DIRECTIONS AND CHALLENGES IN INFORMATICS EDUCATION ON ENGINEERING AND COMPUTER SCIENCES COURSES

Clara Amelia de Oliveira[1]

Abstract *— XX Century culture has emphasized specialization paradigm in all knowledge domains. Globalization times have increased complexity on this scenery putting real challenge to earth people, including Engineering and Computer Sciences domain. In this direction, this paper presents an Educational methodology- the Thematic Oriented Methodology. The concrete experience occurred on a Computer Programming Introductory discipline, on Engineering and Computer Sciences courses. This pedagogic experience pointed out how important is to built a clear object of study definition under Complex Though approach as a knowledge domain. The Complex Though is, by its side, close related with XXI Century educational demands, as proposed Edgar Morin, from UNESCO Itinerant Educational cathedra. The central question to be discussed here is, how new curricular trends can profit from this approach? Some conclusions enhance thematic oriented proposal as an answer to educational demands under globalization approach.*

Index Terms — Complex Though, Computer Sciences and Engineering Education, Educational Methodology Thematic Oriented Methodology.

INTRODUCTION

The presence of Informatics on modern civilization has been a central discussion point on several scientific forums, all over the world. But the informatics contribution on education can be wider than just referring to instrumental support, specifically on technological careers educational scope. Engineering and Informatics curricula have a deep question to be faced, at first. It is how to organize contents, such way, students can develop, both, analytic thinking, required in focused knowledge aspects, and synthetic thinking, required on multifocus knowledge aspects. Some tasks refer to modeling systems practice under very complex environments, but, at same time, at closed systems, leading with specific details. The question is how to promote, pedagogically, this movement causing internal link between broad and specific knowledge aspects? Can engineering and informatics students, at same time, pay attention on special inner machine tool contents, aligned with high abstract values, as society engaged citizens? This is possible, for several reasons, and the simplest one is that because this is natural. This is not only possible, but it is desired on all kind of knowledge domain, including Engineering and Informatics one. Those educational trends looking for necessity of synthesis at curricular level, have been proposed by ABET criteria 2000 [1], as a directive, for engineering careers, emphasizing synthetic approach. Those principles are, also, in accordance with generic educational trends present in recent documents from UNESCO, looking for Complex Though studies proposed by Edgar Morin Itinerant Cathedra [2]. There is notable convergence of educational principles related with engineering, and Informatics, careers because of nowadays demands of modern professional profile. In this direction, there is available a theoretical tool, proposed by Nygaard, applied, at first, in information systems modeling [3], but, ready to support education systems demands, as it will be discussed below.

THEMATIC ORIENTED EDUCATIONAL METHODOLOGY AS A PEDAGOGIC AXIS ON INFORMATICS AND ENGINEERING CURRICULA

Thematic Educational methodology is a proposal that is developed around thematic as a pedagogic axis. The central idea of Thematic Oriented proposal is to lead with enough wide categories of knowledge. Because of wide scope it implies in a long life cycle time activities around proposed activities named as projects. On this sense, a project is a thematic implementation traducing a kind of open knowledge domain category, in witch technical to social, ecological, or economics aspects, can be inserted. It is crucial here the definition of level of generality of object of study. Object of study level must to be carefully defined at curricula instance because of its pedagogic potentiality. It creates new relationships between disciplines, altering traditional disciplines structure. Figure 1 illustrates a pedagogic choice between two different levels of generality associated to the same thematic, or, object of study. It refers to *Water studies* thematic. Water thematic can be chosen at high level of generality, for example, as an Earth Life thematic under an open knowledge domain. It can be chosen at low level of generality, for example, as a Physical Chemical thematic, under a closed scientific knowledge domain. This choice is what is relevant at curricular proposals.

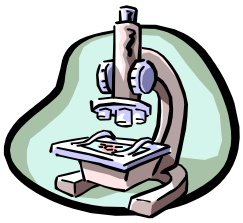
This educational proposal is theoretic inspired in several authors ideas. It expresses a concrete pedagogic implementation of Bertrand Meyer Inverted Curricula idea.[4]. At curricular level, Thematic Oriented design

[1] Clara Amelia de Oliveira, Dept. of Informatics, Technological Center, Federal Univeristy of Santa Catarinna- INE-CTC-UFSC, CxP.476- 880400-900, Florianopolis, Santa Catarina, Brazil, clara@inf.ufsc.br

affects directly basic sciences disciplines organization. Inverted Curricula trend, in terms of disciplines contents suggests insertion of more specific disciplines later on the course schedule. For example, Numerical Methods, Physics and Maths specific contents are better explored, later, on curricula disciplines, when projects are associated to more sophisticated, or specialized categories of knowledge. By the other side, those contents can, indirect, be present, at some first basic approach also in projects at fresh curricula disciplines. Same way, other very abstract and wide aspects as insertion of technologies in society are suggested to be discussed early at all kinds of technological curricula. In addition, it does not matter if curricula is divided in pieces of knowledge called disciplines, or even, projects. At this discussion level, both terms can be treated as synonymous without lacking the pedagogic proposed idea.

Object of Study: WATER
Level of Generality choice:
level 1 (+ generic)
level 2 (– generic)

Level 1 - *Water* associated with *Earth Life* thematic (+ generic)



Level 2 - *Water* associated with *Physical-Chemical* thematic (- generic)

FIGURE. 1
DEFINITION OF THEMATIC LEVEL OF GENERALITY.

But, Thematic Oriented methodology [5] is not, only, a pedagogic proposal to treat knowledge. Actually, it affects the other educational aspects belonging to a teaching/learning environment, such as instrumental issues, evaluation process. This is called Complex Educational Approach that is the central axis of this pedagogic proposal.

A MODELING TOOL TO TREAT AN OPEN KNOWLEDGE DOMAIN

First step: definition of Object of Study, or Thematic searching to a high level of generality. After defining the object of study, as a generic thematic, it emerges the complex view, or open knowledge domain perspective. This aggregates flexibility aspect regarding the way knowledge is treated. This direct affects the way pedagogic tasks can be developed. After this first step, treating knowledge as a wide scope, it emerges a second and important step.
Second step: what a kind of tool is adequate to support open knowledge modeling? This step is related with the necessity of an adequate tool just to support implementation aspects on, day by day, pedagogic activities. What a kind of modeling tool could help and could be closely harmonic to lead with such broad knowledge categories under complex approach? Let's see.

Tribute to Nygaard and Dahl – Two Eminent Scientists of Complex Modeling in Informatics

The answer to pedagogic demands on complex, or open, models of knowledge is given by an Informatics modeling tool. Complex modeling in Informatics is related with Object Oriented tool principles. Those principles were derived at XX century, by the years sixties. The abstract operation principles are operational possibilities, just contributing to convert open models from seeds to big trees. XXI century, certainly, will profit of this. Unfortunately the author of this theory, Professor Kristen Nygaard, emeritus professor of Department of Informatics of Oslo University is died some months ago. The author of this paper met Prof. Nygaard several times and think he was a great man, human people and great citizen. But, what is important is that his voice go ahead because, today, many scientists can develop open models over those derived Object Oriented formal principles. They are special applied and known at computer systems domain, or even, at least, in internet packages. It is possible that, nowadays, young scientists do not remember that some time ago, computer programming and thinking followed a sequential approach. Its evolution toward structured approach was a wonderful but this emphasized horizontal modeling. This Object Oriented formal organization was particular useful in increasing complexity models. Object Oriented practical implementation occurred through Nygaard and Johan Dahl hands. The partner of Prof. Nygaard, Ole Dahl, was also professor from Oslo University. He has implemented Simula compiler on the sixties. Both passed away some month ago, causing consternation on scientist community.

Harmonic wedding between Object Oriented Modeling Tool and Complex Knowledge Domain

Complex approach finds a natural link with Object Oriented modeling tool if pedagogic axis is defined as a broad Thematic as the scenery adequate to build a curricular

design. Here it can be taught about engineering curricula, informatics or elsewhere, it does not matter.

It is considered that the abstract operations are the core of Object Oriented tool. They allow vertical models development. It is in accordance with nowadays necessity regarding complex knowledge models. Informatics domain as information models solver, deep benefit itself from those principles. By the other side, vertical development of knowledge representation can be limited according with modelers objectives. At Informatics domain, the roof of generality can be a concrete project or machine associated with its costs, or its time to run. This is equivalent to a less generic level in terms of knowledge modeling. This is something like level 2 presented on Figure 1. Generality of thematic modeling is a crucial aspect because potentiality of Object Oriented thinking will be limited by this issue. What is absolutely positive is that Object Oriented tool is always potent because of its intrinsic generality of principles. It does not lack the horizontal domain enhanced on structured modeling, which was the precedent modeling paradigm, great performed on the years seventy. Object Oriented proposes includes vertical, as well as horizontal modeling. So it is important to reinforce necessity of changing way to treat knowledge to arrive to globalization times demands. In the case of Object Oriented potentiality, it grows up, exponential way, in complex models associated with real world open domains. In this case, knowledge categories are treated all together. They include economics, ethics, bio, eco and technical issues. Engineering domain, in this sense, seems to be more harmonic than Informatics because it usually, is more generic than Informatics domain of knowledge. So it profits the maximum from this knowledge modeling tool. Object Oriented approach will transform, in the future, the vision also in Informatics, putting it, in a harmonic place of knowledge category, not, at all, at the top of knowledge category, but as a support of knowledge humanitarian vision.

THEMATIC ORIENTED METHODOLOGY TO FACE GLOBALIZATION DEMANDS AT CURRICULA PROFILE

New trends at curricula level points out integrative directives to face globalization context and its demands. In this sense, thematic oriented methodology represent the union of those aspects because it affects the deeper level of contents organization as a central directive. And what is this deeper level? It is the new look to knowledge categories as open knowledge ones. An open knowledge vision facilitates to increase towards vertical direction all pieces of knowledge. Here it is important to perceive that the way you treat knowledge affects much more educational structure than pedagogic practices. Despite of this, all practices, including instrumental one are benefited by integrative curricula trend. This occurs because the integrative view offer a broad approach for all kind of minds, not only to experimental oriented minds but also to abstract ones.

Thematic as a Complex Object of Study

Complexity is a key word considering new professional profiles at globalization context. Complex, following Edgar Morin cathedra about Complex Though, is *what is treated together with its wide context*. This also can be traduced by what can not be fragmented[6]. Here appears the definition to generality level to be associated with thematic as a complex object of study. So, this way, thematic is treated as a real world object of study. There is to say, thematic will be modeled during a long period of activities. Their possibilities are from a discipline period till a whole curriculum built around disciplines or even projects units. In this sense thematic is equivalent to a meta project that can be developed creative way under infinite possibilities.

Pedagogic Directives under Thematic View

There are two pedagogic directives to be considered by thematic vision in education. The first directive is the bi-directional movement between knowledge categories, from generic, as ethics, ecological, economics and social ones, to specific categories, as maths physics, computer sciences ones. The second pedagogic directive is the inversion of general direction of knowledge categories to be treated. The suggestion is to treat first generic categories, and, the specific categories will appear, according to necessity of self inclusion, permitting understanding of thematic aspects increasing. Those two directive alter curricula vision because knowledge is distributed around projects of with longer life cycle than traditional specific knowledge vision.

Some Concepts related with Thematic Approach

Depending on the level of generality, thematic exploration demands a long time cycle to develop all categories to be treated in thematic context. Considering traditional curricula organization built around disciplines, Thematic Life Cycle corresponds, at least, to a whole discipline. It is a previous condition to consider thematic as a complex object of study. Here it appears, again, the concept of complexity related with open knowledge domain. This concept is different from specific concept of complexity of parts, concerning to closed domains of knowledge. For example, complexity of algorithms, or, math complexity are related with closed domain of knowledge. Both, algorithms and math complexity, appear, naturally, embed as part categories, or horizontal categories of open knowledge domain. They correspond to horizontal development of knowledge, encountered in close, or specialized knowledge domains. So it is important to perceive that open knowledge domain is not at all opposite to closed knowledge domain but the open domain embed the close one.

CONCRETE EXPERIENCE WITH THEMATIC APPROACH AT FRESH MAN CURRICULA

After thematic definition level (Figure 1), several versions of meta project implementation are presented (from Figure 2 to Figure 4). Thematic approach here refers to a fresh man curricula experience. Water Studies is related with at government level. The treatment of knowledge, traduced by several project versions, is supported by 'abstraction principle'. Through abstraction, a generic thematic can be treated as several concrete projects with increasing complexity. This way, what is already defined as thematic can be traduced as a meta project. Each project to be implemented during semester, or annual pedagogic activities, normally called disciplines, is a stage of the same metha project. Figure 2 shows a project proposal at energy ministry level. It appears generic aspects as ethics, economics and social ones. Of course here there are no technical details, not at this first moment. They will appear, step by step, soon, as illustrate by figure 3 and figure 4.

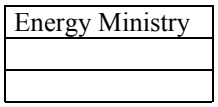


FIGURE. 2
PROJECT INITIAL VERSION: HIGH LEVEL OF GENERALITY AND HIGH LEVEL OF ABSTRACTION.

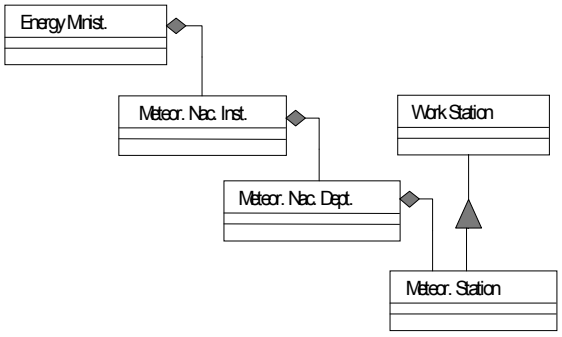


FIGURE. 3
PROJECT VERSION ONE – GENERIC KNOWLEDGE LEVEL.

Figure 3 shows project version N. It is later developed over project initial version. Thematic is still the same. Here they are included aspects, as governmental structure to treat this theme, and, also, it appears some specific aspects, related with professional career technical contents.

As time goes by, thematic exploration arrives to more specific stages as you see at Figure 4. This example refers to details of rain follow data which is manipulated under a math structure of data of an information system. Math, physics and informatics specialized knowledge grow up, as the versions are implemented.

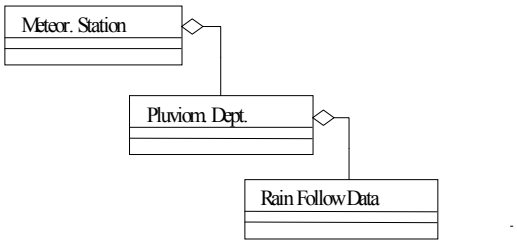


FIGURE. 4
PROJECT VERSION N – SPECIFIC KNOWLEDGE LEVEL.

CONCLUSIONS

*On the Union of Thematic Oriented Approach + Object Oriented Tool as a contribution to Computer Programming disciplines.*Thematic Oriented Approach together with Object Oriented modeling contributes to curricula integration under complex view. From sophisticated modeling principles till little programming details, or even, high abstract values as the insertion of informatics on human life, all can be treated together in an introductory computer programming discipline.

*On the integration of basic disciplines on fresh man curricula under thematic Oriented approach.*Thematic Oriented Approach, supported by Object Oriented Modeling Tool, promotes easy and harmonic integration between several basic disciplines, as introductory computer programming, information systems modeling, numerical methods, statistics methods, physics and maths. The abstraction principle aids to develop several project versions creating reusable knowledge.

*On the Thematic Oriented Vision as an Open Pedagogic Proposal Looking to Tecno Careers New Profile.*Integrated, open, or even, Complex Vision on education contributes to new professional profile and to alter professional life, under globalization demands. Integrative tendency is an important pedagogic option because it considers all educational aspects together changing pedagogic axis to human development process. And this is a high abstract pedagogic directive that is welcomed regarding future life at earth.

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