Quality Assurance of Engineering Education by Outcome Based Evaluation

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Self Introduction of Mitsunori Makino

- Graduated from Waseda University
  - B.Eng. in 1987, M.Eng. in 1989, Dr. Eng. in 1992
- Faculty member of Chuo University since 1992
  - 2004- : Professor
  - 2008- : Leader of Rubric-based Competency Development Project, Faculty of Science and Engineering, Chuo University, (www.facebook.com/ChuoCompetency)
  - 2009-2013: Vice Dean, Faculty of Science and Engineering
- JABEE
  - Chairperson of Criteria Committee, JABEE (www.jabee.org)

Outline

- What is “outcomes-based” ? Quality assurance of higher education
  - Input-based vs. outcomes-based
- Washington Accord --- World-wide accreditation alliance of engineering education
- How to assess graduates’ knowledge and performance
  - Rubric
  - Rubric for achievement in a course
  - Rubric for achievement for ….
- Discussion
- Conclusion

What is quality assurance, especially in higher education?

- The maintenance of a desired level of quality in a service or product, especially by means of attention to every stage of the process of delivery or production.

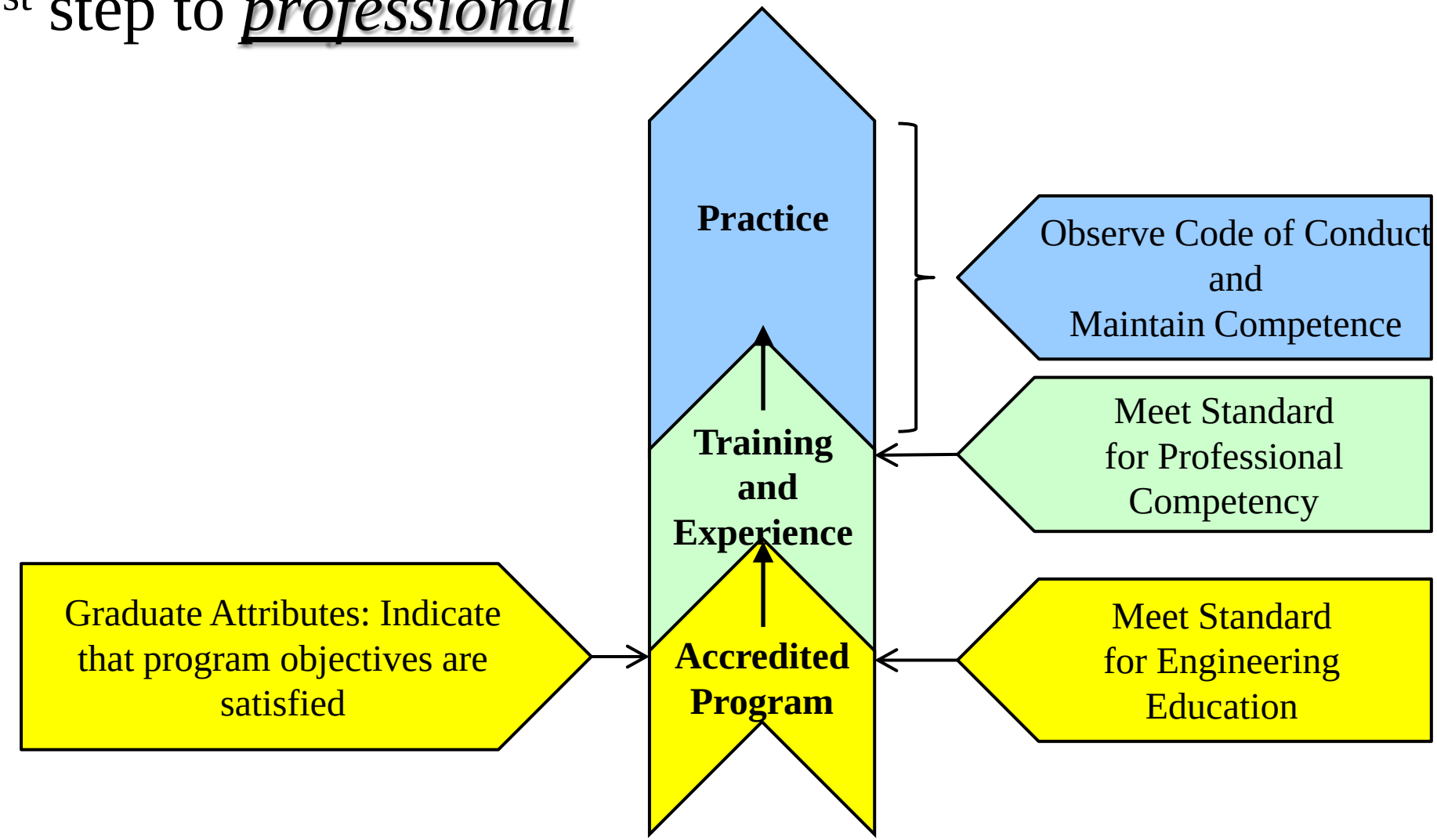
  from Oxford Dictionary

  (http://www.oxforddictionaries.com/definition/english/quality-assurance?q=quality+assurance)

- In the higher education…
  The maintenance of a desired level *or higher* of quality in *graduates* by means of attention to every stage of *the education system*

Why do we need the quality assurance in engineering education by the third party? (1/2)

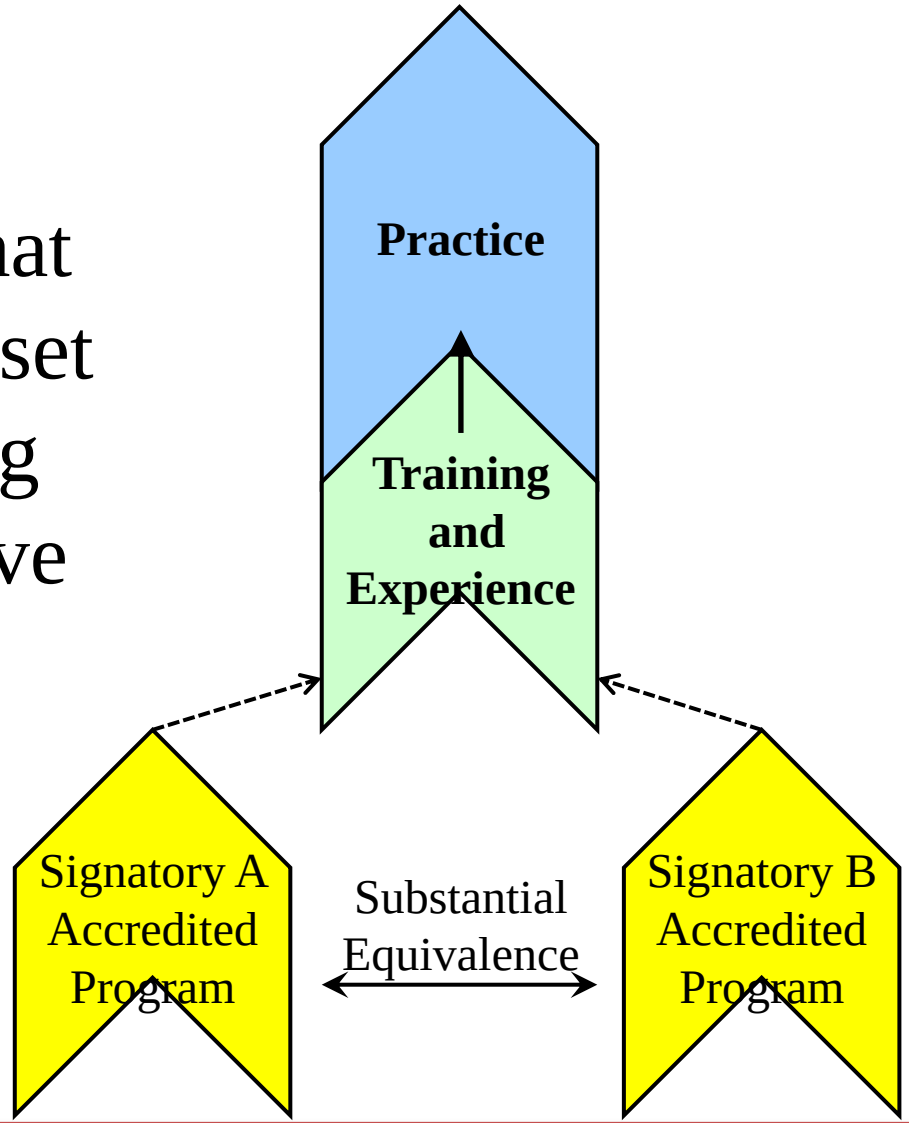
- The 1st step to ***professional***



Why do we need the quality assurance in engineering education by the third party? (2/2)

- The ***substantial equivalence*** in the world:

  Applied to educational programs means that two programs, while not meeting a single set of criteria, are both acceptable as preparing their respective graduates to enter formative development toward registration.



How can we show the quality of engineering education?

- Contents, environment
  - Book of Knowledge
- Environment
  - Budget
  - Facilities
- *Outcomes*
  - Skills & competencies of graduates based on professional knowledge

Benchmarks for what?

Necessity of "educational objective" & "performance criteria"

- Project/Research output (accepted papers, patents...)
- Enrollment numbers in professional qualification
- Employment as engineer
- …

Educational outcomes must inevitably given, not happen

- Educational program is planned in advance, connected with its goal and/or objectives, about graduates' performance and knowledge (not "what is taught" but "what is equipped")

- If so, the educational program can be trusted as assured human resource development. (Graduates are expected a certain level of their knowledge and competency)

Graduate Attributes & Disclosure of Three Policies of Admission, Curriculum and Diploma by MEXT

Exemplified graduate attributes:

1. Knowledge and understanding
   - i. Understanding of knowledge of multiple/different cultures
   - ii. Understanding of knowledge of human culture, society and nature
2. Versatile skill
   - i. Communication skill
   - ii. Quantitative skill
   - iii. Information literacy
   - iv. Logical thinking
   - v. Problem solving
3. Behaviors and intentionality
   - i. Self-control
   - ii. Teamwork and leadership
   - iii. Ethics
   - iv. Social responsibility as civil
   - v. Ability of lifelong learning
4. Integrated learning experiences and creative thinking

Each university in Japan has and discloses its diploma policy regarding the attributes

IEA Graduate Attributes

- The 2nd version was released in June 2009, modified in 2013
- Graduates of engineering schools should equip both of “Engineering Knowledge” and “Graduate Attributes”.
- These profiles are defined for
  - Washington Accord (WA): Engineering education
  - Sydney Accord (SA): Technologist education
  - Dublin Accord (DA): Technician education

Washington Accord Membership (as of 2013)

Accreditation bodies	Provisional status	Signatory
6 Founding Members		1989
HKIE (HK)	No system at that time	1995
ECSA (South Africa)	1994	1999
JABEE (Japan)	2001	2005
IES (Singapore)	2003	2006
BEM (Malaysia)	2003	2009
ASIIN (Germany)	2003 but was removed in 2013	
ABEEK (RP Korea)	2005	2007
IEET (Chinese Taipei)	2005	2007
AEER (Russia)	2007	2012
AICTE (India)	2007	
IESL (Sri Lank)	2007	
MUDEK (Turkey)	2010	2011
PEC (Pakistan)	2010	
COE (Thailand)	Submitted in 2010 but was differed	
BAETE (Bangladesh)	2011	
CAST (PR China)	2013	
PTC (The Philippines)	2013	
Indonesia	Interest	
Peru	Interest	

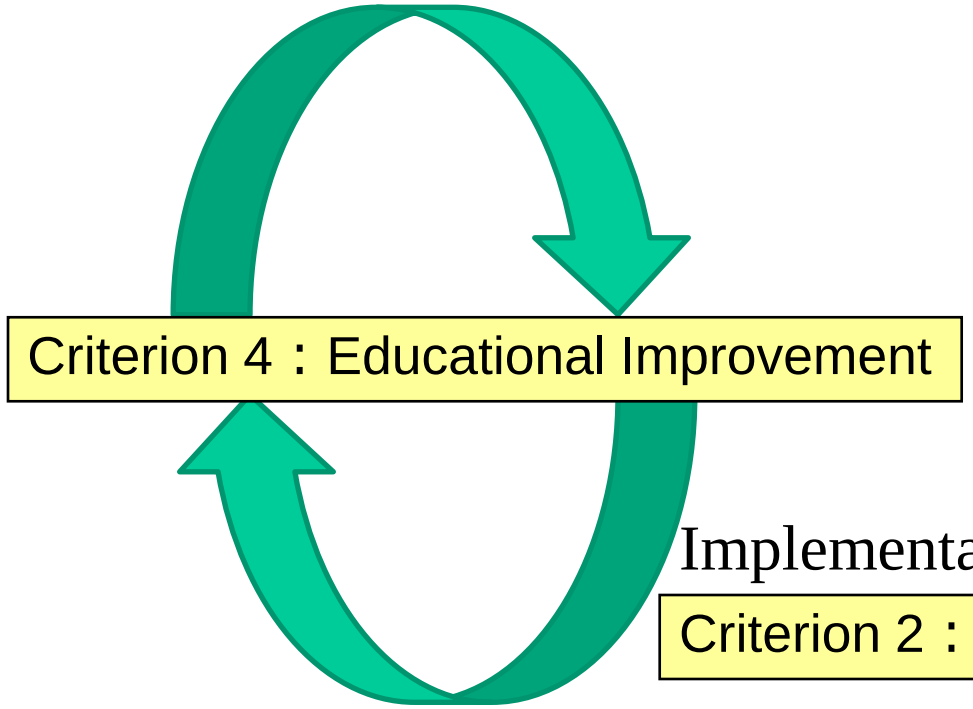
IEA (Engineering) Knowledge Profile

1. Natural sciences
2. Mathematics, numerical analysis, statistics, formal aspects of computer and information science
3. Engineering fundamentals
4. Engineering specialist knowledge
5. Knowledge supporting engineering design
6. Knowledge of engineering practice
7. Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline
8. Engagement with selected knowledge in the research literature of the discipline

IEA Graduate Attributes Profile

1. Engineering Knowledge
2. Problem Analysis
3. Design/development of solutions
4. Investigation
5. Modern Tool Usage
6. The Engineer and Society
7. Environment and Sustainability
8. Ethics
9. Individual and Team work
10. Communication
11. Project Management and Finance
12. Life long learning

Quality Assurance by JABEE Criteria



Criterion 4：Educational Improvement

Criterion 1： Learning Outcomes

A set of clear students' performance, planned by program, enough to achieve the outcomes

Performance Criteria

What & how high?

Implementation

Criterion 2：Educational Methods

Assurance through review and evaluation

Criterion 3：Achievement of Learning Outcomes

Learning Outcomes in JABEE 2012 Criteria

(a) An ability of multidimensional thinking with knowledge from global perspective

(b) An ability of understanding of effects and impact of engineering on society and nature, and of engineers' social responsibilities (engineering ethics)

(c) Knowledge of and an ability to apply mathematics, natural sciences and information technology

(d) Knowledge of the related engineering disciplines, and an ability to apply it to solve problems

(e) An ability to design to respond to requirements of the society by using various sciences, technologies and information

(f) Communication skills including logical writing, presentation and debating in Japanese and fundamental communication skills on the international scene.

(g) An ability of independent and life-long learning

(h) An ability to manage and accomplish tasks systematically under given constraints.

(i) An ability to work as a team member

JABEE's Outcomes-based Assessment

- Instead of structural assessment, the contents of education are assessed as outcomes.
- JABEE does not question the approach of the program as long as the outcomes are assured.
- The program shall set up and demonstrate with benchmarks the outcomes, which the program expects.
- The outcomes of the program are evaluated by the society in the era of information.

How to make students learn by themselves and evaluate appropriately graduates attributes?

- “Knowledge” profile may be assured by suitable curriculum with a certain assessment (paper exam, report, …)(almost input-based).
- “Ability” may be implicit and expressed as his/her action. How do we “teach” action profile?

Rubric-based Competency Development (including assessment) in Chuo University

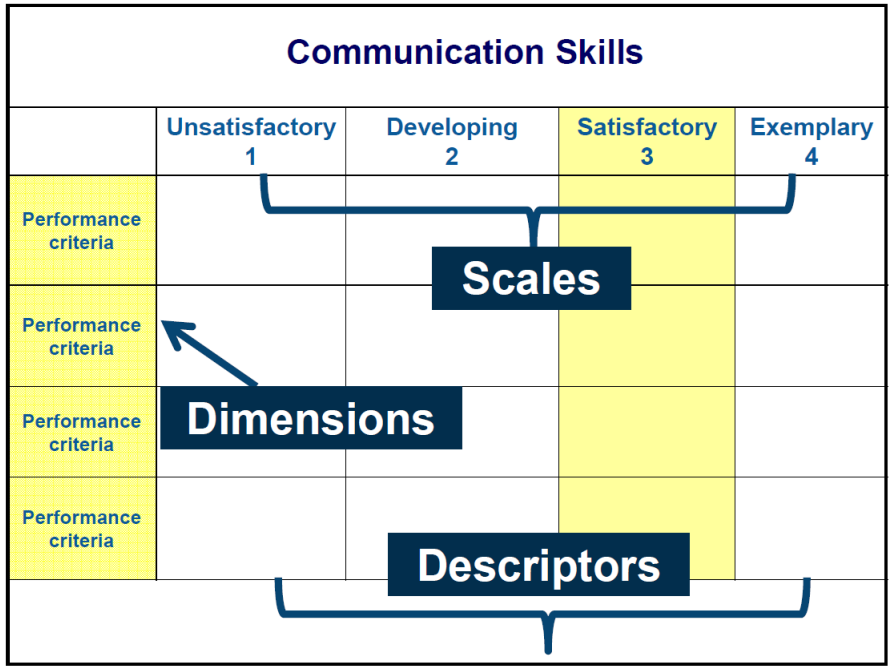
Rubric: Evaluation of Performance & Level

- Nobody can evaluate implicit (inside).
- Rubrics check performance and level which he/she presented as some actions
- For assurance of learning outcomes, behavior characteristics is important. (happened actions is not important)

Therefore, rubrics of “competencies” should be considered.

What is rubric?

- Rubric: a tool to evaluate level of performance
- Three elements:
  - Dimensions
    …performance criteria
  - Scales
    …levels of performance
  - Descriptors
- Evaluation of performance of study items
- Through self-check by students and evaluation by teachers, the rubric help students' awakening.



http://www.abet.org/Linked%20Documents-UPDATE/webinars/webinar-developing-rubrics-2010.pdf

Rubric: Trends in Higher Education

- Especially effective for PBL
- Objectivity of learning outcomes and mutual understanding between students and professors
- Effective of course design and FD

Graduate attributes also use the rubric, showing differences between engineering, technologist and technician education.

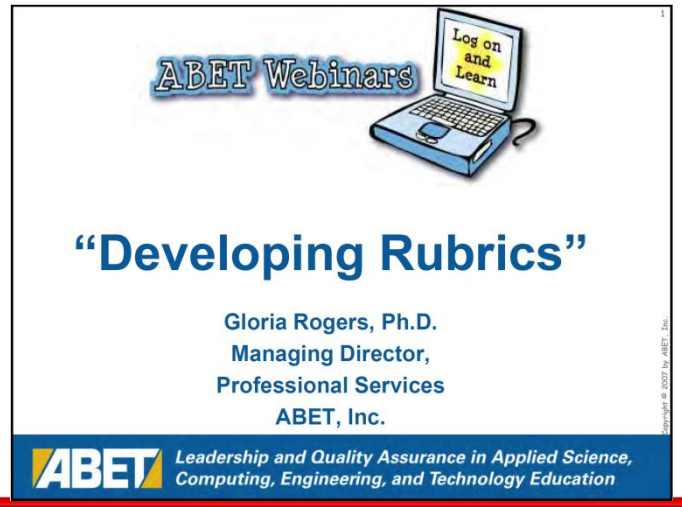
Range of Problem Solving (IEA)

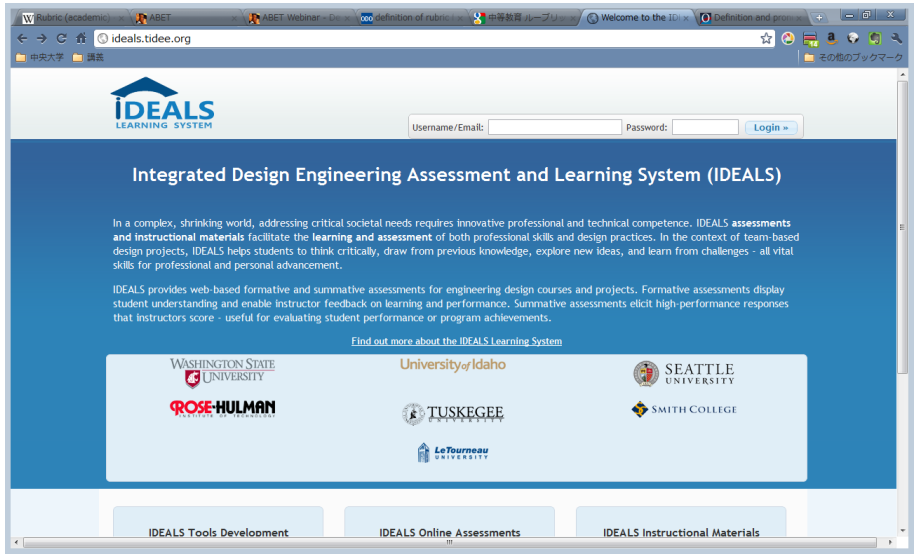
WA requires "complex problems"

	Attribute	Complex Problems	Broadly-defined Problems	Well-defined Problems
1	Preamble	Engineering problems which cannot be resolved without in-depth engineering knowledge, much of which is at, or informed by, the forefront of the professional discipline, and have some or all of the following characteristics:	Engineering problems which cannot be pursued without a coherent and detailed knowledge of defined aspects of a professional discipline with a strong emphasis on the application of developed technology, and have the following characteristics	Engineering problems having some or all of the following characteristics:
2	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues	Involve a variety of factors which may impose conflicting constraints	Involve several issues, but with few of these exerting conflicting constraints
3	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	Can be solved by application of well-proven analysis techniques	Can be solved in standardised ways
4	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach	Requires a detailed knowledge of principles and applied procedures and methodologies in defined aspects of a professional discipline with a strong emphasis on the application of developed technology and the attainment of know-how, often within a multidisciplinary engineering environment	Can be resolved using limited theoretical knowledge but normally requires extensive practical knowledge
5	Familiarity of issues	Involve infrequently encountered issues	Belong to families of familiar problems which are solved in well-accepted ways	Are frequently encountered and thus familiar to most practitioners in the practice area
6	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering	May be partially outside those encompassed by standards or codes of practice	Are encompassed by standards and/or documented codes of practice
7	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs	Involve several groups of stakeholders with differing and occasionally conflicting needs	Involve a limited range of stakeholders with differing needs
8	Consequences	Have significant consequences in a range of contexts	Have consequences which are important locally, but may extend more widely	Have consequences which are locally important and not far-reaching
9	Interdependence	Are high level problems including many component parts or sub-problems	Are parts of, or systems within complex engineering problems	Are discrete components of engineering systems

Rubric: Examples in U.S. Engineering Education

- ABET Webinar: Developing Rubrics
  http://www.abet.org/webinar-developing-rubrics.shtml
- WSU-EERC (Engineering Education Research Center, Washington State University) IDEALS
  http://ideals.tidee.org/





Rubric-based Competency Development Project in Faculty of Science and Engineering, Chuo University

- Kick-off: Summer, 2008
- National Project “Good Practice in Higher Education” from autumn 2009 to March 2012
- Goal:
  - Clarification of graduate attributes (competencies) of Faculty of Science and Engineering, Chuo University
  - Development of systematic curriculum and teaching method of the competencies
- Project leader: Mitsunori Makino
- Leading department: Information and System Engineering (Computer Engineering)

Procedure of Competency Development in Chuo Univ.

1. Definition of Educational Goal
2. Definition of competencies as graduate attributes
3. Detailed competencies with levels
4. Application to courses
5. Sharing information on good practices

Seven Competencies as Graduate Attributes in ISE Department

Competency Keyword	Definition	Level				
		0	1	2	3	4
Communication ability	After having correctly understood other people's opinions or writings, clearly express one's own opinions about them. Use effective explanation methods or techniques to persuade involved parties.	Is unable to understand other people and express his/her own opinions to them.	Is on the whole able to understand other people's opinions and on the whole express his/her own opinion to them.	Listens to other people and communicates smoothly by expressing his/her own opinions to them.	Having understood other people, expresses his/her own opinions in a way that is easy to understand by devising methods for giving explanations, and thus gains a sufficient degree of understanding.	Uses a range of methods or techniques for giving explanations and thus gains a sufficient degree of mutual understanding with people.
Problem-solving ability	Correctly understand the issues. Devise and implement solutions. Verify the results and reflect them in plan reviews or subsequent planning.	Is unable to correctly understand given issues.	Correctly understands given issues and tries to solve them.	Correctly understands self-discovered or given issues. Devises and implements solutions.	Discovers issues by himself/herself, and devises and implements solutions. Verifies the results and reflects them in plan reviews or subsequent planning.	Discovers issues by himself/herself, selects the best solution and implements this systematically. Verifies the results from various aspects and reflects them in subsequent planning.
Knowledge acquisition ability	Having made efforts to continuously gather and sift through a deep and broad range of information, acquire, apply and utilize knowledge and expertise.	Is unable to gather information by himself/herself and acquire new knowledge and expertise.	Is on the whole able to gather information by himself/herself and acquire new knowledge and expertise.	Undertakes a careful examination of gathered information, and acquires, applies and utilizes knowledge and expertise.	Having made efforts to gather and sift through a deep and broad range of information, acquires, applies and utilizes knowledge and expertise.	Having made efforts to continuously gather and sift through a deep and broad range of information, acquires, applies and utilizes knowledge and expertise in ways that other people have not thought of.

Seven Competencies as Graduate Attributes in ISE Department

Competency Keyword	Definition	Level				
		0	1	2	3	4
Organized behavior capabilities	Ascertains in a multifaceted and objective way from multiple perspectives what should be done to achieve team or organizational goals, reach appropriate judgments and act with a sense of ownership. When doing so, demonstrate with others mutual respect for each other's ideas and act while developing and maintaining relationships of trust.	Is unable to work in a team and behaves in a way that is self-centered.	Is able to work when instructed, but does not make an effort to achieve goals by himself/herself	Understands common goals in teamwork and behavior and acts with a sense of ownership in order to achieve these.	Ascertains in a multifaceted and objective way from multiple perspectives what should be done to achieve team or organizational goals, reaches appropriate judgments and acts with a sense of ownership. When doing so, demonstrates with others mutual respect for each other's opinions and acts while developing and maintaining relationships of trust.	Having considered thoroughly what should be done to achieve team or organizational goals and the benefits for all concerned, reaches appropriate judgments and does not act by himself/herself but gives directions and guides people as to what they should aim at .
Creative ability	Demonstrate intellectual curiosity, be interested in things within and beyond one's area of specialization, obtain ideas from those things and conceive unprecedented ideas. When doing so, observe relevant laws and regulations, have a sense of ethics and fulfil the responsibility engineers have to society.	Is not interested in new ideas and technologies, even if he or she knows about them.	Habitually collects information regarding his/her field of interest and pays attention to new ideas and technologies.	Demonstrates wide-ranging intellectual curiosity, regardless of whether things are within or beyond his/her area of specialization, and strives to approach things by actively incorporating new knowledge.	Demonstrates intellectual curiosity, is interested in things within and beyond his/her area of specialization, obtains ideas from those things and conceives unprecedented ideas. When doing so, observes relevant laws and regulations, has a sense of ethics and fulfils the responsibility engineers have to society.	Demonstrates intellectual curiosity, is interested in things within and beyond his/her area of specialization, obtains ideas from those things and conceives unique ideas of the kind that contribute to the development of science and technology. When doing so, observes relevant laws and regulations, has a sense of ethics and fulfils the responsibility engineers have to society.

Seven Competencies as Graduate Attributes in ISE Department

Competency Keyword	Definition	Level				
		0	1	2	3	4
Self-realization ability	To elevate oneself, constantly pursue new goals, consider paths towards these goals and strive to achieve them. When doing so, always act to improve self-control.	Does not try to find goals and does not achieve them, even if given.	If he/she has a goal, expresses a desire to achieve this goal and strives toward it.	Determines clear goals by himself/herself, considers paths towards these goals and strives to achieve them. When doing so, demonstrates self-control.	To elevate himself/herself, constantly pursues new goals, considers paths towards these goals and strives to achieve them. When doing so, always acts to improve self-control.	To elevate himself/herself, constantly searches for new goals and, when found, thinks up the shortest route to achieving these goals and strives to achieve them by following this path. Even if fails, makes repeated efforts to achieve goals.
Specialization (Department of Information & System Engineering)	On the basis of broad and deep knowledge and experience, make appropriate use of programming and ICT tools, engage in accurate work and utilize information engineering.	Does not possess an academic ability or knowledge to form the foundations for studying information and system engineering.	Possesses a fragmentary academic ability and knowledge, is able to understand simple information, judge its accuracy and make small-scale assertions, but the precision and accuracy of his/her work is insufficient.	Largely understands specialist knowledge, and is able to understand information related to this, judge its accuracy and make his/her own assertions. Is able to undertake work that has a certain standard of precision and accuracy.	Possesses a systematic understanding of specialist knowledge, and is able to understand highly specialist information, judge its accuracy and make his/her own assertions. Is able to undertake work that is above a certain standard of precision and accuracy.	Possesses an extremely advanced specialist knowledge, is able to understand highly specialist information and judge its accuracy at the level of a specialist and communicate his/her own assertions both domestically and overseas. Is able to undertake work that is above a certain standard of precision and accuracy through superior innovations.

Two points for applying rubric to course assessment

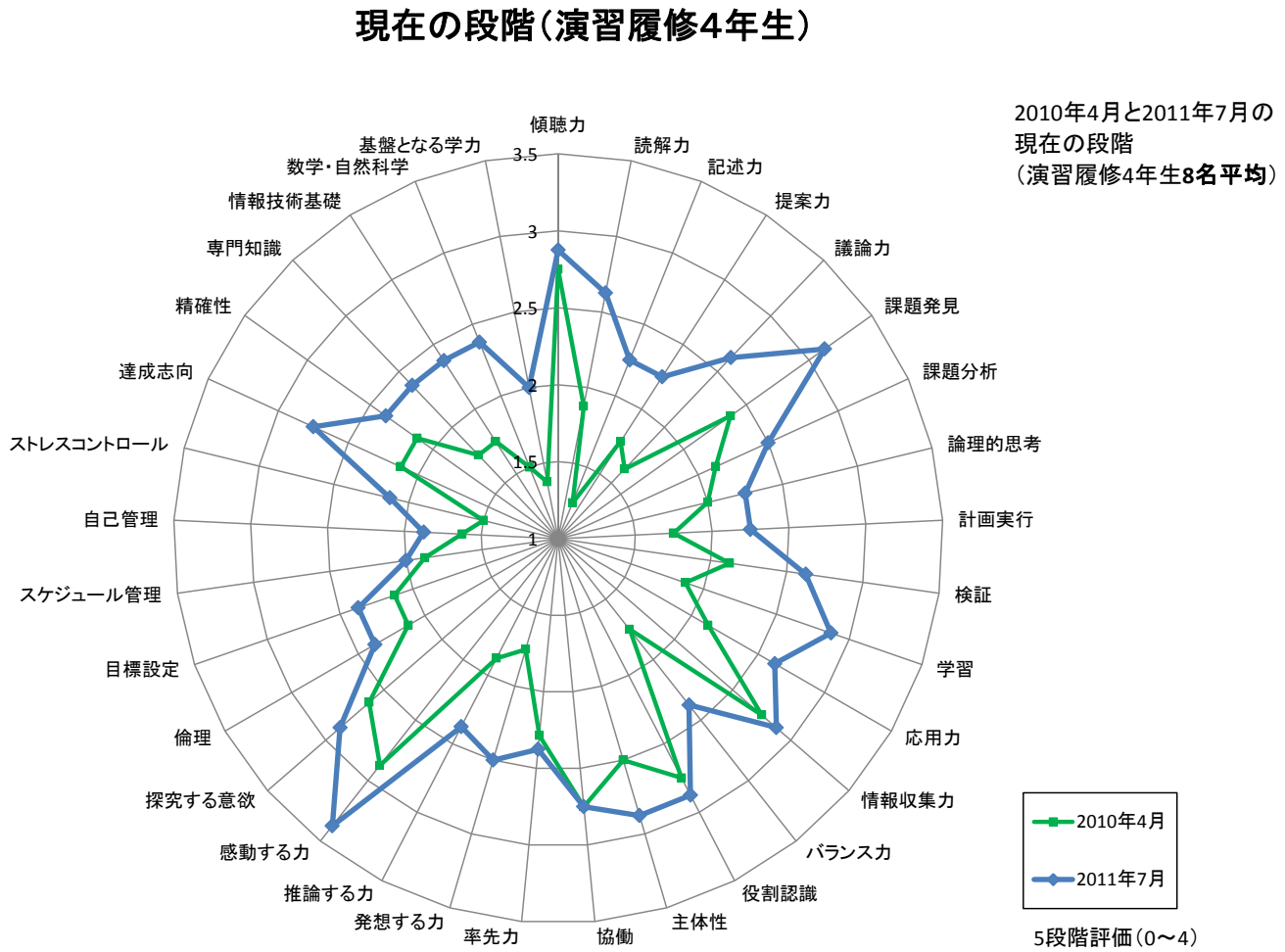
1. Define the dimensions and scales which can be checked in the course. Then descriptor at each level can be described according to supposed students' action.
2. If necessary, revise course which encourages students' "awareness" and "innovation."

Introduction of Competency Development to Course (Software Design Team Project)

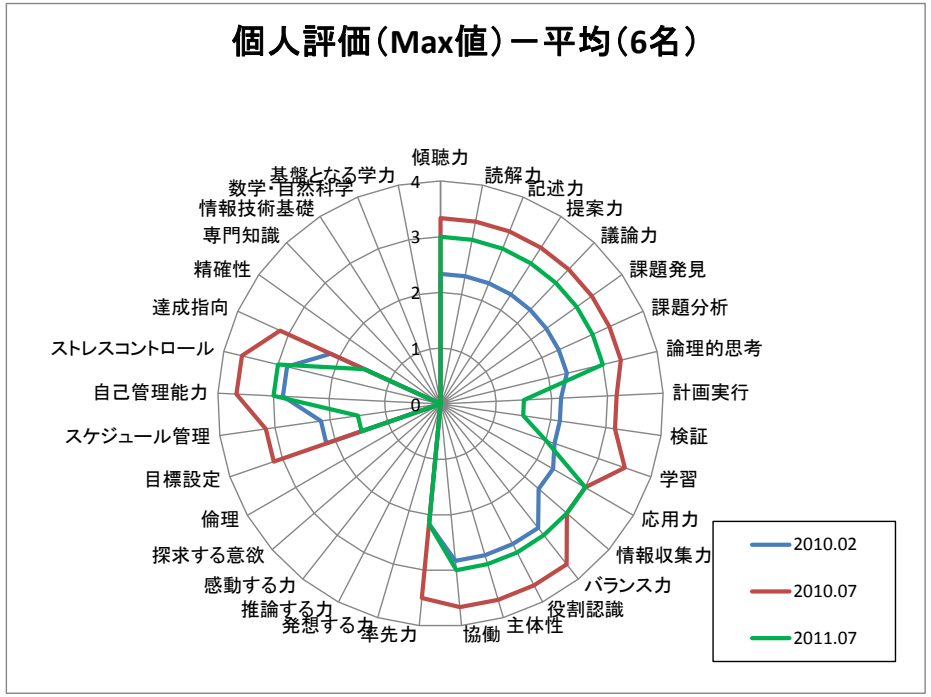
Clarification of competencies which can be observed at each class

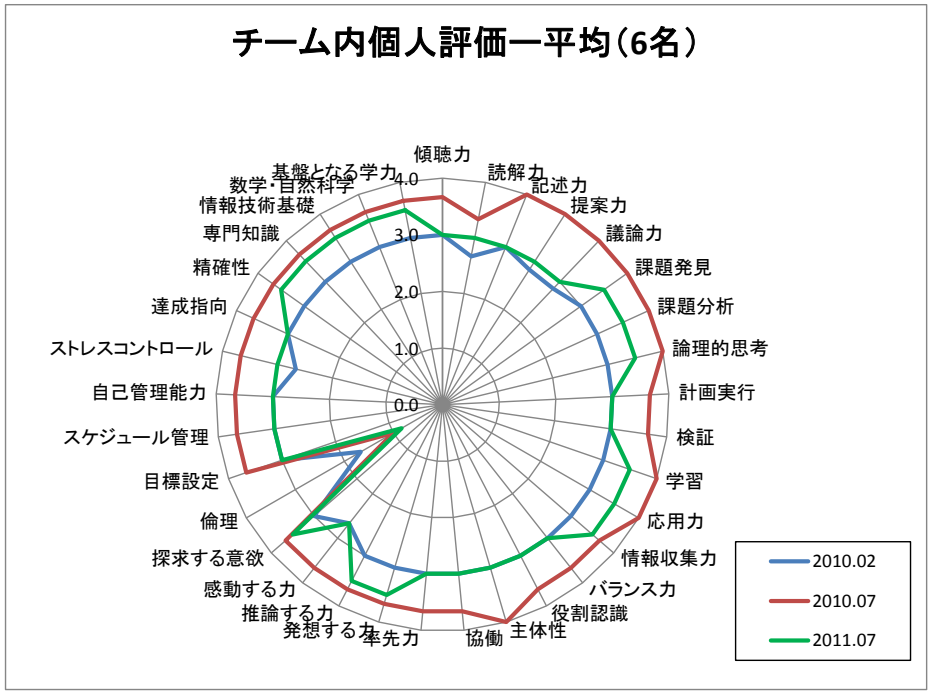
画像・映像コンテンツ演習(仮称)計画案						コミュニケーション力					問題解決力（デザイン）				
授業	工程	内容	行動のポイント	次回迄の宿題（教員等が次回迄に提出内容を確認できる時間の猶予が必要）	提出物	傾聴力	読解力	記述力	提案力	議論力	課題発見	課題分析	論理的思考	計画実行	検証
1	概要紹介、班分け、テーマ発表	進め方の説明、演習ノートシステム利用方法説明、チームの(仮)決定、プロジェクトテーマの発表	・テーマを理解する ・チームを作る	テーマに関するチームの意識合わせ、メンバーの知識・能力の相互確認		◎	◎								
2	基礎実習(1)	必要知識やシステム利用方法の習得(複数名でのプログラム開発における留意事項を含む？)	・基礎知識習得		実習成果	◎	◎								
3	基礎実習(2)		・テーマ解決方法の検討	テーマ解決方法の選択・考案	実習成果	○	○		◎	◎	◎	○	○		
4	仕様作成(1)	モデル・アルゴリズムの選択、関数単位での仕様書作成、TA・教員からの助言	・仕様を作成する(関数単位) ・助言を得る	上級生から助言を得た上での、必要な修正・追加	仕様書(案)	○	○	○	○	○		◎	◎	◎	
5	仕様作成(2)、役割分担	仕様書の完成(TA・教員への説明を含む)と役割分担の決定、次回以降の作業の確認(特に動作確認方法について)	・仕様書を完成する ・役割分担をする ・動作確認方法を検討する	動作確認方法案	仕様書、役割分担書	○	○	◎	○	○				○	

Evidence of Competencies Development (1)
Self-Assessment by Students



Evidence of Competencies Development (2)
Assessments by Faculty Staff, Graduates and TA





- All departments in the Faculty of Science and Engineering, Chuo University have the rubrics, respectively, and apply them to some courses.
- The faculty includes the competencies as the graduate attributes in its both of diploma and curriculum policies.

Conclusion and Future Work

For assurance of educational quality through achieving graduate attributes

- Competency development is becoming mandatory in higher education in Japan as well as global engineering education.
- Combination of the rubric-based competency development with engineering education seems positive result from our project.
- How do we promote the rubric-based competency development to wide area of engineering education ?
  - Understanding of importance
  - Re-organization of courses, if necessary

Thank you for your attention!

It’s my honor to be involved in establishment of accreditation system for engineering education in Indonesia.

I hope I will be here for further discussion in near future.

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