Teaching Drawing in Engineering Courses in Santa Catarina State – Brazil

Clóvis Neumann
University of Juiz de Fora/UFJF, Campus Universitário, Juiz de Fora/MG - Brazil
clovis.neumann@ufjf.edu.br

Abstract: - **The purpose of this research is to identify the disciplines' participation which are related to the drawing teaching in 74 engineering undergraduate courses in the Santa Catarina State, and to figure out what are the disciplines' focus in their 19 modalities. We have opted for an analysis in the curricular grid's use for these courses in order to spot which disciplines work with contents related to drawing's teaching, and, after a data collection, we have tabulated them and grouped them by the disciplines' similarity in 4 groups, namely, G1 – Descriptive Geometry; G2 – Technical Drawing; G3 – Emphasis in Software Use; G4 – Emphasis in the Modality. We have concluded that the disciplines participation is, in average, 83.5 hours, which represents 2.04% of the total number of hours of the courses. Also, we have evidenced that there is, in these disciplines, a tendency to privilege contents which are focused in the software use rather than disciplines that will develop competences like space vision, space intelligence and creativity.**

Index Terms – Teaching, Drawing, Engineering.

INTRODUCTION

The increasing speed of the scientific and technical development is influencing some areas of the human society, being responsible for important transformations of the contemporary life. These transformations have less predictable impacts in this same society, and, with the acceleration of the development of new techniques, the task to verify its consequences, which were sufficiently complex before, became still more difficult.

In Brazil, technological education has in the engineering schools its main leading role in the process of diffusion and development of knowledge, which it was initiated with the Royal Military Academy created in 1810; and almost two hundred years later, it is composed for a set of 1.368 engineering courses, where 73 are running in the State of Santa Catarina [15].

In front of the regional necessities' diversity, and aiming to reformulate and in a certain degree to make flexible the engineering education in Brazil, the Chamber of Superior Education of the National Education Council, through resolution CNE/CES 11, dated 11 March 2002, set up the new National Curricular Lines Direction in the Engineering Undergraduate Course [11], which defines that all engineering course, independent of its modality, must possess in its programme three kinds of cores contents, namely, basic contents core, professionalizing contents core and a specific contents core, which characterize the modality.

In the basic contents core, specifically speaking, there are some topics that are concentrated (amongst these, the Graphical Expression), which are structural for the engineer's formation and whose assimilation is essential to develop the competences and abilities required for the professional exercise, independent of the modality.

In engineering, 92% of the projects processes are based on graphical processes [12], and according to Arnheim [10], his study reveals a tendency to minimize the language's role in the productive thought: he suggests that unless one can evoke an image of some process or concept, one is incapable to think clearly on it.

The importance of these topics goes beyond the engineer's profession formation, because they are essential to extend the culture, humanities and languages of the engineer. Some investigations show that there are several common knowledge, abilities, competences and attitudes and that due to occupational deviation; these topics should be emphasized in detriment to the modality's technique specific formation, as in almost all areas, the specialized formation only matters for the first job [6].

How then someone faces a globalized environment characterized by interdependent phenomena and continuous changes from a human formation which privileges the reductional and fragmented thought? [23]; if today the Brazilian engineering school forms, in its almost totality, individuals who are experts in technique, with little or no capacity of context analysis in which they are inserted and, as consequence, incapables to act as a transforming element of the reality? [1].

The working market prioritizes itself in the professional aspects of formation broader than the techniques. Attesting these issues, we must consider the fact that after 5 or 10 years of graduation, the graduates see themselves in the market and with success in the most varied functions and/or roles, the method of adopted education are so important so that the future engineer can win the professional challenges that the reality will demand from him/her [6].

The engineering education, as any educational system, is a subject in permanent discussion. Especially in last decades, there has been a constant debate about the following issues: what students must learn; what are the abilities and knowledge that the good practical in engineering requires; what are the new educational tools which can be introduced in order to improve education; what is the role of the modern technologies, such as learning aided by the computer or the Internet, etc. [19].

An interviewing study was carried out with a sample of the graduated class of 1980, 1990, 1996 and 1998 and amongst the abilities pointed as important with respect to the professional exercise, the interviewed ones judged that the school contributes adequately for the development of the professional ethics; the capacity to work in teams; but it does not contribute to the development of the initiative, creativity, adaptation to the changes and leadership [4].

The study in this paper focuses on the Superior Teaching Institutions (STI) of the Santa Catarina State which offer engineering courses in any of its modalities, and it was carried out between 23 May 2006 and 07 July of 2006, and involved the following activities: (i) documental research, where these documents have been accessed from the courses' web pages on the Internet, or they have been sent to us via e-mail in reply the questions sent the secretariat of the course; (ii) study of the collected material, (iii) data organization and treatment; and (iv) analysis of the results, from a conceptual bibliographical review.

LITERATURE REVIEW

In this chapter, the literature review is presented, in which we intended to summarize the most pertinent aspects that are related to the objectives of this exploratory study. However, we do not intend to exhaust the subject, due to its scope and its possible approaches and inter-relations.

I. The STI's Role in the Competences Definition

The globalized environments, which are current in this century, have presented some challenges to the professionals of the technological area. The laboriousness in this century goes necessarily through the capacity of educational institutions in providing the development of competences in a structured and coherent way with the social necessities. The organizations had understood that it is necessary to develop basic and specific competences in its employees [5].

In order to define competence, three great classic elements prevail as reference for a classification in this field: the personal capacity to articulate knowledge (to know), the abilities (how to make) and the attitudes (to be/to act), inherent to the work situations.

It is impossible to formulate and to maintain a sustainable economic and social development project without knowledge, and the university, which by its nature, has a role to play in order to overcome the disharmony in the process of changes, as a 'catalyser element' in the process of formation of the global man, through investments in science, research, technology and innovation, forming professionals capable to generate technological changes, and not only following them.

Reflecting upon this context of change of paradigms, [20] highlights that the current moment is a point of inflection between the certainty age and the logical reasoning (industrial age); and a new age which is characterized for the imprecision, the unknown future and the infinite number of objective possibilities that are presented (knowledge age).

The information is considered the raw material of knowledge and [8] stresses that knowledge is information provided with value. According to [16], knowledge is an organized form of information consolidated by the human mind by means of cognitive mechanisms of intelligence, memory and attention.

According to [24], the Pedagogical Project of a Course is an instrument which contains the orientation decisions of the featured educational actions of an institution or a sector of this institution. The *curricular grid*'s structure can be seen as a strategy for attainment of its objectives. When elaborating the Pedagogical Project of the Course, the desired profile of the graduate (i.e. egress student) is defined, and this is represented by the *curricular grid*, in which it is expressed and can be visualized the 'spinal column' of its pedagogical project.

II. Learning Methodologies

Due to the diversity of contents and the agents' personal features in the teaching-learning process, there is no tool or education methodology of universal use. The learning methods and techniques must vary in accordance with the domain in which they relate and with the capacities of their agents. Besides using methods and appropriate techniques; it is a teacher's responsibility keeping the students' attention, and using for this, strategies and/or processes in which students learn to think and to discover things.

According to [7], one of the crucial issues for our pedagogical practice is the conception that we have about knowledge. In this sense, the author reflects on the following question: the knowledge acquisition process is carried out by means of discovery or construction?

In accordance with [5], for the development of competences, the most adequate educational methodology is the constructivism education, particularly called teaching through competences, where the knowledge (i.e. the truth) is not in the subject side (rationalism) and nor in the object side (empirism), but in the interaction between them, that is, the knowledge is given by the relation between the subject that knows and the knowledge's object.

An example is the Cooperative Learning Methodology, as Smyser [16] explains; it is a strategy where the students help each other during the learning process, acting as teacher's partners and of themselves and aiming to learn a specific subject matter.

In order to illustrate the example, there is a report produced in a teaching seminar, in the Lancaster Management School, 1994. The report refers to the problem that the majority of the world's schools still are more focused in the learning by experience than the education for the future [18].

Paradigms changes start by stretching the reasoning processes, outside of the focus on things, entities and events, towards the affinities, symbolisms and interconnections. It starts outside of the universal order which is peculiar to the human species; it follows analyzing the culture conditioned to the man's perception, in order to arrive at the recognition of the possibility of ways to see the world dramatically and differently. [18].

III. Basic Competences for the Engineer's Formation

III.I- Space Vision

Space vision is one gift that, in principle, everyone has; it gives the capacity of mental perception for space forms. To perceive mentally a space form means to have the feeling of that space without seeing the object [9].
The space vision depends on a logical reasoning and also on ludic, creative and subjective schemes, which the pure reason not always can hardly explain. As an example, in the engineer's formation, there is a discipline called Descriptive Geometry which needs the space vision and the creativity in order to be understood.
According to [21], the drawing has, as the main purpose, the precise representation, in the plane, of the material world's forms, and, therefore, three-dimensional (i.e. 3-D), in order to make possible the construction and constitution of these forms.
The Technical Drawing is a form of graphical expression that has as purpose, the representation of the form, the dimension and position of objects in accordance with the different necessities required for the various modalities of engineering and architecture as well [9]. In the Technical Drawing discipline, there exists a complete 'load' of complexity which comes from the necessity of discerning the correlation between space and plane.
According to [21], even though the development of new project tools, the previous knowledge for the basics of Descriptive Geometry and Technical Drawing will continue to be essential to allow the designer brings together his/her representation technique with his/her creative capacity supported by a representation technique and a graphical tool in a even more surprising way.
With difficulties, as much in teaching as in learning, several courses and universities have preferred to remove those disciplines (i.e. Descriptive Geometry and Technical Drawing) from their programmes, in a moment where the new professional profiles associated to the new technologies require from the professionals a great capacity of abstraction, the discernment exercise and behaviour qualities related to the confidence and team working. [13].

III.II - Creativity

Changes always occur, but they had been always absorbed by the succession of generations. Nowadays, science and technology make the panorama to become chaotically unstable, due to the innovation speed. However, we can go far beyond the adapted condition. But the condition change's agent must elapse from a conscious positioning, which contemplates our natural trend [18].
All the man's creative process develops itself in the 3-D space. When we need to put our ideas ahead, we make use of a representation technique [22]. A research shows results about loss of creativity from infancy to the adult life [3], in which it observed the capacity to generate original ideas. The resulting punctuation, comparing "original" and "standard" answers, was: 5 years or less – 90% of originality; 7 years – 20% of originality; adults – 2% of originality.
Any analysis which intends to anticipate the competences that will gain priority is in the direct dependence of the mutant panorama. The experience tends to lose value, while the capacity to coexist and/or to promote the change assumes prominence. People who apply systemic thought (focused on the book called The Fifth Discipline, by Peter Senge), and have the capacity to deal with the innovation, through intuition and improvisation, will be better and more comfortably placed in the future. Thus, it can be said that the world soon will have different owners [18]. In conclusion, the author deduces which type of ability will start to be valid more in function of a new environment than, in turn, will be occurred from born variables of the described conditions. He also says that we certainly will value different competences differently from the current ones, and that they will be defined by new conditioning situations, which will be able to escape very little from these three realities:

- The normal abilities, mostly rational, currently, can complete the majority of the tasks of the present time, which were not yet moved too much in relation to the time that will come. There is, for the time being, an index x of changes, but in a significantly increasing level.
- With the index of changes' increasing, from a certain level, the normal abilities will reveal insufficient. New problems are not faced nor equated for the experience.
- We started already to have necessity to develop abilities like "beyond the rational" in order to face problems like "beyond the normal". Considering "normal" everything what we can predict.

III.III - Space Intelligence

The human intellectual competence must present a set of abilities for problems resolution enabling one to solve problems or genuine difficulties that he or she finds, and when adequate, to create an adequate product, must also present the potential to find or to create problems, and, by means of this, propitiating the steadiness for acquisition of new knowledge [10].
Reference [2] describes that Gardner offered a method for mapping the wide gamma of capacities of the human beings, when grouping these capacities in eight categories or including "intelligences", namely, Linguistics, Logical-Mathematics, Space, Corporal-Kinaesthetic, Musical, Interpersonal, Intrapersonal and Naturalist.
The Space Intelligence is distinguished amongst these, which is described as the capacity to perceive with precision the visual-space world and to carry out transformations regarding these perceptions. This intelligence involves sensitivity to colour, line, form, configuration and space, and to the existing relations amongst these elements. It also includes the capacity to visualize, to represent visual or space ideas graphically, and to orient approximately in a space matrix [2].
The space intelligence abilities are: perception, memory and reasoning. For [10], a person who desires to occupy a job position which requires talent in the space area, like engineering, for instance, must learn the "space language" and think in this "space environment".

RESEARCH RESULTS

We have obtained that 15 STIs offer engineering courses in Santa Catarina State, and two are public institutions (e.g. UFSC and UDESC). The number of offered engineering courses is 74, and they are offered in 19 modalities, which are subdivided in 7 qualifications.

Table 1 presents the STI's list, sorted in descending order by the amount of engineering courses that they offer.

TABLE 1
SUPERIOR TEACHING INSTITUTIONS WHICH OFFER UNDERGRADUATE ENGINEERING COURSES IN SANTA CATARINA STATE

Superior Teaching Institution	Courses No.
Universidade Federal de Santa Catarina – UFSC	12
Universidade do Contestado – UnC	7
Universidade do Sul de Santa Catarina – UNISUL	7
Instituto Superior Tupy – IST / SOCIESC	7
Fundacao Univ. do Estado de Santa Catarina – UDESC	6
Universidade Regional de Blumenau – FURB	6
Universidade do Oeste de Santa Catarina – UNOESC	6
Universidade do Extremo Sul Catarinense – UNESC	4
Universidade do Vale do Itajaí – UNIVALI	4
Centro Universitário de Jaraguá do Sul – UNERJ	4
Universidade Com. Reg. de Chapecó – UNOCHAPECO	3
Universidade da Região de Joinville – UNIVILLE	3
Universidade para o Des. do Alto Vale do Itajaí – UNIDAVI	2
Faculdade SATC – FASATC	2
Universidade do Planalto Catarinense – UNIPLAC	1

Amongst a total of 110 STIs authorized to offer undergraduate courses in the state [11], only 13.63% of institutions offer engineering courses. The UFSC is amongst the public STIs which offers the biggest number of engineering courses (12 courses) and amongst the private ones, UnC, UNISUL and SOCIESC are tied up, offering 7 courses.

Table 2 presents the 19 modalities offered for the engineering courses in Santa Catarina State. Observing the table, we can conclude that the Production Engineering course presents the biggest number of courses in the state, followed by Civil Engineering and Electrical Engineering courses.

TABLE 2
ENGINEERING COURSES' MODALITIES IN SANTA CATARINA STATE

Modalities	Courses
Production Engineering	11
Civil Engineering	9
Electrical Engineering	7
Chemical Engineering	7
Food Engineering	6
Environmental Engineering	6
Mechanical Engineering	5
Forest Engineering	4
Control and Automation Engineering	3
Computer Engineering	2
Industrial Engineering	2
Telecommunications Engineering	2
Materials Engineering	2
Sanitary and Environmental Engineering	2
Horticulture Engineering	2
Surveyor Engineering	1
Foundry Engineering	1
Plastic Engineering	1
Aquaculture Engineering	1

Originated from the approaches diversity about the issue of what to teach and which the emphasis that must prevail in the formation process of the engineering students, observed in the theoretical reference, the methodological procedures have had in the question "What are the engineering courses disciplines in Santa Catarina which work with contents related to drawing?", the scientific hypothesis which helped in the formatting and logical structuring of the problem of this study.

Doing an analysis in the *curricular grid* of these courses, we have identified the disciplines that ensure the study issues and, after the data collection we have tabulated and grouped them by the similarity of disciplines in four groups, namely, Group 1: Descriptive Geometry; Group 2: Technical Drawing; Group 3: Emphasis in Software Use; Group 4: Emphasis in the Modality. Table 3 below presents the results:

TABLE 3
DISCIPLINES WHICH THE CONTENTS ARE RELATED TO DRAWING IN THE ENGINEERING COURSES IN SANTA CATARINA STATE

G1: Descriptive Geometry	No.
Space Graphical Representation	2
Descriptive Geometry	12
Drawing and Descriptive Geometry	2
Geometrical Drawing and Descriptive Geometry	1
Descriptive Geometry and Technical Drawing	1
Graphical Expression	2
G2: Technical Drawing	**No.**
Drawing	5
Fundamental Drawing	4
Basic Technical Drawing	6
Basic Drawing	1
Technical Drawing	43
Technical and Geometrical Drawing	2
Technical Drawing and Descriptive Geometry	1
G3: Emphasis in Software Use	**No.**
CAD – Computer Aided Design	9
Mechanical Drawing – CAD II	1
Mechanical Drawing – CAD	1
Production Drawing Aided by Computer	1
Geometrical and Modelling Drawing	1
G4: Emphasis in the Modality	**Nº**
Technical Drawing for Electrical Engineering	3
Drawing for the Electroelectronics	1
Technical Drawing for Civil Engineering	3
Civil Construction Drawing	2
Drawing applied to Civil Engineering	2
Architectural Drawing	2
Technical Drawing for Mechanical Engineering	1
Mechanical Drawing I	1
Industrial Drawing	1
Drawing applied to Electrotechnique	1
Technical Drawing for Materials Engineering	1
Technical Drawing for Sanitary Engineering	1
Technical Drawing for Chemical and Food Engineering	2
Drawing applied to Chemical Engineering	1
Drawing applied to Forest Engineering	1
Technical Drawing for Forest Engineering	1
Drawing applied to Forest Engineering	1
Rural Technical Drawing	1

Analyzing the table above we can conclude that the Descriptive Geometry Group presents 20 occurrences; the

Technical Drawing Group presents 62 occurrences; the Emphasis in Software Use Group presents 13 occurrences; and the Emphasis in the Modality Group presents 26 occurrences. Under this approach, we can conclude that the Technical Drawing Group is the greater of this study and represents 51.24% of the occurrences, in second position the Emphasis in the Modality Group represents 21.48% of the occurrences, in third place the Descriptive Geometry Group represents 16.52% of the occurrences and finally the Emphasis in the Software Use Group with 10.76% of the occurrences.

Relating the number of hours that each discipline contains to the total number of hours of the course where it is offered, we can obtain the discipline's percentage of participation in the composition of the total number of hours of the course. Table 4 presents these percentages grouped by modality.

TABLE 4
PARTICIPATION OF THE DISCIPLINES GROUPS IN THE MODALITIES

Modality	G1	G2	G3	G4	Total
Surveyor Engineering	-	3,64	-	-	3,64
Civil Engineering	1,16	1,27	1,12	-	3,55
Mechanical Engineering	0,73	1,39	-	1,29	3,41
Production Engineering	0,75	1,41	0,54	0,70	3,40
Sanitary and Environmental Eng.	0,80	0,79	0,80	0,79	3,18
Foundry Engineering	-	-	-	2,96	2,96
Plastic Engineering	-	1,21	-	1,62	2,83
Industrial Engineering	0,56	1,44	0,69	-	2,69
Control and Automation Eng.	0,49	1,77	-	-	2,26
Horticulture Engineering	-	1,65	-	-	1,65
Electrical Engineering	0,21	0,79	0,61	-	1,61
Environmental Engineering	-	1,59	-	-	1,59
Telecommunications Eng.	-	0,84	0,68	-	1,52
Aquaculture Engineering	-	-	1,50	-	1,50
Food Engineering	0,31	0,67	0,34	-	1,32
Computer Engineering	-	1,32	-	-	1,32
Materials Engineering	-	0,80	0,48	-	1,28
Chemical Engineering	-	0,71	0,49	-	1,20
Forest Engineering	-	0,27	0,93	-	1,20

The percentages presented in the table above inform that, on average, the disciplines related to Drawing in Engineering Undergraduate Courses in their 19 modalities represent a range between 3.64% and 1.20% out of the total number of hours of the courses. Also, a great variation between the modalities is perceived, totalling 3 times between the greater and minor participation of these disciplines groups in the total number of hours of the course.

Only 8 out 19 modalities offer disciplines from Group 1: Descriptive Geometry; 17 offer disciplines related to Group 2: Technical Drawing; 11 offer disciplines from Group 4: Emphasis in the Modality; and 5 modalities offer disciplines from Group 3: Emphasis in the Software Use. One perceives that various modalities have disciplines in only one discipline group, which demonstrates what the approach these modalities give when they teach these contents.

We have calculated the total average per group. The results are: Group 1: Descriptive Geometry is 0.22%; Group 2: Technical Drawing is 1.06%; Group 3: Emphasis in Software Use is of 0.40%; and the average of Group 4: Emphasis in the Modality is 0.35%.

Also, under this approach, we have concluded that the Technical Drawing Group is the greater of this study and represents 52.21% of the occurrences; the second one is the Emphasis in Software Use Group with 19.70% of the occurrences; in third place is the Emphasis in the Modality Group with 17.24% of the occurrences; and finally the Technical Drawing Group with 10.85% of the occurrences.

CONCLUSION

The general objective of this research was to identify the participation of disciplines related to the teaching of drawing in the Engineering Undergraduates Courses in the state of Santa Catarina, and to identify what is the focus of these disciplines in the diverse modalities of engineering teaching. In this direction, through a documental research, we have built and structuralized a data base with the research results, in order to obtain pertinent information to the research objectives, where we have presented a new way of looking at the issue which deals with the disciplines' teaching related to drawing, and grounded by the analysis of a set of transcendental objectives occurrences to the author whom it investigates.

In this intention, it was identified that there are 15 Superior Teaching Institutions in Santa Catarina which offer courses for graduation in engineering. Also, it was identified that there are 74 courses of engineering running in the first semester of 2006 in the state of Santa Catarina in 19 modalities; we also have identified in the *curricular grid* of these courses which disciplines are related to drawing; as well as we have classified them in 4 groups.

A diagnosis of the current scenario of this exploratory study is presented, where we have shown the disciplines related to the teaching of drawing in the engineering courses in Santa Catarina, in which we have computed, respectively, the number of hours each one of these disciplines have, and their relation to the total number of hours of the course where they are offered. This relation was presented in terms of percentage of their participation in the composition of the total of the course.

We also have calculated the number of hours' average of the undergraduate courses in engineering in the state, which is 4,094 hours. And considering that the total participation of disciplines related to drawing's teaching in the undergraduate courses is 2.04%, we have concluded that these disciplines correspond to 83.5 hours in average.

Dividing this number of hours (i.e. 83.5) by the 4 groups defined in this research, we obtain that Group 1: Descriptive Geometry presents 9.25 hours (10.85%); Group 2: Technical Drawing presents 43.50 hours (52.21%); Group 3: Emphasis in Software Use presents 16.45 hours (19.70%) and Group 4: Emphasis in the Modality presents of 14.25 hours (17.24%); all these numbers in average.

Even though the low participation of these disciplines in the *curricular grid*'s composition of the engineering undergraduate courses, excellent and worrying questions are raised, but certainly to analyze which contents that are really being taught in these disciplines are still more important, in order to allow an assessment of relevance and to think in terms of relevancy in the formation of the engineering professional, but due to some difficulties found for accomplishment of this research, we indicate them as a recommendation for future works.

Although modalities like Foundry Engineering and Aquaculture Engineering do not have clearly disciplines related to Descriptive Geometry and Technical Drawing, when the 74 courses of engineering have been analyzed individually, it is evidenced that out of 62 occurrences of Technical Drawing Group, about 50% of these concomitantly works contents related to the software use's teaching.

Correlating the results of this research with the bibliographical review, in which we have approached main issues like some excellent basic abilities for the engineer's formation for instance, and specifically the development of the space vision, the creativity and space intelligence; it is perceived that the development of these competences practically is neglected in some modalities of engineering undergraduate courses in the state, and thus jeopardizing the formation of enabled professionals who have to compete in a changing scenario and have to rewrite the future of our society, so engaged for the current development model.

Because we are living a moment where, disciplines related to the drawing teaching suffer reduction in the number of credits, it is fundamental that we must prioritize the valuable hours' course which are still available for the development of competences in space intelligence, because despite the reasons showed in the literature review, the space knowledge constitutes in a graphical language which normally can be understood only by the person who studies it, needing the lecturer's active participation for a successful teaching-learning process.

Reference [10] affirms that the space knowledge can serve for a variety of scientific purposes, such as a useful tool, an aid to the thought, a method to catch information, a mode to formulate problems or as a appropriate resource to solve the problem, and concludes saying that perhaps McFarlane may be right when he suggests that, after an individual has reached an established minimum verbal aptitude, the space capacity is the ability which determines how far the person will progress in sciences.

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