Follow-up on Rubric-Based Assessment of Student Outcomes by Senior-Year Graduation Design Project and Continuing to Improve by Performance Indicator Breakdown-Based Assessment

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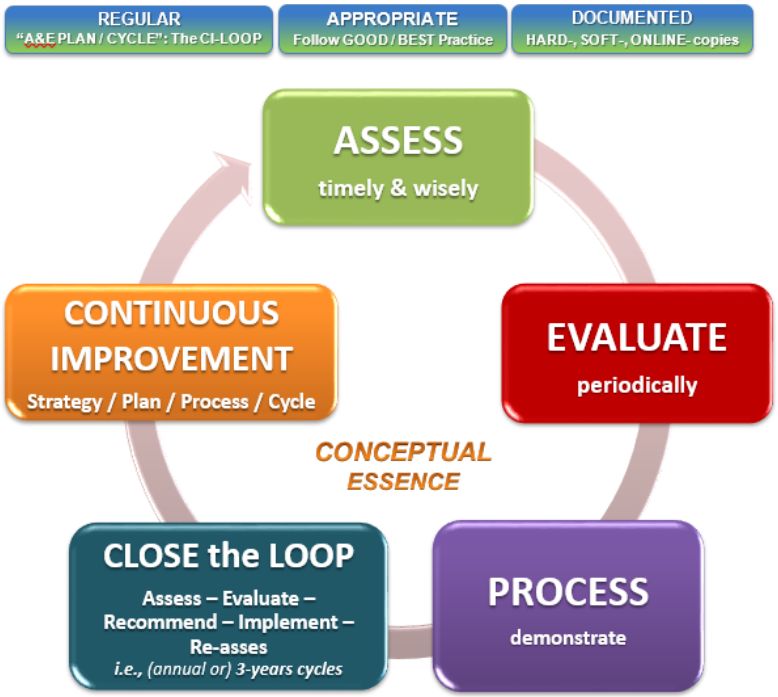

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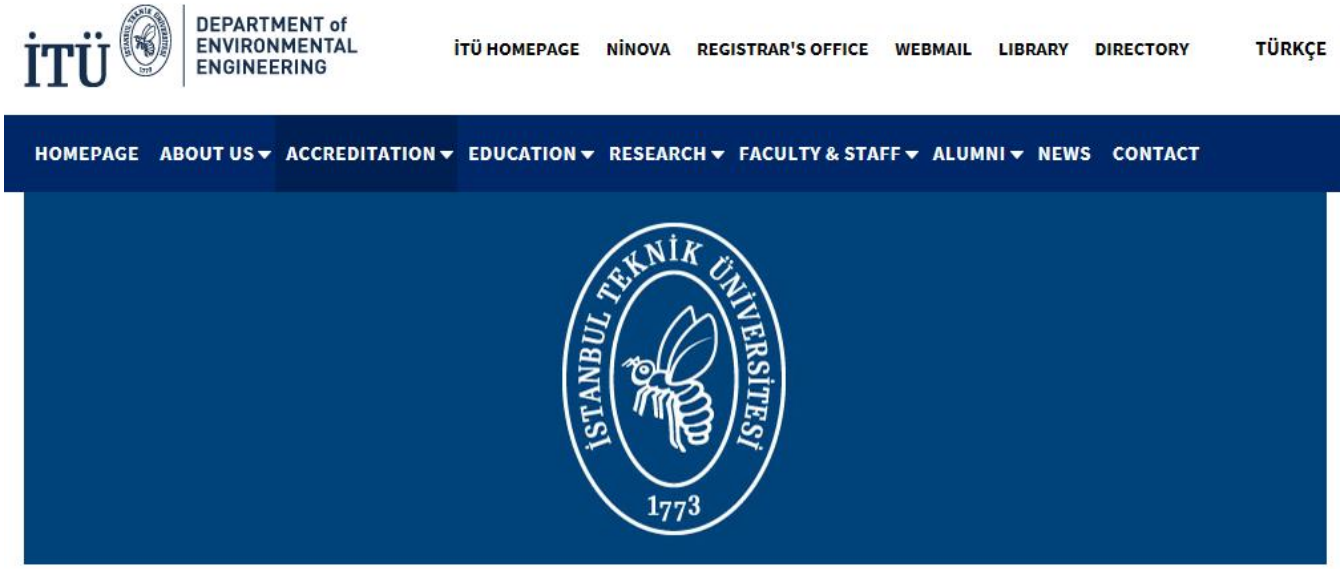
ITU / EEUP

Environmental Engineering Undergraduate Program (EEUP)

Istanbul Technical University (ITU)

- **1 out of 23 engineering undergrad programs → accredited by ABET EAC** (Engineering Accreditation Commission, www.abet.org , USA)

http://www.cevre.itu.edu.tr/en/accreditation/abet



ITU / EEUP – GDP

ITU - Environ Engr Undergrad Curriculum

- **> 50%** of total credits → **"Engineering Science" + "Engineering Design"** courses in **junior-** and **senior-years**
- **senior-year students** → ***«today's students, tomorrows' colleagues»***
- **equip them** with engr, sci & technol skills/tools useful **in professional life**

Graduation Design Project (GDP)

- one of the **anchors** of effective engineering education and of significance in design and content of ITU-EEUP → **Problem-Based Learning (PBL)**
- several **compulsory courses** (junior/senior years) → designed & taught mainly w/a specific focus on PBL → e.g. **Graduation Design Project (GDP)**
- **final engineering design course** of the curriculum (senior-year)
- designated for **summative enhancement** of the expected sum of **gradually accumulated knowledge and skill-sets** of the senior-year **students** right before graduation
- **educational objectives** include but not limited to **helping students** →
  - **improve** their **critical problem-solving skills** and **decision-making abilities**,
  - **engage** in **active** and **collaborative/cooperative learning**
  - **develop self-learning strategies**,
  - **engage** in **team-work**, **structure solutions** to **real-life problems** etc.;
- **all linked to PBL + as well as to ABET EAC Student Outcomes (SOs)**

***GDP → significant role** in **assessing** level of attainment of **several SOs** by the EEUP*

APPROACH and TOOLS – *the GDP*

Graduation Design Project (GDP)

- **Compulsory** → offered in both semesters at the **senior-year**
- **Student teams** → 4-5 students/team
- **Assignment** (18-19 weeks) → **design an environ engr system** to provide **solutions** to the **real-world environ problems** of selected regions in Turkey
- **Weekly meetings:** Student Team + 2 Profs + 2 TAs → Presentation of results
- **Weekly seminars:** invited experts from professional life

  → *Mostly: design of a WWTP (incl. sewer system, wastewater treament facility, treatment sludge handling & management, etc.]*

Project management work packages:

- overall framework,
- prep work and info collection regarding the project area:
  - population, demography, current infrastructure & public services, environ impacts, etc.
  - technical site-visits, meetings with local authorities,
- conceptual design,
- comparative evaluation of process/system alternatives,
- detailed process-, hydraulic-, and architectural-design and piping,
- instrument selection and P&I,
- brief risk assessment,
- financial analyses,
- project management,
- feasibility report,
- technical drawings,
- final project report
- defense in front of a jury and audience

NEW entries
introduced
2014-2015 Spring

APPROACH and TOOLS – *Student Outcomes*

Student Outcomes (SOs) addressed by the GDP

[3]:Emphasized(Assessed&Evaluated): **SO1, SO3, SO4, SO5, SO7, SO8, SO11**
corresponding to the ABET EAC student outcomes of (a), (c), (d), (e), (g), (h), (k), respectively.

SO# ABET EAC (a to k)	Description *(Student Outcomes: knowledge, skills, abilities of students at the time of their graduation)*
SO-1 (a)	An ability to apply knowledge of mathematics, science, and engineering
SO-3 (c)	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
SO-4 (d)	An ability to function on multidisciplinary teams
SO-5 (e)	An ability to identify, formulate, and solve engineering problems
SO-7 (g)	An ability to communicate effectively
SO-8 (h)	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
SO-11 (k)	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

APPROACH and TOOLS – *Assessment Tools - I*

Assessment → from 2010-11 Spring to 2014-15 Spring

***9 consecutive semesters** / 272 senior students (210+62)*

Tools for SO1, SO5, SO8 A&E:

- *OBEx (Outcome-Based Exam):* specific questions addressing those SOs, → asked in the "technical exam" given by the end of each semester

Tools for SO3 A&E:

- in the first 4 runs, results from OBEx questions
- in the next 5 runs, scores from the relevant parts of the GDP-Rubric

Tool for SO4 A&E:

- analytic rubric comprised of 4 PIs, designed by the assigned faculty (SO4-coordinator) for assessing students' performances in team-work

Tool for SO7 A&E:

- two analytic rubrics, each comprised 6-8 PIs, designed by the assigned faculty (SO7-coordinator) for assessing students' abilities in written and oral communication

Tool for SO11 A&E:

- Drawings: scores collected by the student-teams from the "Technical drawings" chapters of their GDP final reports

APPROACH and TOOLS – *Assessment Tools - II*

GDP-specific grading rubric (2010-11 Spring)

Detailed and comprehensive rubric, designed specifically for GDP assignments

Introduced in 2010-11 Spring to assess student performance on all features of the GDP assignment

both for grading and for SO A&E between 2010-11 and 2014-15 Spring terms (9 consecutive semesters)

Main sections w/ various sub-sections:

- **content quality and technicalities → 18%**
- **process and system design → 60%**
- **cost analysis → 18%**
- **time and project management → 4%**

Further details given elsewhere

APPROACH and TOOLS – *Assessment Tools - III*

1st Remedial Action to Improve the Assessment Tools (2015-16 Fall)

2015-16 ABET EAC Program Criteria for Environ Engr → new themes:

"The curriculum must prepare graduates to……; design environmental engineering systems that include considerations of

- ***risk,***
- ***uncertainty,***
- ***sustainability,***
- ***life-cycle principles,***
- ***environmental impacts; and***
- ***apply advanced principles and practice relevant to the program objectives.***

NEW entries
introduced
2014-2015 Spring

The curriculum must prepare graduates to understand concepts of

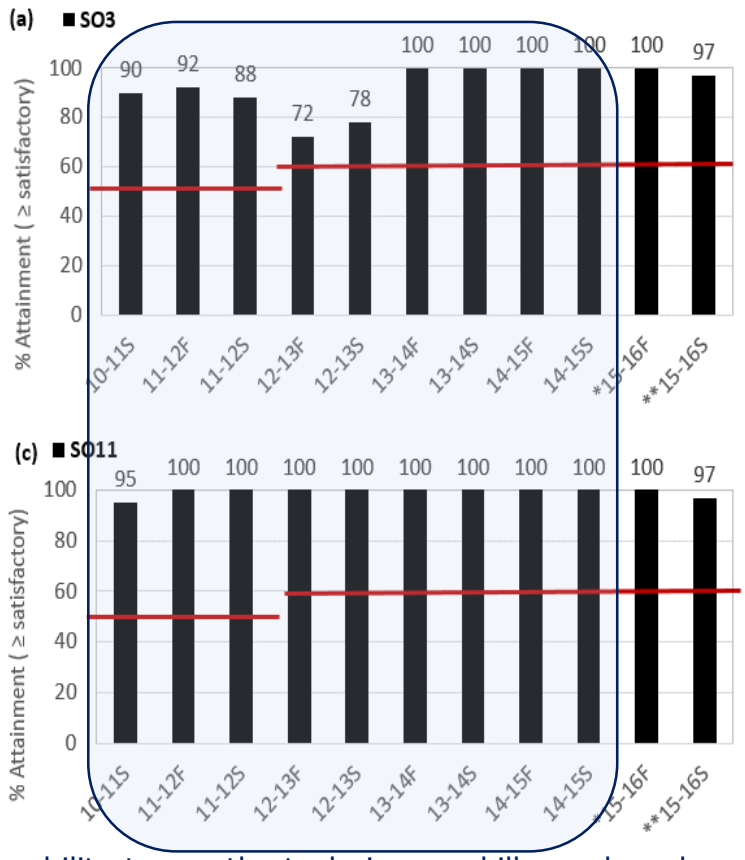
- ***professional practice,***
- ***project management, and***
- ***the roles and responsibilities of public institutions and***
- ***private organizations pertaining to environmental policy and regulations."***

2014-15 Spring → new themes introduced to the GDP assignment
2015-16 Fall → related PIs incorporated to the GDP grading-rubric
→ GDP-iRubric

Assessment RESULTS – I

SO-3: An ability to design a system, component, or process to meet desired needs within realistic constraints…….

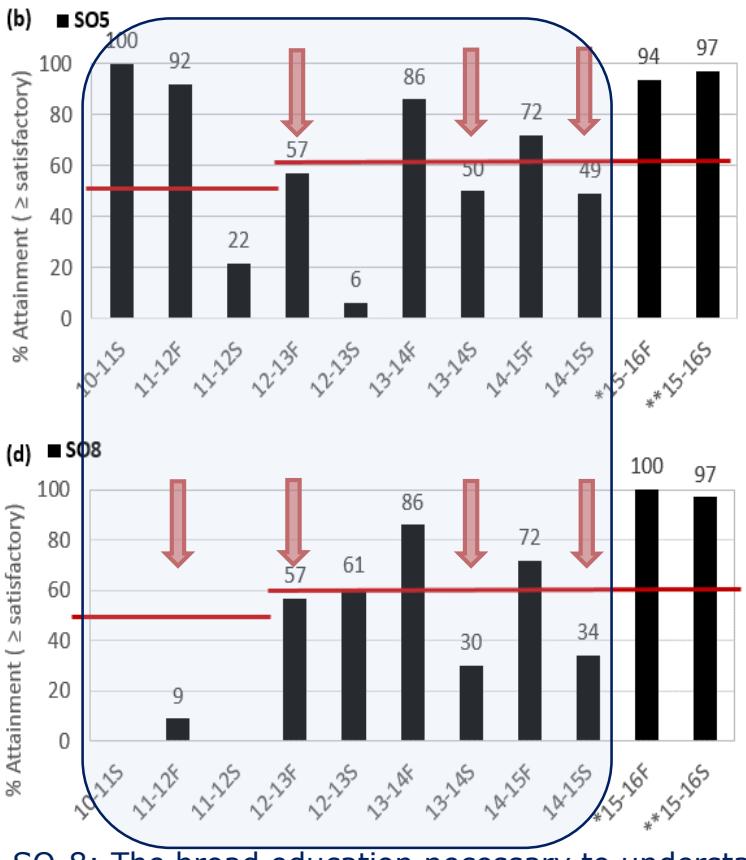
Above threshold all years



SO-11: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

SO-5: An ability to identify, formulate, and solve engineering problems

Below threshold some years



SO-8: The broad education necessary to understand the impact of engineering solutions in a global, economic, environ, and societal context

Fig. 1. Overall assessment of level of attainment (at or above "satisfactory") of SO3 (a), SO5 (c), SO8 (b), and SO11 (d) by the GDP in 11 consecutive semesters between 2010-11 Spring and 2015-16 Spring terms. Horizontal lines show the set thresholds.
*See Table 1 for the additional assessment tools used in *2015-16 Fall and **2015-16 Spring terms*

EVALUATION – I

Considering

- features, objectives, content, and operation of the GDP, and the final product –the report prepared by student teams-,
- *recent addition of the new EMC titles both to the assignments and to the grading rubric (GDP-iRubric);*

RESULTS below thresholds (e.g., SO5, SO8) seemed CONTRADICTORY

PROBLEM?

in STUDENTS' PERFORMANCES or in ASSESSMENT TOOLS?

→ NEED for REMEDIAL ACTIONS →

I- assessment tools need to be **improved/changed →**

Use of IMPROVED / ADDITIONAL TOOLS

II- aggregative measures of students' performances were **required to be broken down** to **address individual SO-related PIs →**

PI BREAKDOWN-BASED ASSESSMENT

Assessment Plan & RESULTS – II

Assessment Plan & **Comparative Results:** Level of Attainment of the SOs by the GDP **(2014-15 S, 2015-16 F)** and **Recently Added Assessment Tools (2015-16 S)**[i]

	% Level of Attainment[a,b]								Assessment Tool USED		Assessment Tool ADDED
	U		D		S		O				
SO#	14-15S	15-16F	14-15S	15-16F	14-15S	15-16F	14-15S	15-16F	14-15S[c,f]	15-16F[d,e,g,h]	15-16S[i]
SO1	40	0	11	31	40	19	9	50	OBEx	OBEx	SO1-Rubric
SO3	0	0	0	0	9	25	91	75	GDP-Rubric	GDP-iRubric[d]	SO3-Rubric
SO4	0	-	0	-	6	-	94	-	SO4-Rubric[f]	Survey[g]	SO4-Rubric
SO5	11	0	40	6	38	75	11	19	OBEx	OBEx	SO5-Rubric
SO7	0	0	0	0	9	19	91	81	SO7-Rubric *(Oral)*	SO7-Rubric *(Oral)*	SO7-Rubric *(Written)*
SO8	32	0	34	0	19	25	15	75	OBEx	GDP-iRubric[h]	SO8-Rubric
SO11	0	0	0	0	9	0	91	100	Drawings	Drawings[e]+ OBEx[e]	SO11-Rubric

a-# of senior-year students assessed: 2014-15 Spring and 2015-16 Fall: 47 & 16;

b-SO assessment performance vectors: U: Unsatisfactory, D: Developing, S: Satisfactory, O: Outstanding;

c-Tools used (before and) in 14-15S: "OBEx"- Outcome Based Exam, "GDP-Rubric, "SO4 and SO7"-specific Rubrics, "Drawings"-Technical drawings chapter of GDP final report;

d-Additional/improved tools used in 15-16F: "GDP-iRubric"- based on overall grades;

e-Additional/improved tools used in 15-16F: sum of scores obtained from (i) question asked in OBEx (60%) and (ii) technical drawing chapter of GDP final report graded in the GDP-iRubric (40%);

f-Scores given to each student by the Advisory Team in the SO4-Rubric;

g-Mini survey (4 questions) given to senior-year students at OBEx;

h-Additional/improved tools used in 15-16F: sum of scores obtained from "Environmental Management Considerations" and "Cost Analysis" chapters of GDP final report (graded in the GDP-iRubric);

i-Additional/improved tools recently recommended and used in 15-16S: rubric-based assessment of SOs with **PI breakdown-based approach**

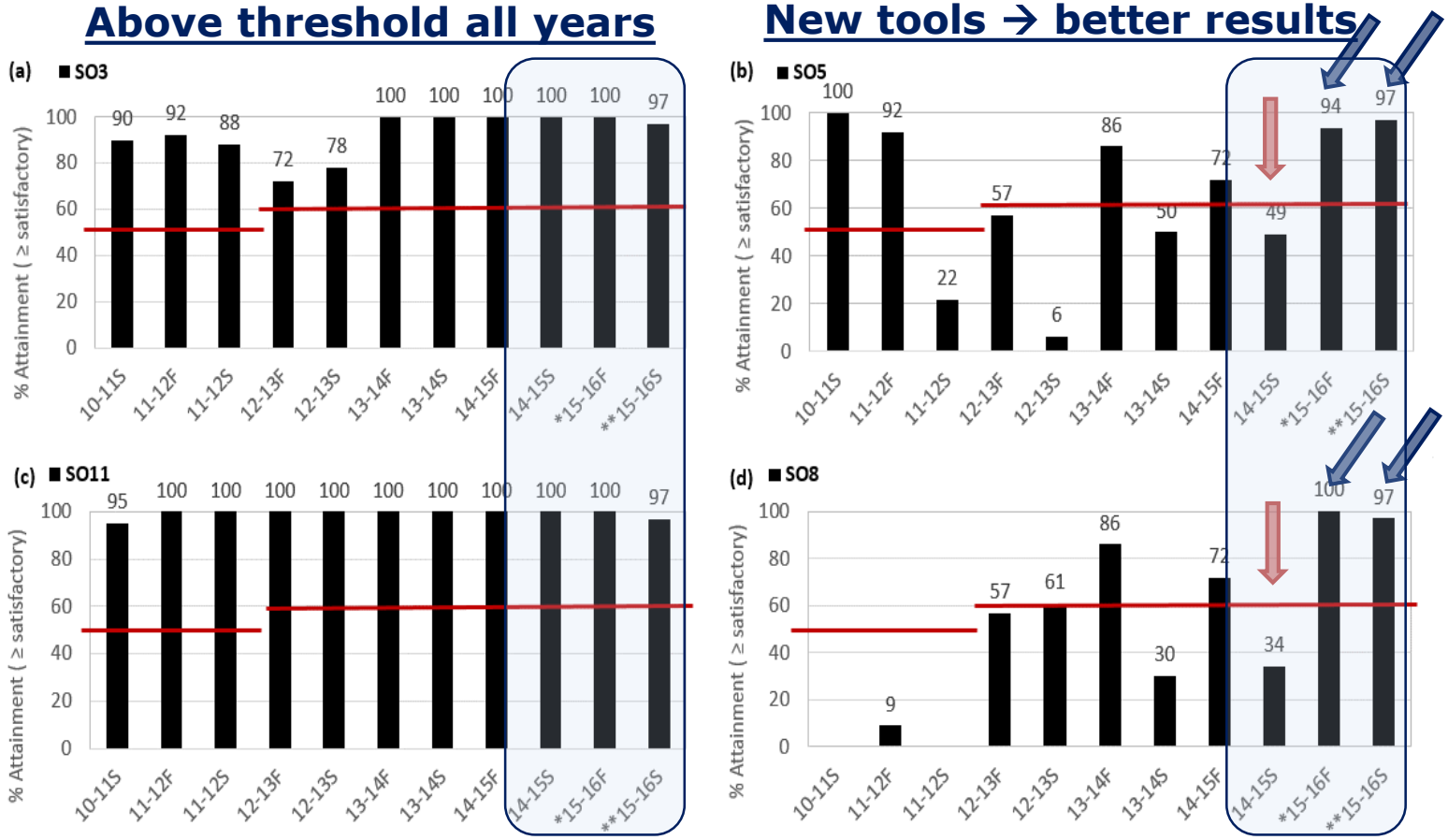
Assessment RESULTS – III

SO-3: An ability to design a system, component, or process to meet desired needs within realistic constraints…….

Above threshold all years

SO-5: An ability to identify, formulate, and solve engineering problems

New tools → better results



SO-11: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

SO-8: The broad education necessary to understand the impact of engineering solutions in a global, economic, environ, and societal context

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*See Table 1 for the additional assessment tools used in *2015-16 Fall and **2015-16 Spring terms*

APPROACH and TOOLS – *Assessment Tools - IV*

2nd Remedial Action to Improve the A&E Process (2015-16 Spring)

- **Determine** senior-year students' **strengths** and **weaknesses**,
- Better insight, more **elaborate** and **informative** A&E process,

"PI breakdown-based" assessment

assess students' performances *both by;*

- *using* ***GDP-iRubric*** *and other assessment tools,*
- *using* ***detailed analytic rubrics specifically designed for each SO*** *addressed by the GDP.*

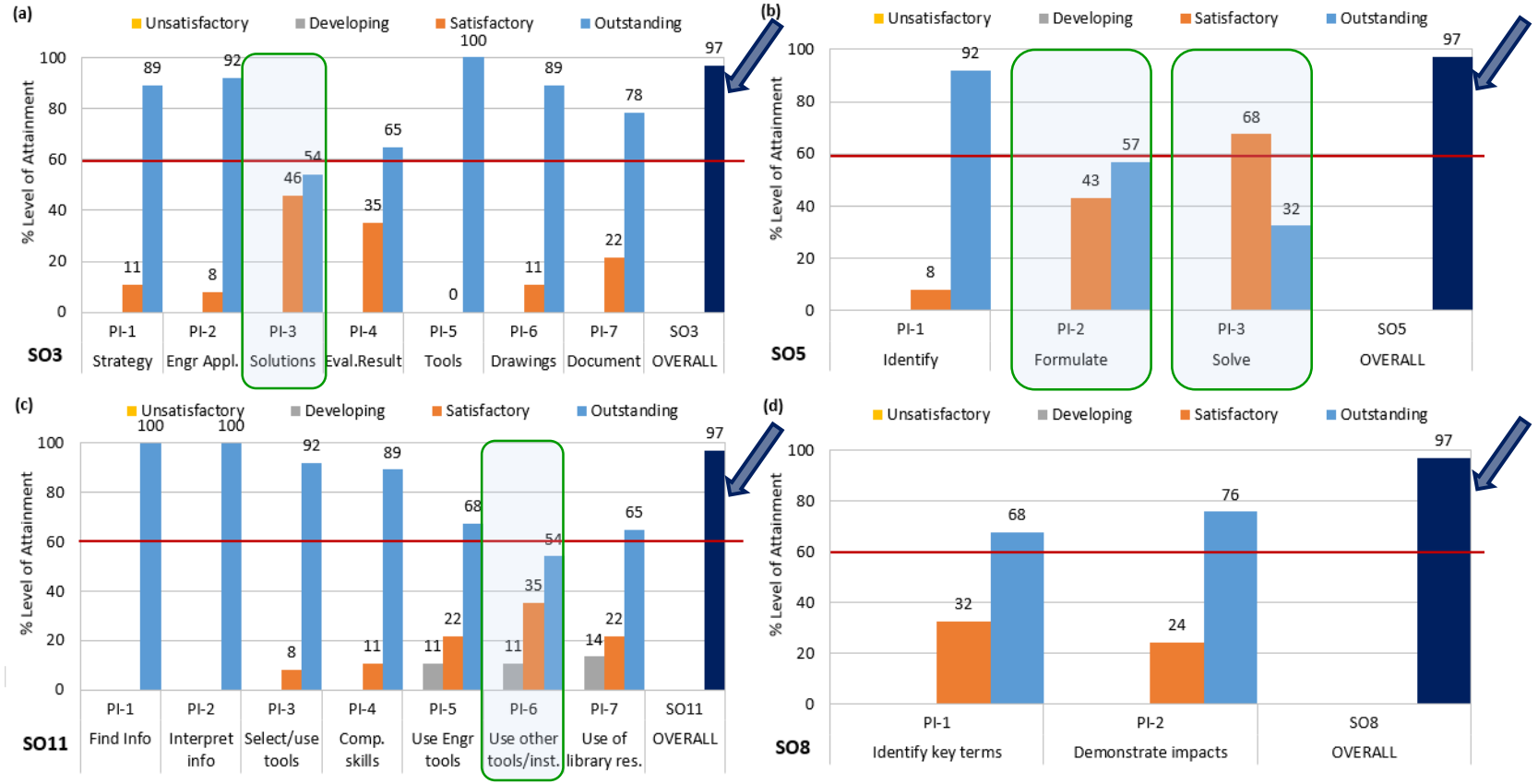
STUDENT OUTCOME 5: An ability to identify, formulate, and solve engineering problems						
PI #	Performance Indicator [Weight]	Unsatisfactory	Developing	Satisfactory	Outstanding	Score
		1 point	*2 points*	*3 points*	*4 points*	Max
PI1	Identification of the problem [1]	Most students are unable to identify problems (even those that were explicitly discussed in class)	Most students struggle with identification of the problem	Most students identify and describe issues associated with the situation of interest	Most students identify and describe issues associated with the situation of interest and assemble new information from multiple sources	4
PI2	Formulation of the problem [1]	Most students are unable to describe environmental engineering problem solving approaches	Most students struggle with the identification of engineering principles necessary for formulation of the problem	Most students demonstrate sufficient ability to formulate the problem by using basic mathematical, science and engineering knowledge	In addition to formulation of the problem, most students examine different approaches to solving the problem in order to choose the more effective approach	4
PI3	Solution to the problem [1]	Most students are unable to provide a correct answer/solution	Most students are able to provide a nearly correct answer within reasonable and logical range, but need improvement on problem solving ability	Most students demonstrate clear ability to solve problems	In addition to providing a solution, most students assess solutions relative to measures of effectiveness and feasibility	4
OVERALL PERFORMANCE		Unsatisfactory	Developing	Satisfactory	Outstanding	TOTAL
POINTS REQUIRED		0-3	4-6	7-9	10-12	12

Informative RESULTS – IV → *w/ PI-breakdown*

SO-3: An ability to design a system, component, or process to meet desired needs within realistic constraints…….

SO-5: An ability to identify, formulate, and solve engineering problems

Strengths & Weaknesses APPARENT → Valuable info for further fine-tuning



SO-11: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

SO-8: The broad education necessary to understand the impact of engineering solutions in a global, economic, environ, and societal context

Fig. 2. Comparison of **overall** (at or above "satisfactory") **and PI-based assessments (w/ performance vector details)** of level of attainment of SO3 (a), SO5 (b), SO8 (d), SO11 (c) by GDP in **2015-16 Spring**. Horizontal lines show the designated threshold.
See Table 1 for the additional assessment tools used in 2015-16 Spring

CONCLUSIONS

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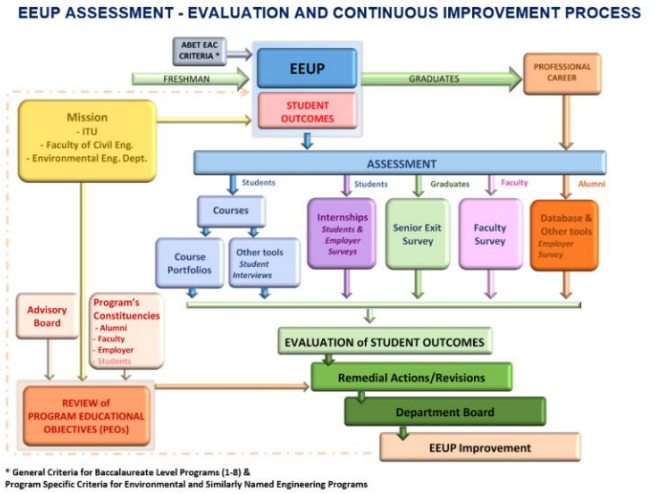
Continuous Improvement Strategies (CIS)

- Not only in **Education**
- But also in **Assessment and Evaluation (A&E)**



Appropriate **remedial actions;** successfully **implemented** in 2015-16 Fall and Spring terms → **A&E process continues**

"New assessment tools" incorporated → 2015-16 Fall

"PI-breakdown" based assessment implemented → 2015-16 Spring

→ *facilitated attainment of **more realistic** and **meaningful results***

→ *enabled **determining** the particular **performance indicators**, at which **students' abilities might be improved further***

→ *provided **insight** for **further fine-tuning** of **education** and **A&E***

RECOMMENDATIONS

Continuous Improvement Strategies (CIS)

- **Results of "PI breakdown-based assessment"**
- **"Suggestions for Changes" by the GDP Coordination Team**
- **"Recommendations for Changes" by the SO-Coordinators**

All **communicated** to the related responsible bodies *(i.e., Dept. Admins, Curriculum Development Committee, Accreditation Coord. Committee, etc.)*

→ for further **discussion** and **evaluation**

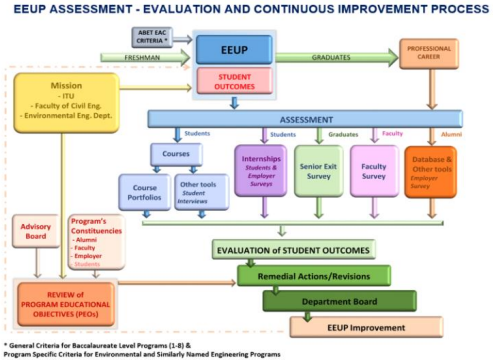
→ prior to be directly implemented in the next run

→ course-level "remedial action decisions - RADs"

To be **communicated** to the *higher administrative units*

→ for **discussion** and **approval**

→ curriculum-level "remedial action decisions - RADs"



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THANK YOU

for

YOUR ATTENTION

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WHAT's NEW in ABET?

Changes in Program Criteria for Environ Engr

ABET EAC 2010-2011 Prog Criteria

1. Curriculum

The ***program*** must ***demonstrate the graduates have***:

- ***proficiency in*** mathematics through differential equations, probability and statistics, calculus-based physics, ~~***general***~~ ***chemistry***, an earth science, ~~e.g., geology, meteorology, soil science, relevant to the program of study~~, a biological science, ~~e.g., microbiology, aquatic biology, toxicology, relevant to the program of study~~, and fluid mechanics ~~relevant to the program of study~~;
- ***introductory level knowledge of environmental issues associated with*** air, ***land***, and water systems ~~and associated environmental health impacts~~;
- ~~an ability to~~ conduct laboratory experiments and to ~~critically~~ analyze and ***interpret data*** in more than one major environmental engineering focus areas, e.g., air, water, land, environmental health;
- ~~an ability to~~ ***perform engineering design by means of design experiences integrated throughout the professional component of the curriculum***;
- ***proficiency in*** advanced principles and practice relevant to the program objectives;
- understanding of concepts of professional practice and the roles and responsibilities of public institutions and private organizations pertaining to ***environmental*** ~~***engineering***~~.

ABET EAC 2015-2016 Prog Criteria

1. Curriculum

The **curriculum** must **prepare graduates to**

- **apply knowledge** of mathematics through differential equations, probability and statistics, calculus-based physics, **chemistry (including stoichiometry, equilibrium, and kinetics)**, an earth science, a biological science, and fluid mechanics.

The curriculum must prepare graduates to

- **formulate material and energy balances**, and **analyze the fate and transport of substances in and between** air, water, and **soil** phases;
- conduct laboratory experiments, and analyze and **interpret the resulting data** in more than one major environmental engineering focus area, e.g., air, water, land, environmental health;
- **design environmental engineering systems that include considerations of risk, uncertainty, sustainability, life-cycle principles, and environmental impacts;** and
- **apply** advanced principles and practice relevant to the program objectives.

The curriculum must prepare graduates

- **to understand concepts of professional practice, project management, and the roles and responsibilities of public institutions and private organizations pertaining to environmental policy and regulations.**