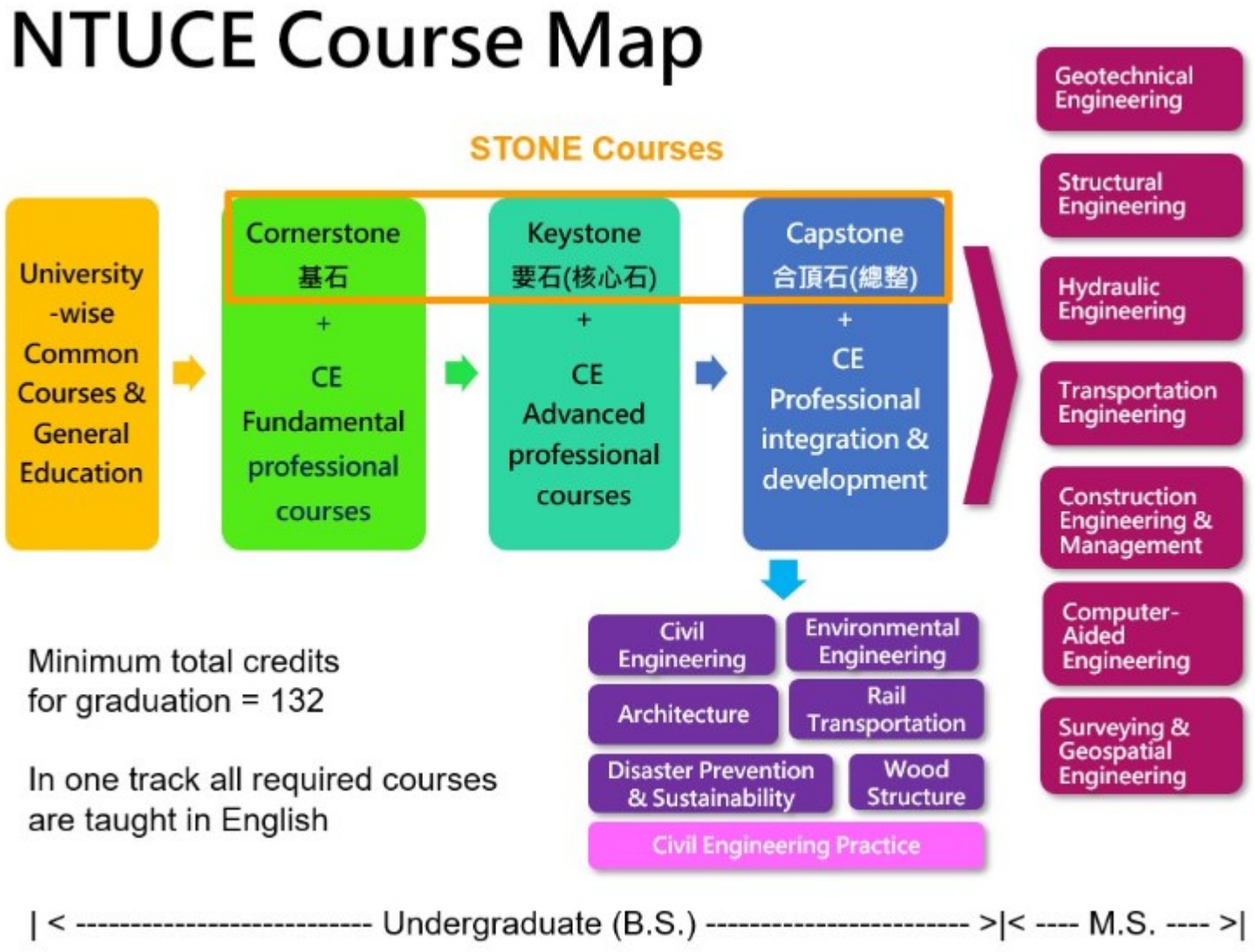
Capstone Assessment (Whole Class)

#	Graduate Attribute	Weight	Team A	Team B	Team C	Team D	Team…	Aver-age
1	ability to apply knowledge of mathematics, science, and engineering	10%	90	90	91	89	…	90
2	ability to design and conduct experiments, as well as to analyze and interpret data	15%	80	67	87	74	…	80
3	ability to apply techniques, skills, and modern tools necessary for engineering practice	20%	70	85	90	85	…	88
4	ability to design an engineering system, component, or process	20%	90	70	80	65	…	68
5	ability to manage project, communicate effectively, work in multi-disciplinary environment, and function on teams	1				65	…	72
6	ability to identify, formulate, research literature, analyze and solve complex engineering problems reaching substantial conclusions	8%	80	75	80	75	…	85
7	knowledge of contemporary issues; an understanding of the impact of engineering solutions in the environmental sustainability, social good, and global contexts; and the ability and habit to engage in life-long learning; and	10%	87	80	93	80	-	-
8	apply ethical principles and commit to professional and information ethics and responsibilities and norms of engineering practice, and a sense of respect for diversity	7%	85	78	90	85	…	86
	Team Score		82	76	86	76	…	80

Must improve the training of GA 4 and 5

In 2011, NTU-CE asked…

- Why students aren't motivated in learning?
- How do we enhance students' interest in civil engineering?
- What do we change in the curriculum to meet the industry needs?



IEET, the accreditation body asks for …

evidence of student outcomes, evidence of engineering design, evidence of student ability in solving complex problems…

IEET is the only accreditation body in Taiwan for accrediting engineering/technology/computing /architectural/design education programs, and the signatory of Washington Accord/Sydney Accord/Seoul Accord and a provisional signatory of Canberra Accord.

Using Capstone Course to assess student outcomes in complex problem solving: ability to identify, formulate, research literature, analyze and solve complex engineering problems reaching substantial conclusions (IEET Criterion 3.6)

Starting from the intake students of 2014, all students must take a major culminating design project, i.e. capstone course before graduation as required by IEET.

NTU-CE department requires all the intake students of 2013 take a capstone course before graduation, which is one year ahead of IEET's mandate.

IEET Newly Released Criterion 3 Graduate Attributes

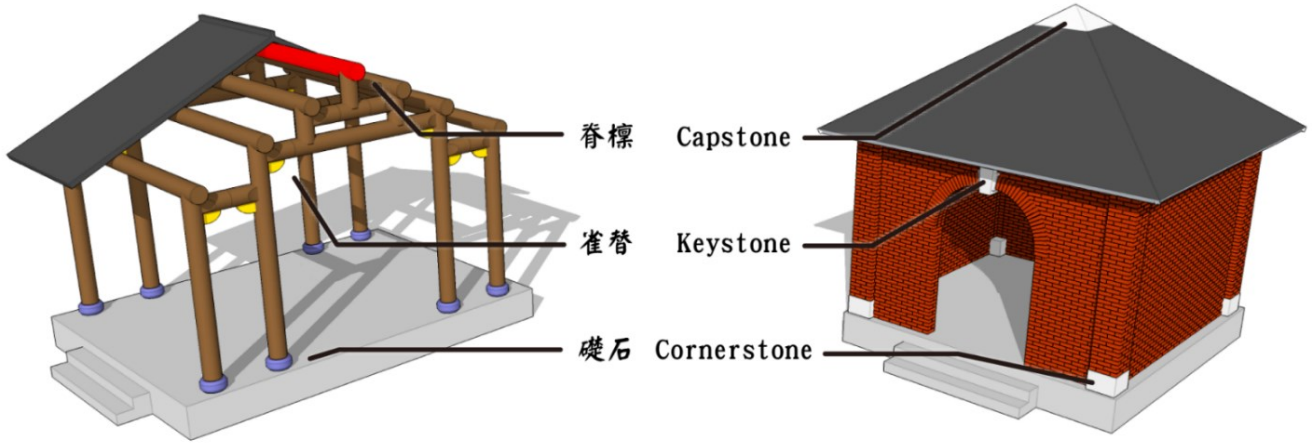
EAC (Washington Accord)

- 3.1 ability to apply knowledge of mathematics, science, and engineering;
- 3.2 ability to design and conduct experiments, as well as to analyze and interpret data;
- 3.3 ability to apply techniques, skills, and modern tools necessary for engineering practice;
- 3.4 ability to design an engineering system, component, or process;
- 3.5 ability to manage project, communicate effectively, work in multi-disciplinary environment, and function on teams;
- 3.6 ability to identify, formulate, research literature, analyze and solve complex engineering problems reaching substantial conclusions;
- 3.7 knowledge of contemporary issues; an understanding of the impact of engineering solutions in the environmental sustainability, social good, and global contexts; and the ability and habit to engage in life-long learning;
- 3.8 apply ethical principles and commit to professional and information ethics and responsibilities and norms of engineering practice, and a sense of respect for diversity.

TAC (Sydney Accord)

- 3.1 ability to apply with familiarity of knowledge, skills, and current tools required for engineering technology practice;
- 3.2 ability to conduct standard operating procedures and to design, conduct, analyze, interpret, and apply experiments to improve engineering technology practice;
- 3.3 ability to apply innovation in engineering technology practice;
- 3.4 ability to manage projects, communicate effectively and function on teams;
- 3.5 ability to identify, analyze, and solve broadly-defined engineering technology problems within realistic constraints;
- 3.6 knowledge of contemporary issues; an understanding of the impact of engineering solutions in the environmental sustainability, social good, and global contexts; and the ability and habit to engage in life-long learning;
- 3.7 apply ethical principles and commit to professional and information ethics and responsibilities and norms of engineering practice, and a sense of respect for diversity.

That's why and how NTU-CE came up with… Trilogy of Design Projects

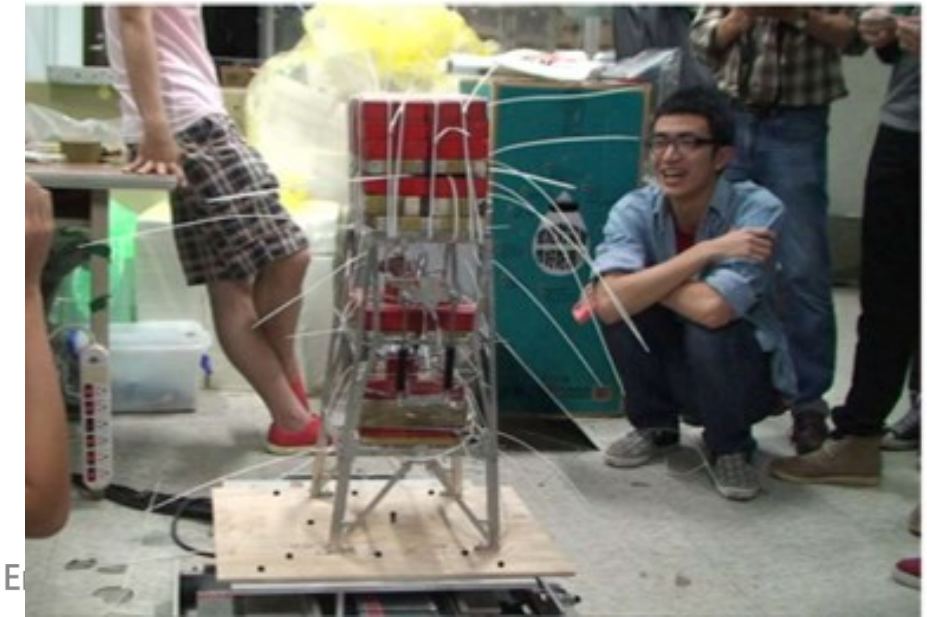


Design projects	Targeted students	Relation to disciplinary courses
Cornerstone (Compulsory) **#1 1st semester: Conceptual Design** **#2 2nd semester: Design to Fabrication Lab.**	**First year**	**Before**
Keystone (Elective) **Fluid & Structure Lab.**	**Second year**	**During**
Capstone (Compulsory) **Civil Engineering Capstone Challenge**	**Third/Fourth year**	**After**

NTU-CE: Cornerstone

In the Cornerstone stage, students implement civil engineering projects before any engineering training, to motivate their thirst for knowledge of the discipline.

During the cornerstone stage, the first-year students take two courses: Conceptual Design Studio and Physical Model Design Laboratory.



Keystone (4th Semester): Fluid & Structure Lab.

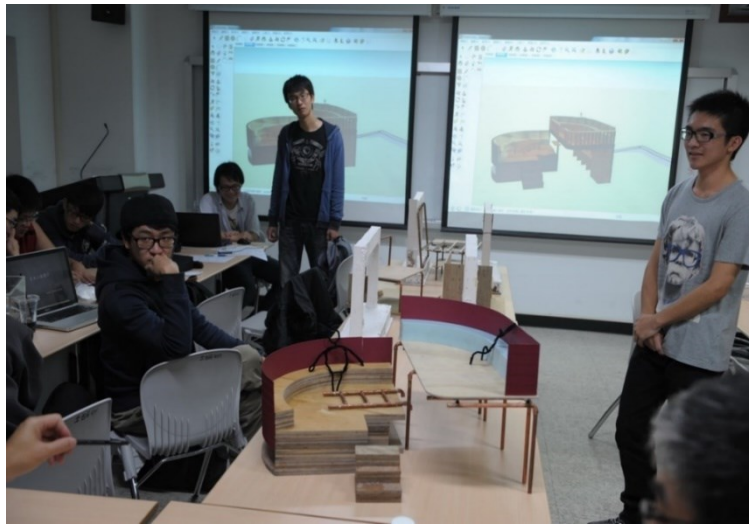
Second year students interested in hands-on projects are invited to enroll in the following 3 optional courses, called Keystone B, C and D. Each course is of 2 credits and includes a collaborative workshop with another university program.

- B: Treasure Hill Topology Workshop/ Earthquake-Resistant Tower Project
- C: Lab, Monitoring, and Design Analysis of Dike
- D: Micro Air Vehicle Project/ Tainan Floating Structure Workshop

NTU-CE
Capstone Project: 3rd or 4th Year

Team Work…Less Lecturing… Engineers Participation

Students are to design, build, test, and do oral and written reporting



Let Them Make

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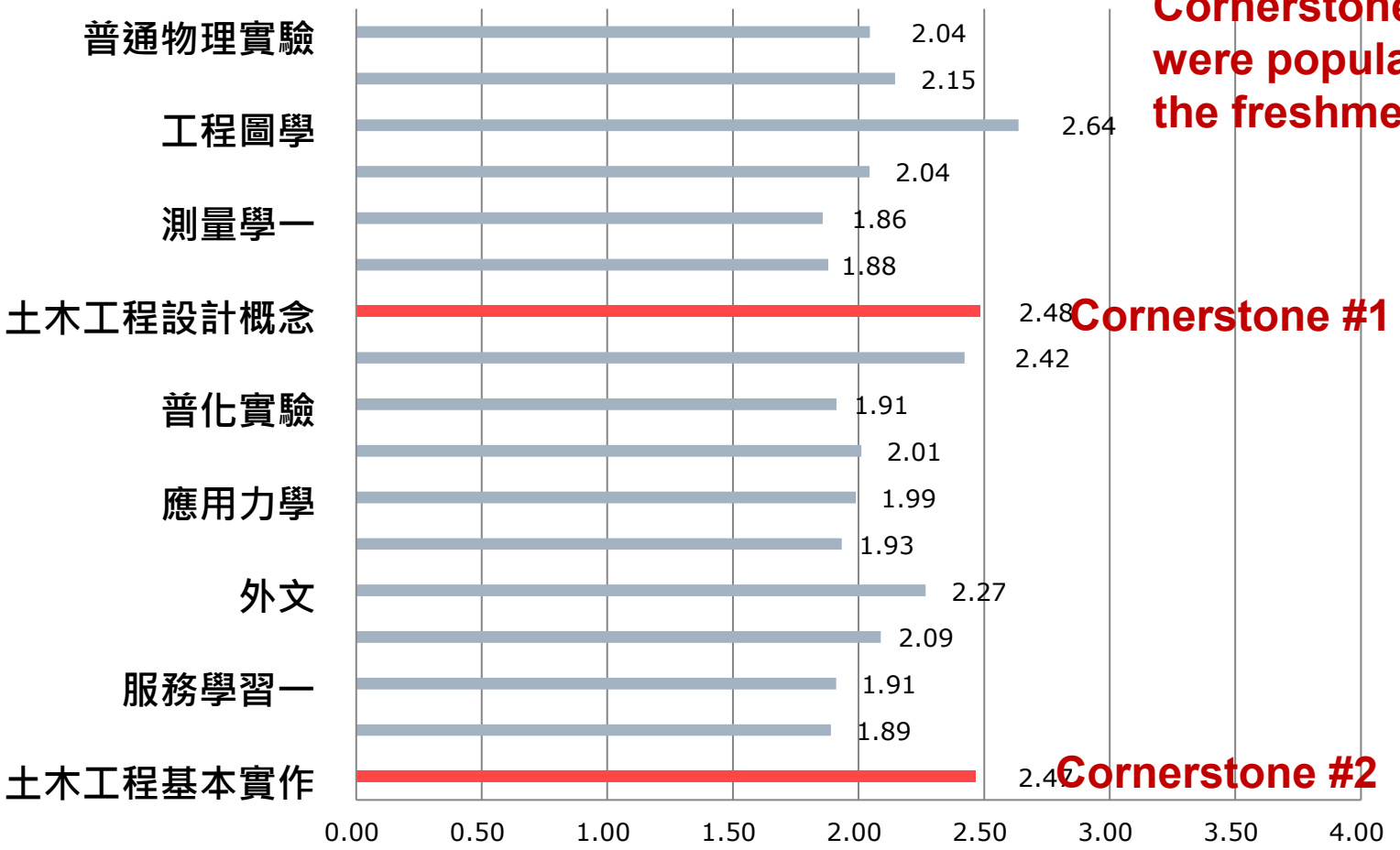
Topics for NTU-CE Capstone Design (5 Topics Every Year)

- Feasibility Assessment and Planning of a Cableway System in Xitou Forest
- Preliminary Planning and Feasibility Assessment of a Desilting and Anti-silting System in the Wushe Reservoir
- The Assessment of Design of the Humanities Building of NTU
- The Renovation of Student Space of the Civil Engineering Department of NTU
- Flood Monitoring of the Lao-Nong River and the Design of a Temporary Bridge for Emergency Evacuation
- The Retrofitting of the Student Space of the Civil Engineering Department of NTU
- The Roof Renovation and Retrofitting of the Management Building of NTU
- Design of a Pedestrian Bridge in Xitou Forest
- Safety Assessment of the Shihmen Reservoir and Disaster Prevention
- Design and Operation of a Resident Sports Center
- Building Structure Renovation and Retrofitting of the Forestry Department of NTU
- Case Study of the Road Pavement of the City Street, Greening and Revitalizing of the Apartments of South Airport
- Safety Assessment of the Hushan Reservoir
- Detailed design and prototyping of a roof-supporting wood structure for the Civil Engineering Building basement
- The Sustainable She-Zi Island – The Development Blueprint of She-Zi Island Considering the Ecosystem, the Flood Control, and the Transportation Infrastructure Plans
- Understanding of Seismic Design of Building Structures – From Structural Dynamic Experiments to Real-World Applications
- Hydropower

Student Feedback on Cornerstone



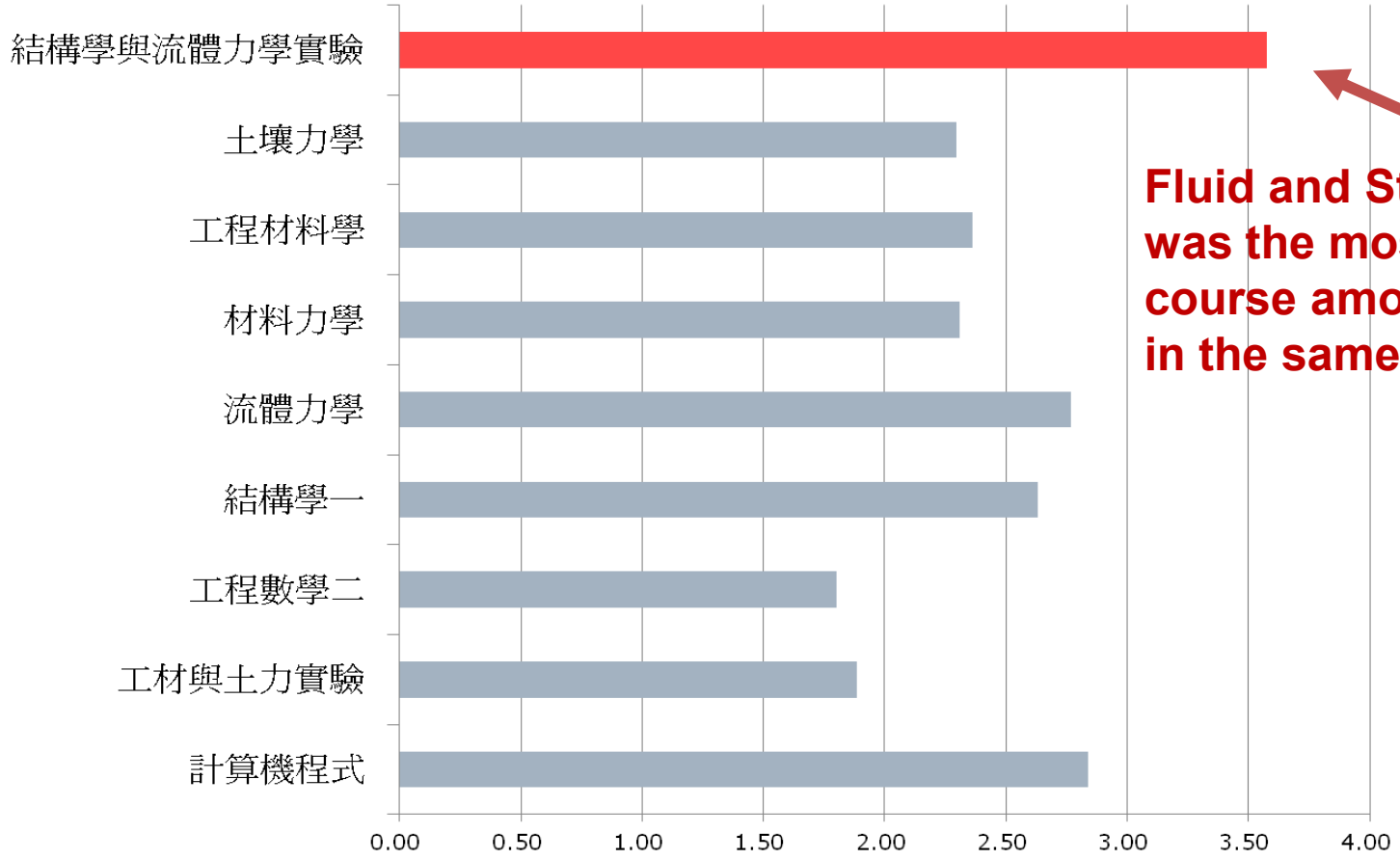
Cornerstone #1 & #2 were popular among the freshmen courses

Cornerstone #1

Cornerstone #2

Very Dislike = 0 Dislike = 1 No Comment = 2 Like = 3 Like Very Much =4

Student Feedback on Keystone



Fluid and Structure Lab. was the most popular course among courses in the same semester.

Very Dislike = 0 Dislike = 1 No Comment = 2 Like = 3 Like Very Much =4

Reflections

1. Students love the design courses more than we expected, even though the time and energy consumed were much more than the other courses.

2. NTU-CE students used to be good in theories, less prepared for engineering practice, and now the design courses changed that.

3. Students with basic design courses, such as cornerstone and keystone, perform much better in capstone than those that without.

4. TRUST THE PROCESS!

5. After all, we are training engineers for now and the FUTURE.

Sample of Capstone Project Student Outcomes

Ginkgo Bridge

Footbridge located in Xitou Forest Park, Taiwan/36 meters long and 1.6 meters wide

Designed by Xitou Bridge Design Team (Students in the Department of Civil Engineering of NTU)

Completion for use in March 2017

Harvard Graduate School of Design

Harvard Graduate School of Design

TRUST THE PROCESS

Thank You

ljleu@ntu.edu.tw