

Reflections on the "Basic Cycle" of engineering studies at the Polytechnic School, University of São Paulo: Contemporaneity and Problems

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Abstract - This article presents a discussion about the disciplines of the first two years of undergraduate studies in engineering, as offered by the Escola Politécnica da Universidade de São Paulo (EPUSP) / Polytechnic School of the University of São Paulo in Brazil, and which are common to students of all specialization fields. These first two years are referred to as the Basic Cycle of the Polytechnic School, and contain all the fundamental Engineering subjects, such as Physics and Calculus. After this cycle, there is a mandatory advanced professional cycle of three years, consisting of subjects specific to each specialization, or emphasis in Engineering, which is based upon the theoretical foundations acquired during the Basic Cycle of the Polytechnic School. This article begins with a brief historical account and the reasons for implementing the Basic Cycle of the Polytechnic School, and its development through the years. This paper also aims to thoroughly explain the "Basic Cycle" nowadays and demonstrate that it has its *raison d'être* in particular contemporaneous problems, such as evasion, very little interdisciplinarity, the decontextualization of disciplines, the lack of integration among students and the internal competition due to a gradual selection system. Furthermore, it is explained how students and professors face these problems, and a reflection on the solutions in relation to these problems is proposed. A comparative approach between the activities of this cycle and some of the propositions of the Declaration of Bologna is also presented.

Index Terms – Basic Cycle, decontextualization, interdisciplinarity, undergraduate in engineering

THE FORMATION OF THE UNIVERSITY OF SÃO PAULO (USP) AND THE BASIC CYCLE

To better understand the Basic Cycle of the Polytechnic School of the University of São Paulo it is necessary to identify the objectives of an university and, in particular, of the University of São Paulo, from its creation to the present time. In accordance with Heládio Gonçalves Antunha [1],

during the Middle Ages, the universities' organization and functioning had experienced almost no change. In XVIII century, a university was still a place that held the conservative values of intellectual and pedagogical teaching and its main objective was the perpetuation and transmission of the classic culture and the graduation of liberal professionals proceeding from the courses of Arts, Theology, Medicine and Law.

From the Renaissance on, with the advent of new technologies and the birth of the State-Nation, at the beginning of XIX century, the University structure suffers modifications. Deep changes in the economic and socio-political organization occur. The causal relations between these changes are difficult to define, but a reorganization in the way of production (characteristic of the Industrial Revolution) is evident.

In response to the new forms of production, as well as the sprouting of new emergent social classes, universities had to redefine themselves in order to address the challenge: how to graduate the students in an Industrial Age?

In the XIX century, different answers were given and two fundamental reforms indicated the direction: the Humboldtian and the Napoleonic. Although being different concepts, both had in common the affirmation of the nationality of the universities and its integration as a basic element in the national reorganization of a country. In this context, the universities start to be national institutions worried about the instruction of the citizen and the professional, still preserving ecumenical characteristics. The characteristics of the main models at that moment [2] and that still exists [3] are demonstrated in Table I.

TABLE I
UNIVERSITY MODELS

	Napoleonic	Humboldtian	Anglo-Saxon
Student access	Directed at a small social elite	Directed at a small social elite	Mass education in its majority
Administrative organization	Connected to the State, without university autonomy	State functioning and financing, but with university	Of private character, independent in relation to the

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		autonomy	State
Function of the professor	Chair system – with public functions, serving the State and with great prestige and power inside the State, ending up influencing the elaboration of courses and university politics	Freedom of the Chair - freedom of education and research	Freedom of the Chair - freedom of education and research
Curricular structure	Hypercentralization (only one curriculum nationwide)	Decentralized	Decentralized
Objective	Education with emphasis on technical knowledge (technicist). It is directed at the formation of the body of civil servants (the elite), as a way to promote the economic development of society.	Education with emphasis on the erudite and encyclopedic knowledge. It is directed at the formation of the researcher.	Taylorist education (industrial standards are transferred to education causing productization, normatization and the collective organization of intellectual work)

Under this new conjuncture, philosophical questions are raised on the existence of universities and among those questions, Antunha presents the following question: *What are the objectives of the University itself? What kind of relations must the university keep with the State and the Academies, institutions and other establishments? What are the universities relations with rising science, philosophy, and also with new industrial professions?* [1]

From the XIX century until the beginning of the XX century, the most distinguished works were: Cardinal Newman's "The Idea of a University", and "Rise and Progress of Universities", Abraham Flexner's "Universities: American, English and German", Ortega y Gasset's "Mission of the University", Whitehead's "The Ends of Education") and Karl Jaspers' "The Idea of the University".

Within this context, the University of São Paulo was created in 1934 under its founders' view of a liberal university model. Mesquita, one of the founders of University of São Paulo, quotes the Governor Armando Salles de Oliveira's speech: "Universities have the objective to cultivate the sciences, to help the human spirit progress and to give elements to society for the incessant renewal of its scientific, technical and political bodies" [4].

The University of São Paulo was based on two complementary principles: universality and integration. The universality principle is opposed to the specialized character of closed objectives, which is typical of technical universities, and cultivates the universality of knowledge in all aspects. Promotion of pluralism and critical conscience were expected in all the areas of knowledge. The idea of integration was intertwined with the creation of the University itself. The University was also created to surpass

the isolation and dispersion of São Paulo's higher education at that time, which was comprised of small independent schools without bonds and any suggestion of approach and exchange of experience. This integration was intended to be not only geographical but also related to the student bodies.

In order to enable the integration of knowledge a common course term named the "Basic Cycle" was created for all the students of the University. This Basic Cycle would unite the freshman students of all fields in basic disciplines to promote a common and joint education. This structure favors the social and affective companionship among the students regarding that the interaction among people with different ideals is fundamental, because it stimulates the critical spirit and the respect for diversity. Therefore, the College of Philosophy Science and Letters was created as a central institute to assemble the general disciplines such as Mathematics, Chemistry, Physics, and Biology. The motive behind the creation of this college was to form a unit of knowledge common to all regardless of future specializations and to hinder the dispersion of knowledge and scientific fragmentation.

The creation of the University of São Paulo and its ideals were fervently contested at that time, especially by the more traditional colleges, which feared the loss of power through this union. The Polytechnic School also had a pedagogical argument to preserve its authenticity and specialized education [1]. Diverse opposition had hindered the University to implement some ideals, such as the common Basic Cycle for all specializations.

Some polytechnics were in favor of segregating the formation of engineers and "scientists", and of the organization of Technical Universities directed at the professional formation of "industrial agents". Mesquita comments on the subject: "In the domains of engineering, a strange conception of things reigns. It seems that, in the opinion of the majority of those who profess it, for engineers there is a Physics that has nothing to do with the physics of Fermi or Broglie. There lies the probable explanation for the almost non-existent influence of those who think so, on the evolution of nationality. In truth, there is no non-contribution that came directly or indirectly from this circle for the solution of any of the national problems pertinent to engineering." [1]

The concept of Basic Cycle was implemented at the Polytechnic School in the 1970's due to the reforms at the University of São Paulo. Contradictorily, a common course term has not yet been implemented for all the courses at the University of São Paulo. The Polytechnic School began to offer it in 1976 through a resolution which created its minimum curriculum "comprised of two parts, one common to all areas and another diversified, according to each area of graduation" [5]; this was the first step towards the current configuration of the engineering courses. The curricular structure of engineering in the Polytechnic School is resembled to the Napoleonic model in the first year, but later, it resembles Humboldtian and the Anglo-Saxon model. However, when examining the objectives, the first two years resemble the Humboldtian model and the following years resemble a combination of Napoleonic and Anglo-Saxon models.

Currently in Europe, the Declaration of Bologna has generated much discussion about format and function of higher education. The discussion aims at the improvement of education and mobility of students and professors among the educational institutions, and it has among its objectives the adoption of a two cycle system, of undergraduate and graduation, the latter mandatory after the former. The undergraduate cycle, with at least a three year duration, is directed at the work market. The graduation cycle is directed at students that want to master in science or obtain a PhD.

THE ENGINEERING COURSE AT THE POLYTECHNIC SCHOOL

The Polytechnic School is located in the city of São Paulo – Brazil, and has more than 450 Professors and 4,500 undergraduate students in the engineering course. This course lasts five years, which enables a student to obtain a Bachelor Degree of Engineering, and confers on the graduate the possibility to fully exert the engineering profession, without the necessity of further certification.

The Polytechnic School offers a 6 month specialization terms or a four month specialization terms depending on the chosen field. The six month term specializations are: Environmental, Automation and Control, Civil, Computer and Digital Systems, Energy and Automation, Materials, Mechanics, Mechatronics, Metallurgy, Mining, Marine and Naval Architecture, Petroleum, Production, Electronic Systems, and Telecommunications. The four month term specializations are: Computer and Digital Systems and Chemistry. There is a two year mandatory prerequisite cycle for all specializations, named the Basic Cycle of the Polytechnic School. That is followed by three years in each field. Currently, the first year is common for all the students and has basic disciplines as Physics, Calculus, Graphical Geometry, Introduction to Engineering, Materials Science, Technological Chemistry, Linear Algebra, Introduction to Computing, Numerical Calculus, and Mechanics.

To enroll in the first year at the Polytechnic School the student must be selected in a two phase nationwide examination - called “vestibular”. The first phase is comprised of multiple choice questions and the second phase in comprised of written questions. In recent years the relation between candidates and vacancies offered for the engineering course has diminished as presented in the Table II:

TABLE II
RELATION BETWEEN CANDIDATES TO VACANCIES FOR THE ENGINEERING COURSE AT THE POLYTECHNIC SCHOOL, COMPUTING AND APPLIED

MATHEMATICS	
Year	Relation
2001	13.38
2002	13.28
2003	11.79
2004	11.06
2005	10.11
2006	10.31
2007	9.74

At the end of the first year, the students go through a second selection, where they can choose among four areas (referred to as GA's - Great Areas) related to the different specializations offered:

1. Civil Area (Environmental and Civil)
2. Electrical Area (Automation and Control, Computer and Systems, (4 month terms), Computer and Digital Systems (6 month terms), Energy and Automation, Electronic Systems, Telecommunications).
3. Mechanical Area (Mechanics, Mechatronics, Marine and Naval Architecture, Production)
4. Chemical Area (Materials, Metallurgy, Mining, Petroleum and Chemistry).

Depending on the students performance throughout their first year and the “vestibular” grades they are able or not to enter one of the four GA's related to the specialization they desire. If the student fails to obtain a vacancy in the desired GA they end up studying their second year in a different GA with vacancy.

In the second year of the engineering course, the common disciplines for the GA's are Physics and Calculus, but the Physics discipline for the Electrical GA possesses more weekly class hours and more content, than others GA's. The other disciplines also possess a more specified character, directed at the objectives of each specialization.

At the end of the second year, there is a third selection. Based on the performance of the two first years, the student can obtain the desired specialization, once it belongs to the same GA. The gradual selection finishes at the end of the second year and from the third year on each specialization possess its own objectives and curricular structure.

BASIC CYCLE AT THE POLYTECHNIC SCHOOL ADVANTAGES AND DISADVANTAGES

The format of Basic Cycle at the Polytechnic School provides a series of advantages and disadvantages for the engineering course. With a minimum curriculum offered for all the engineering courses it is possible to bring closer the different specializations, such as curricular aspects, social issues and students and professor's integration; in a way which is similar to the objectives of the Basic Cycle designed for the University in its creation but only for engineering students. This exchange of experiences enables the future engineer to achieve a minimum common base of transit among the different fields of engineering, regardless of their specialization.

However, a course evaluation research done between 2004 and 2006 presented that the curricular structure of the Polytechnic School favored a segregation and discontinuity between the basic disciplines and the specific ones. In accordance with the obtained data and discussions, it was verified that the basic disciplines contents have low relationship with engineering applications and/or with the subjects of the specific disciplines. The students end up in a course where the first two years are distant from engineering, this happens because they only learn concepts without context. The lack of contextualization causes the student to lose interest in the teaching content, and induces

apathy and little participation in the classes. The interdisciplinarity absence also provokes the same consequences.

These characteristics appear mainly in more basic disciplines, such as Physics, Calculus and Linear Algebra. The curriculums of these disciplines do not complement themselves in an ordered way and do not lead to an application of the subject matter.

This does not mean that all taught content must have a practical application in engineering learning, but at least the content has to have connection with the reality of the profession. The type of education that is utilitarian and practical and abstains from the responsibility to mean something beyond the disciplines own scope, would likely be more suitable for Technical Universities, opposed to the proposal made by the University of São Paulo.

Another disadvantage was observed from the results of these researches is the gradual admission process in the engineering courses which is a theme currently debated between students and professors.

In principle, this process makes it possible for the students to better understand the options in the first two years, and later, with better access to information and more time for reflection, choose their course. However, in 2005, a research about the admission form was performed, where students from all terms of engineering were consulted, in which it was observed that only few students changed their minds about their course options in their first two years, as observed in Table III.

TABLE III
INSIDE THE POLYTECHNIC SCHOOL, HAVE YOU CHANGE YOUR IDEA ABOUT WHICH SPECIALIZATION YOU INTEND TO GRADUATE?

	1st year	2nd year
No	73.4%	73.7%
Yes, because I acquired more information	16.1%	13.2%
Yes, because I will not have grades to be admitted in the course I desire	4.4%	3.2%
Yes, because I realize that the market is inclined towards a specific course.	0.4%	1.2%
Yes, for another reason.	5.6%	7.4%

This type of admission does not influence the majority of the students to change their course option, and it stirs up the competition among them, since the selection criterion pertains to school performance. The competition affects the students' behavior to pursue better grades. This may be considered an advantage for some, but on the other hand it develops some values considered negative such as individualism. The students, for example, stop studying in groups or tutoring each other, because they could be helping a "rival" and "losing time" that could be used for their individual learning. In the researches it was also discussed that the better evaluated professors were those who emphasized the exercises more likely to be on their exams, thus validating the competitive system of the gradual selection among the students. The best evaluated didactic materials were those that possess all the answers and texts directed towards the exams. Professors who explore subjects that are not demanded in tests and propose complementary

text reading were evaluated worse by the students due to the competitive environment in which they live.

In 2005, research was conducted on the admission process in which students from all terms and all courses of engineering were consulted. The Table IV shows that a significant part of the students considered the gradual admission system not advantageous.

TABLE IV
DO YOU CONSIDER THE GRADUAL ADMISSION SYSTEM ADVANTAGEOUS, WHERE THE GA AND THE SPECIALIZATION ARE DEFINED AFTER THE VESTIBULAR?

	1st year	2nd year	3°, 4° e 5° years
Yes	44.9%	53.8%	50.4%
No	45.1%	38.5%	40.5%
Indifferent	9.9%	7.7%	8.9%

The segregation of the basic and specific disciplines leads to a lack of contextualization and interdisciplinarity. Together with the gradual admission process, they contribute to students abandoning the course, as we can observe in the data of the 2005 research, in Table V, where more than 42% of the students, of all years, had felt discouraged, thinking about abandoning the Polytechnic School of USP.

TABLE V
HAVE YOU CONSIDERED ABANDONING THE POLYTECHNIC SCHOOL?

	1st year	2nd year	3°, 4° e 5° years
No	58.1%	52.9%	46.0%
Yes, because some disciplines are difficult.	21.6%	20.3%	22.4%
Yes, because it is not exactly what I expected.	14.5%	22.8%	26.7%
Yes, because I think I will not be able to obtain my first option of specialization	5.2%	1.5%	3.3%
Yes, because I do not have the financial means to maintain myself at the Polytechnic School.	0.4%	1.5%	0.8%

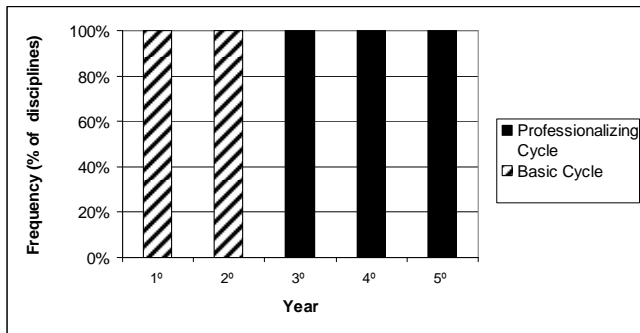
The research data, the contemporary problems of the Basic Cycle of the Polytechnic School and finally other more common models of universities around the world, suggest that a necessary change is apparent.

Furthermore, this change has to not only involve the Basic Cycle of the Polytechnic School, but also all the course structure, rediscussing the objectives in the formation of the engineer and the mission of the University.

A NEW BASIC CYCLE - REFLECTIONS

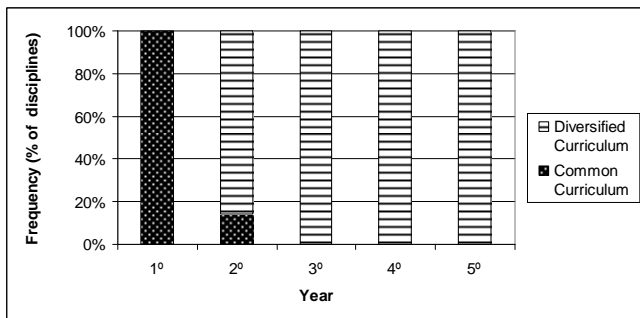
The Basic Cycle of the Polytechnic School can be observed from three perspectives: by time/duration of terms; by common curriculum/common disciplines for different courses and/or specializations; and conceptually, aggregating disciplines with a certain characteristic.

The time prospective, as noted in Graph I, is in the first two years of the course, because the following are years of specialization.



GRAPH I
BASIC CYCLE AT THE POLYTECHNIC SCHOOL – BY TIME

On Graph II is demonstrated that the first year students have the same curriculum and second year students have the same curriculum only if they belong to the same GA. From the third year on this situation changes, because all future graduates follow their own specializations. Considering all the specializations the common curriculum exists during the entire first year and partially in the second year.



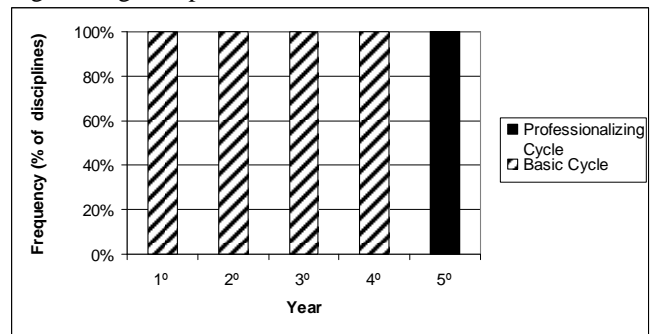
GRAPH II
BASIC CYCLE AT THE POLYTECHNIC SCHOOL – BY CURRICULUM

Conceptually, the Basic Cycle of the Polytechnic School does not present a very clear definition. In principle, it serves as a base for learning the concepts seen in disciplines of professional character, but in the second year it begins to present disciplines that deal with applied concepts, such as “Practice of Electricity and Electronics”, “Characterization Techniques of Materials”, “Introduction to Manufacture Mechanics” and “Resistance of Materials and Statics of Construction”.

When analyzing the Basic Cycle at the Polytechnic School by diverse perspectives a lack of coherence is perceived. There is no time, curriculum and conventional confluence, conversely to the Basic Cycle proposed at the time the University of São Paulo was created. It is also difficult to analyze the Polytechnic School Basic Cycle in relation to others university’s model-matrices, because it has a different character.

A proposed solution would be to have the Basic Cycle of the Polytechnic School in the first four years, with just basic disciplines and the same curriculum for all the engineering courses, as presented in Graph III. The last year of the course would have specific disciplines in engineering. However, this proposal would only segregate even more the basic contents from the specific ones, diminishing the contextualization and eventual interdisciplinarity. Furthermore, it would frustrate the student’s expectations

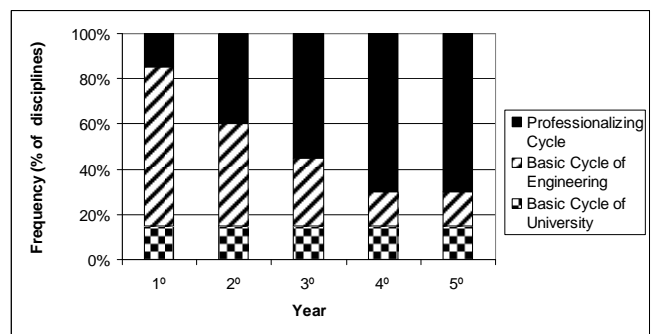
and would discourage the students with only seeing engineering disciplines at the end of course.



GRAPH III
BASIC CYCLE IN THE FIRST FOUR YEARS

Having these questions in mind, it would be attractive to have a course structure composed of three cycles: the Professional, the Basic Engineering and the Basic of the University.

The Basic Engineering Cycle would be formed with the concept of basic content common to all the engineering courses, and would last five years, and would decrease its occurrence from year 1 to year 4. The Professional Cycle, having specific content and being different for each offered engineering course, would be spread throughout the years, increasing its occurrence from year 1 to year 4. The Basic Cycle of the University would be common in all University courses, presenting occurrence in all years, and would have common disciplines that approach subjects directed to the formation of the citizen, such as Law, Economy, Philosophy, Arts and Politics (according to Graph IV).



GRAPH IV
THREE CYCLES – AN ALTERNATIVE PROPOSAL

This model differs from the model considered in the Declaration of Bologna, because it presents all cycles in all the years, and has the only Professional Cycle directed towards the working market. Moreover, the Polytechnic School’s proposed structure possesses a cycle with disciplines intended for the formation of the citizen, therefore, with a broader character.

CONCLUSIONS

In the researches and discussions between professors and students it was observed that the Basic Cycle of the Polytechnic School has to be modified. Initially, it is necessary to have a clearer definition on the general

structure of the course and emphasize the Basic Cycle of the Polytechnic School through diverse parameters. The Basic Cycle of the Polytechnic School has to be cohesive and also transmit significancy to the student who is avid for knowledge about his future profession. An interconnection between the basic concepts and its application is fundamental as an incentive to the study and to encourage student participation. All aspects previous considered must be strengthened with a change in the admission process for the offered specializations. The Polytechnic School has to have a system that favors the contribution, instead of the competition.

The three cycle course model can be an attractive alternative, because it will bring applied knowledge in its first year, and will bring a larger flexibility to each specialization, enabling them to have their own curricular structure, and will propitiate the integration among the engineering students in the Basic Engineering Cycle, because it will be spread over 5 years. The three cycle course will also favor a deeper study connected to specific disciplines. It will also facilitate the exchange of experience and integration with students of other courses and, last but not least, will graduate engineers who possess knowledge of other areas and are capable of fully exercising their citizenship in society.

This pattern differs from the models previously described and is closer to many concepts cited by Antunha, and in certain ways, reestablishes the ideals of the University of São Paulo.

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