Geodesy and Geomatics Engineering Curriculum at the Institute of Technology, Bandung, Indonesia

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Key words: curriculum development, course structure

SUMMARY

Compliance to international standard, tie to national qualification framework, and employment opportunities are factors in the external environment that have transformed foundation for development of geodesy and geomatics engineering curriculum at the Institute of Technology, Bandung (ITB), Indonesia. This paper comes out from elaboration of conceptual link between factors in external environment and approach for developing composition of courses. The need to provide broad-based and fundamental competences is highlighted. While there have been widespread applications of geodesy-geomatics, spatial aptitude and mathematical skill are still maintained as core focus of learning. We spot selected points from previous curriculum and elaborate them to indicate how they reflect transformed foundation in curriculum development. The resulting set of course structure introduces new subjects, sharpened learning roadmap, as well as branding of compilation of conventional learning materials.

RINGKESAN

Nohonan kana katangtuan sadunya, oge luyu jeung rarangka parisarat nagara, tur ta lolongkrang pakasaban, mangrupakan rundaykara nu aya di lingkungan luar anu geus ngamalihrupa tatapakan pikeun mekarna tata piwulang Rinêka Guna Pariwangenan Bumi - Paitungan Bumi di Panti Atikan Luhur Pangaweruh Rinêka Guna Bandung (ITB), Indonêsia. Daluangwiwiaha ieu medal tina ngarambahna simpay-sinambung rarancang paham antara rundaykara di lingkungan luar jeung upaya ngagugunturtuwuhna susun-ramu pangalapan pangaweruh. Kabutuhan pikeun panyayagian pangabisa dasar tur mibanda ambahan lega estu jadi caturangga. Parandênê geus aya panglarapan Rinêka Guna Bumi - Paitungan Bumi sakuliah janapria, kaparigelan ngeunaan tata rohang sarta kapinteran paitungan masih dipikukuh kênêh minangka jejer pancer pangalapan pangaweruh. Kuring saparakanca nyirian saniskara anu parenting tina tata piwulang anu samêmêhna, sarta ngembangkeunnana sangkan bias nuduhkeun kumaha saniskara anu parenting tadi mintonkeun dadasar anu geus malih rupa dina sejeroning kembangropeana tata piwulang. Panglarapan hasil tina runday waruga pangalapan pangaweruh nyaeta ngawanohkeun pasualan-pasualan anyar, ngaronjatatrakeun pangaweruh palintangan bumi, sarta ngageugeus runtuyan bahan-bahan pangalapan pangaweruh anu geus ilahar.

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1. INTRODUCTION

Degree program in geodesy has been established since 1950 as Geodesy Section at the Institute of Technology, Bandung (ITB) was span off from Civil Section and became a department. Education and training of human resources in support to cadastre works and land administration were the primary thrust of the establishment of the program. Two decades later, in the 1970ies, there were high demands in infrastructure developments that led to numerous surveying projects. Surveyors contributed as supporting roles in various construction works of mainly land transportation (road), irrigation system, and development of new settlement of inhabitation. It was also era when surveying and mapping appeared as individual project. The name of the program changed into Geodesy and Geomatics Engineering since 2003.

Later in 2006, the program is structured under the Faculty of Earth Science and Technology and ranked A ('Leading Institution') by University National Accreditation Board (*Badan Akreditasi Nasional Perguruan Tinggi* - BANPT) of the Republic of Indonesia according to Decree Number 011/2006. These have been a significant milestone for the study program to face a new era in contributing more towards earth dynamics' and life layer problems. While cadastre, mapping, and infrastructure development remain among of graduates' career paths, challenges in dealing with spatial planning, natural resources management, maritime development, and mitigation of natural hazard are becoming novel field of contributions of surveyors in our national contexts. In the pace of these widening fields of contributions, undergraduate program in geodesy and geomatics engineering is exposed to complex and challenging environments in higher education and professional contributions.

This paper emerges among members of ITB's Geodesy and Geomatics Engineering curriculum evaluation and development team. Curriculum evaluation and development is five-year basis agenda to keep up higher education learning at ITB with new challenges, advance of scientific method, technology improvement, and trend in governmental and industrial spheres. The following aspects are suggested for curriculum evaluation and development (ITB Rector, 2012):

- State of body of knowledge;
- Challenge in the next 10 years;
- Stakeholders' opinions;
- Program educational objectives;
- Program outcomes; and
- Correlation between outcomes and educational objectives of program.

State of body of knowledge is related to compliance of what is learned to novelty in professional practices. This includes fundamental set of concepts and definitions of its education. Judgment on relevant challenges in the next 10 should be made to fit curriculum design with future trend of job market and employment. Opinions from stakeholders (primarily employer, user, and alumni) must be also taken into account. These provide thought in assessing output of study program (i.e. graduates). Program educational objectives (PEO), program outcome (PO), and correlation between them including derivatives to Courses' Outcomes (CO) are prominent elements of outcome-based education (OBE) (e.g. Lam, 2009; Davis, 2003).

On the basis of these re-evaluation aspects, necessary revision, or -when demanded-modification of existing curriculum for implementation in the next five years, i.e. 2013-2018, shall be proposed. In this presented paper, we discuss how the suggested aspects of curriculum re-evaluation are defined and linked to proposed conception of curriculum, which result in new set of course structure.

2. CONSIDERATIONS AND APPROACHES

2.1 Curriculum re-evaluation aspects

2.1.1 Body of knowledge

The presently known Geodesy and Geomatics Engineering at ITB was originated from surveying education. The set up began in 1920 with the establishment of Department of Road and Water (Civil) Engineering at Technical Science Faculty of the Technical High School (*Technische Hoogeschool* - THS) Bandung (ITB, 2013). Throughout the next decades, since 1950 when Geodesy Section is established, the way surveying discipline in Indonesia is understood and new surveyors are educated were based on classical references, such as Helmert (1880, 1884), Bomford (1952), Vanicek & Krakiwsky (1992), Wolf (1974, 1983), and Aronoff (1989). These have been the core of surveying expertise and remain contemporaneous with the advance of technology and industry.

With growing understanding of earth dynamics and increasing complexity of problem across earth's life layer, modern surveyors should possess both strong fundament in their core expertise and integrated perspective on spatially-related issues: spatial aptitude. It is a specific quotient to invent or to establish scientific or technological solution for intervening spatially-related or spatially-contained problems, proposed as geospatial engineering. A recent concept in "surveying body of knowledge" (Greenfeld, 2010) might depict the integration of knowledge, skill, and attitude of modern surveyor at micro and macro levels. The micro and macro levels' surveying body of knowledge provides scope of knowledge area from which learning materials are derived for the content of the curriculum.

2.1.2 Future challenges

There has been development in national regulatory with the issuance of National Act Number 4 on Geospatial Information in 2011 (Indonesian Geospatial Agency, 2011). This act regulates all aspects in geospatial information at national scale. Under this act, Geospatial Information Agency (*Badan Informasi Geospatial* - BIG) is the single Indonesian authority to facilitating the implementation of the act. This brings consequence in the preparedness of issues related to education, training, qualification, and certification of human resources. In addition to that, Presidential Regulation Number 8 on Indonesian National Qualification Framework was released in 2012 (Indonesian Labor Ministry, 2012). These provide guidance on recognition, equivalence, integration, and recognition of education, training, and experience of human resources. In the case of surveyor's role in national context, the following sectors are considered relevant: mapping, infrastructure, management of natural resources, disaster management, spatial planning, maritime, and cadastre.

Related to regional context, Association of the Southeast Asian Nations (ASEAN) Free Trade Area - AFTA (Cuyvers & Pupphavesa, 1996) is to name one of rationale in seeing towards Indonesia's regional contributions. In this instance, focus on human resource is among of the focus of development in addition to infrastructures, information and communications technology, and regional economic integration (Pangestu, 2009). We are anticipating this by requesting assessment from Association of South East Asian Nation University Network (AUN) - Quality Assurance Geodesy and Geomatics Engineering Study Program. Siite visit was made by 18-21 September 2013 and during the submission of this manuscript, decision on the result is not yet issued.

2.1.3 Stockholder's opinion

Roughly 90% of ITB's Geodesy and Geomatics Engineering graduates are directly entering job market. The rest continues their study to pursue higher academic qualification in various disciplines. We propose to interpret that this indicates the attractiveness of trading, governmental demand, and occasionally industrial sector. Graduates' competitiveness in the job market is becoming an integrated measure on how ITB curriculum for undergraduate study in geodesy and geomatics engineering should be best developed.

It is therefore necessary to bring competitiveness issue in graduates' role, career, and their personal development and to facilitate how these attributes (i.e. role, career, personal development) contextually match our national issues: the unique characteristics of Indonesia as a developing archipelagic nation in the view of stronger regional contribution to the South East Asian region.

ITB tracer study confirmed several aspects of graduates' competences, which are considered important in their work for improvement (ITB Career Center, 2012). This is seen as stakeholders' opinions or user of our alumni. Four out of five competences, which are seen as stakeholders' opinions also fit with priority competences reported by Passow et al. (2012), i.e. problem identification, formulation, and solving, communication skill, function on multidisciplinary team, and design of data acquisition, analysis, and interpretation. In our case, professional ethics and responsibility are an aspect of competence in our graduates that requires improvement.

2.1.4 Link between Program Educational Objectives and Program Outcomes

The purpose of education program is to transform among undergraduate students their behavior, mindset, and capability, which should be reflected by their attitude, knowledge, and skill. Such a transformation should enable them to becoming scholar and member of society. In this instance, we would need to characterize which roles would they significantly play. In a more specific scope of discipline, being graduates in geodesy and geomatics engineering, it should be clearly defined what type of career they should achieve. They also need to develop themselves throughout their active contribution period to the society. We consider roles, careers, and self-development as substantial attributes that value graduates. Students' learning outcomes are crucial to assess at the time they finish their study. This is believed to assure the way they are able to achieve the predefined purposes of their education.

2.2 Conception of curriculum

Aspects in curriculum re-evaluation are in an in-line implication with the changing perspective of ITB organizational vision: to becoming a research university (from a teaching university). This will require redefinition on how graduates shall learn and be educated, their learning strategy and the corresponding assessment methods, as well as compliance of their competences against national and international standards. It is expected that graduates shall take more initiative in contributing to the identification and solving of national problems. In this regard, self-starting motivation and leadership, as well as communication skill among students must be developed. We also believe that students should be educated to becoming the subject in problem identification and solving instead of as an object or sub-ordinate player in circumstances where problems are already defined.

Further to these, the context of curriculum must reflect and conform to the understanding of the following fundamental definitions:

- Aim of education program including its societal relevance;
- State of body of knowledge, including international standards and guidances;
- University vision and mission; and
- National and regional contexts.

Based on stakeholders' input, it is necessary to link societal relevance in academic, business, and governmental spheres with Program Educational Objective (PEO). This provides linear reasoning on why graduates are educated. Following this, we adopt eleven Accreditation Board of Engineering and Technology (ABET) criteria (Terry et al., 2002) to construct Program Outcome (PO). Consecutively, learning materials, mastery level according to revised Bloom taxonomy (Krathwohl, 2002), learning methods, and students' assessments are designed in an in-line corridor of body of knowledge, PEOs, and POs.

With a plan to submit recognition from FIG/IHO/ICA International Boards for Standards and Competences (IBSC), we include subjects listed in IHO S-5 (International Hydrographic Bureau, 2011) as primary reference of learning materials. Method of assessments are derived from both ABET criteria and ITB institutional vision, in which we are able to establish basis of standard students' performance on equally substantial cognitive and affective aspects. University guidance with its vision and mission is included into composition of type of course in curriculum structure. Figure 1 shows how elements of curriculum (Program Educational Objectives - PEO, Program Outcomes - PO, and content of courses) are linked to their respective sources of learning contents.

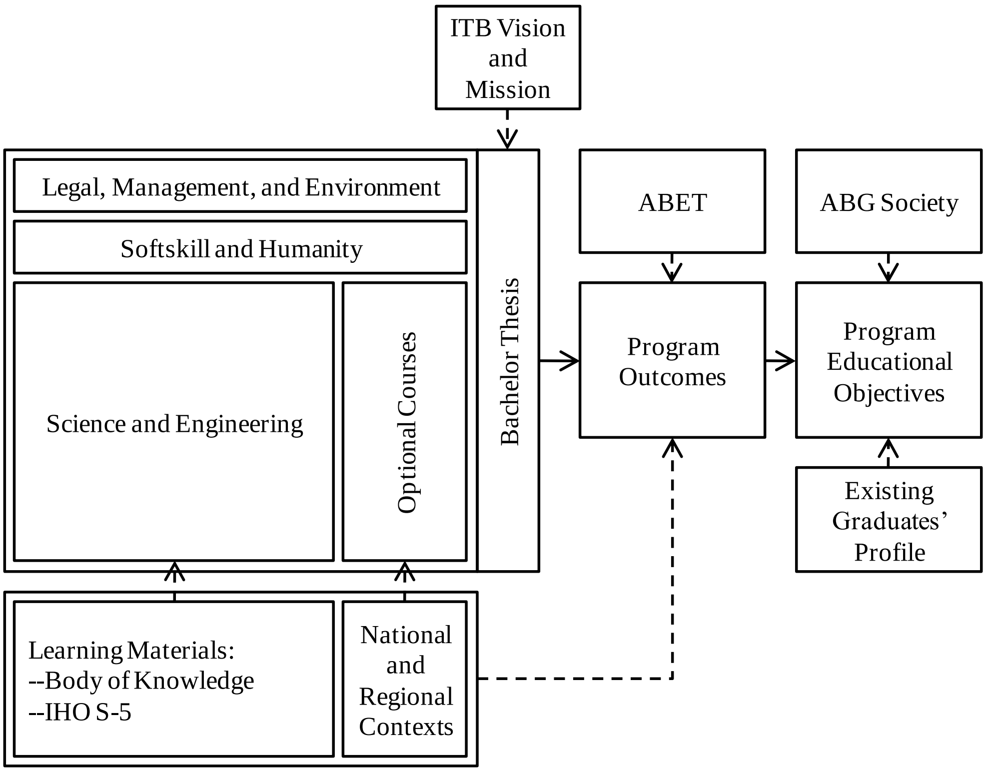

Figure 1 Conceptual scheme of elements of curriculum

Notes: ITB: Institute of Technology, Bandung; ABET: Accreditation Board of Engineering and Technology; ABG: Academic, Business, and Government; IHO S-5: Publication Number S-5 on Standard of Competences for Hydrographic Surveyors from the International Hydrographic Organization

2.3 Course structure development

On the basis of learning materials and the corresponding mastery levels, we compose courses and the respective credits, following sequence discussed in Felder & Brent (2003):

- PO linked list of competences
- Learning materials and their properties
- Mastery level and assessments

- Classification and weighting
- Roadmap and branding
- List of courses

Credits assigned to each course represent relative weight of each course with respect to the minimum total obligatory undergraduate education credits, i.e. 144. Structure of courses is constructed according to the presumed learning roadmap, understanding integrity among students, including branding (representative name) given to each of group of learning materials, and the available weekly working hours. This development introduces new subjects in the course structure, branding of new groups or modified contents of materials and new philosophy of optional courses: comprehension in blended knowledge and skill contextual to existing industrial practices.

3. CURRICULUM DESIGN

3.1 Program Educational Objectives (PEO) and Program Outcomes (PO)

The newly designed curriculum are intended to develop among graduates, competences in the application of geospatial science and technology, possession of competitive advantage within national and regional contexts, and capability of self-development through lifelong learning. List of PEO is given as:

- Possession of professional attitude and mindset with contributing role as individual or part of team for a spectrum of application of geospatial science and technology
- Capability of application of knowledge and skill, as well as solving of a defined routine problem in the application of geospatial science and technology
- Develop him- or her-self and improve their career in various sectors in the community and possession of high-standard qualification for further study

Table 1 shows the summarized statements of educational purposes and the corresponding learning outcomes at the final end of the study period.

Table 1. PEO-PO matrix

	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
PEO1	×			×		×	×				×
PEO2	×	×	×		×		×		×		
PEO3		×		×		×		×	×	×	×

New subjects in curricula structure are thematic mapping, geospatial expedition, law and legal, quality management, and introduction to spatial system. In order to avoid students' misconception on learning purposes, we propose branding of groups of learning materials or contents. This results in 'positioning', instead of what we had 'plane surveying'; geometric reference system, instead of 'geodetic network'; geospatial industry, instead of 'surveying and mapping management'; and geodetic computation, instead of 'adjustment computation'. As consequence, modified content of courses (with respect to earlier curriculum) is demanded for the following conventional courses: undergraduate research, internship, field camp, positioning, and terrestrial mapping. We shift GIS, cartography, and cadastral system to the final year, in order to comply with pedagogical road map.

3.2 Structure of course schedule

The resulting semester-by-semester structure of courses is shown in Table 2. Credits shown in Table 2 indicate students' learning-hour dedicated to a course on weekly basis. One credit is equivalent to three learning-hours; comprising of lecture, supervised activity, and independent work. One learning-hour is equal to fifty minutes work plus ten minutes break. Specific courses are listed for particular purposes, i.e. new subjects, branding, content modification.

Table 2. List of courses and credits

Semester I	Credit	Semester II	Credit
Physics I ◆	4	Physics II ◆	4
Calculus I ◆	4	Calculus II ◆	4
Chemistry I	3	Chemistry II	3
Sport	2	English	2
Earth Resources	2	Information Technology ◆	2
Engineering Design I	2	Engineering Design II	2
Technical Writing	2		
Semester III		Semester IV	
Positioning I ◆	3	Positioning II ◆	3
Geometrical Geodesy ◆	4	Geometric Reference System ◆	3
Statistics ◆	3	Estimation and Approximation ◆	3
Geodetic Computation I ◆	3	Geodetic Computation II ◆	3
Introduction to Spatial System	2	Satellite Geodesy ◆	2
Geospatial Expedition	2	Law and Legal ◆	2
Religion and Ethics	2	Citizenship	2
Semester V		Semester VI	
Terrestrial Mapping	3	Cartography ◆	3
Hydrography I ◆	3	Hydrography II ◆	3
Photogrammetry I	3	Photogrammetry II	3
Spatial Database ◆	3	Thematic Mapping	3
GNSS Surveying ◆	3	Remote Sensing ◆	4
Optional	2	Field Camp	2
Semester VII		Semester VIII	
GIS	3	Geospatial Industry	2
Cadastre	4	Quality Management	2
Environmental Geography	2	Undergraduate Thesis	6
Internship	2	Optional	2
Optional	3	Optional	3
Optional	3	Optional	3
Optionals			

Physical Geodesy	2	Quantity Surveying	3
Environmental Remote Sensing	3	Deformation	3
Hydroinformatics	3	Marine Boundary	3
Construction Surveying	3	GIS Engineering	3
Selected Topics	3	Marine Geodesy	2

Note: ◆ = IHO S-5 cross-referenced

As seen in Table 2 core courses are delivered from the second year on. In the first year, students should follow Common Preparatory Level (*Tahap Persiapan Bersama* - TPB). The cap stone of the curriculum is research work and the corresponding writing of scientific report in the final semester for presentation of undergraduate thesis. Summary of courses' content in the new curriculum is given in Table 3.

Table 3. Summary of course content

Level and Content	Credit
I. Common Preparatory Level (Year-1):	
A. Engineering and science	30
B. Soft skill and humanity	6
II. Undergraduate Level (Year-2, Year-3, Year-4):	
A. Engineering and science	74
B. Soft skill and humanity	8
C. Management, legal, and environment	8
D. Industrial contexts or problem domain	12
E. Undergraduate thesis	6
Total	144

4. CLOSING REMARK

Yet, efforts for effective implementation of this curriculum must be attempted and the best method for assessing the criteria of their accomplishment must be continuously maintained. We understand that this newly design curriculum shall be seen as a hypothetical concept that is based on interpreted facts, existing references, and state of our perspective. Success of implementation would still be dependant to the best measure of achievements.

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