Integration of Research and Teaching in Engineering and Computer Education – Research Projects as a Source for Curriculum Development in Response to Globalization Challenges

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Abstract **- The present paper describes and analyzes a Portugal-Brazil research project focusing the development and transference of knowledge in the Civil and Production Engineering field under supervisor engineer point of view. The work refers to three aspects: outer knowledge management by companies, the organizational environment, and, how engineer develop his professional competence. Possibility of transference from those kinds of sophisticated research works, also called "real world" focus to class room is desired to modify the *status quo* from traditional engineering curriculum looking to integrative view in education. On this direction, the UNESCO cathedra form "Complex Thought" offers a theoretical support to the migration of research experiences under "real world" perspective to curriculum development. In this direction, it is presented the seven steps of "Thematic Oriented" teaching practice. Thematic Oriented practice is a "complex thought" application in education. From this, it can be pointed out the importance of changes in Engineering and Technological curriculum focus from specialized towards generic view. The "real world" perspective reinforces pertinence of knowledge, a "complex thought" principle enounced by Edgar Morin, the president of the itinerant "Complex Thought" cathedra. In addition, it supports students motivation in technological careers facing educational crisis in globalization times.**

Index Terms – Integrative View, Integration, Research, Teach, Complex Thought, Thematic Orientation.

INTRODUCTION

The present paper goal is to show how to integrate research specific knowledge with educational practice looking for curricular perspective in engineering education. The Civil Engineering theme is discussed and analyzed in educational perspective. This text is resultant from the authors Oliveira and Souto meet in the "I Colloquium in Complexity Studies", last November, at Paraiba Federal University, Brazil. Oliveira has also analyzed the pedagogic project from several institutions or research groups, e.g. National Institute of Telecommunication – INATEL, Minas Gerais, Brazil [1], University of Sao Paulo- USP Civil Engineering course [2], University of Porto, Portugal and Peninsula Technikon, Belleville, South Africa [3] and also Statistics Applied Laboratory-LEA from UFSC, Florianopolis, Brazil, [4].

The Civil Engineering chosen theme will be analyzed under Oliveira Thematic View proposal, a theoretical contribution on curriculum development in technological areas concerning higher education. This educational proposal has been published in the 2005 iNEER special annual volume, and in the 2005 iNEER special edition [5]. Additional information is suggested in the references, [6-16].

Wide themes knowledge central focus is supported by "complex thought" theory [17] under thematic approach view and by Rapoport [18] conception of world order that considers *indissoluble interdependence of earth problem.* And this concept is deep related with educational role under thematic approach, following Oliveira [5],[19]. It offers a good support to innovation concerning curriculum development in technological careers.

PORTUGAL AND BRAZIL CIVIL ENGINEERING CONTEXT – FROM RESEARCH THEME TOWARDS EDUCATIONAL FOCUS

Management of Knowledge in Civil Engineering has been presented by Souto researcher, from Paraiba Federal University in her doctoral thesis, [20]. It was presented a portrait from Portugal and Brazil situation in the Civil and Production Engineering field in the supervisor engineer point of view.

The present paper analyzes the mentioned research theme under educational perspective. The civil engineering management of knowledge, and knowledge transfer, between enterprises in Latin-America context (Brazil) and European-Union context (Portugal) is a typical wide and sophisticated subject in engineering knowledge field. It offers a wide range of possibilities in terms of implementation and exploration of knowledge subjects. Migration from broad research theme towards pedagogic practice is a nowadays reality need. Pedagogic advantages from this knowledge approach is justified in several theoretical proposals [5], [17], [19].

A broad theme can be divided and converted in several projects with different levels of knowledge generality. The Civil Engineering theme in Souto research is divided in three

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levels of knowledge generality: the "outer knowledge management" by companies (associated with broad context), the "middle knowledge organizational management" (associated with the know-how of companies) and the "micro knowledge management" (associated with practical competence related with engineer functions).

THEME MODELING THEORETICAL FOUNDATION

Integrative view means it is recognized permanent and intrinsic association between several kinds of knowledge all together. Focus is always directed from whole to specific parts. In this sense, knowledge central focus refers to a wide scope, called thematic, in opposition to specialized and fragmented focus of isolated pieces of knowledge. The integrative knowledge model is called thematic model. The integrative view is also called "real world" focus. This expression has been presented in the last decade of XX century mainly in Informatics literature [21]. It embeds the same principles from complex thought in education, the theory supported by UNESCO, under Edgar Morin presidency [22].

Complexity concept, following Morin can be summarized as: "*complex is what is treated together with its wide context*". This concept of complexity embeds integration of wide knowledge areas. Separation of knowledge in specialized and specific domain areas are considered as an illusion, or as a kind of reality simplification. The simplification of world reality is called abstraction and it is the way human mind tries to understand complex environment. On this sense, complexity word assumes an ambiguous character depending on the applied knowledge model. The term complexity must to be redefined aggregating its specific name, for example, math complexity, physics complexity, algorithm complexity, and so on. This helps to differentiate complexity in integrative focus from complexity in particular specialized focus.

KNOWLEDGE MODEL UNDER DIFFERENT LEVELS OF GENERALIZATION

Thematic focus contains projects, problems, case studies and other pieces of knowledge issues. The description of a hierarchy of generalizations in complex approach facilitates comprehension of broad knowledge models. This way, It is adequate to treat pedagogic demands. Engineering education, specially in engineering curriculum development, can benefit from this spirit.

Knowledge subject classification from high generality till very specific issues has been presented by Oliveira, [5]:

- **Thematic** – is a kind of project inserted in its wide context. It unifies abstracts and concrete subjects. In this sense, a theme contains a sequence of different projects with different abstraction levels. Example of thematic: "Brazil-Portugal Comparative Study of Management of Knowledge in Civil Engineering".
- **Project** – is a kind of thematic implementation. It refers to concrete issues which can be implemented and solved with concrete results. By the other side, it is known abstract theme issues also influence technical implementation. Project orientation is also considered a non traditional vision in Engineering Education. Difference from thematic vision and project vision is conceptual. Both can concern to the same level of generality. Thematic and project view treat knowledge from context towards details. Example of Project: "Enterprise 1 and Enterprise 2 Comparative study of Management of Knowledge in Civil Engineering".
- **Case Study** – is a kind of problem inserted in a practical context not so wide as a theme or project, but enough wide to refer to some aspect from real world model. Case study is a very popular approach and it often appears in discipline oriented engineering curriculum. Example of case study: "Enterprise 1 Management of Knowledge in a specific context".
- **Problem** – is a kind of issue already classified. It usually concerns a technical aspect to be solved. It refers to specific knowledge demand. It is strong used in discipline oriented curriculum. It often appears in an isolated discipline with somehow weak link between other disciplines or even with engineering reality. Example of problem: "Lost material calculus in a building construction".
- **Algorithm** – is a kind of instructions sequence. It refers to commands, operations, or tasks in practical implementations usually done by computer tool. Example: "Interpolation method about lost material in civil construction".
- **Operation** – is a kind of task usually belonging to an algorithm. Example of operation: "Two values comparison (if- then-else operation)".
- **Data** – is a kind of content concerning operations or algorithms. Example of data: " Cement Quantity".

CIVIL ENGINEERING THEME – THREE LEVELS OF KNOWLEDGE GENERALITY

The proposed civil engineering theme is divided in three knowledge contexts. From generic context to specific one, knowledge is treated always from whole to parts. Figure 1, Figure 2 and Figure 3, below, illustrate theme approach under three symbolic levels of generality.

Figure 1 (high generality = level 1) represents a first and diffuse outer context civil engineer look.

Figure 2 (middle generality = level 2) represents a refined theme look including, for example civil engineer enterprises and organizational subjects.

Figure 3 (specialized level = level 3) represents deep refinement of details enhancing theme inner look. It includes interpersonal, human behavior, and technical aspects related with engineer competence.

FIGURE 1
GLOBAL OUTER CONTEXT : WORLD WIDE INCLUDING ECONOMICS-SOCIAL-CULTURAL-TECHNOLOGICAL FEATURES

Knowledge Level 1 – High Generality Level: Figure 1 illustrates whole and diffuse theme vision. For instance, the adopted knowledge system refers to earth life and social life aspects integrated with engineering aspects in two different regions, Portugal and Brazil, from two continents, Europe and Latin America.

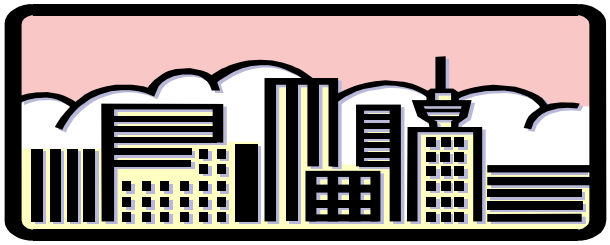

FIGURE 2
LOCAL CONTEXT : CIVIL ENGINEERING ENTERPRISES GENERIC FEATURES

Knowledge Level 2 – Middle Generality Level: Figure 2 illustrates sub systems of knowledge management through parameters of organizational level and organizational environment. Each building represents different enterprises dealing with specificities concerning civil construction management work. Institutional, technological and human behavior subsystems emerge at this level of knowledge model. At this level, similarities and differences between Portuguese context and Brazilian context are discriminated.

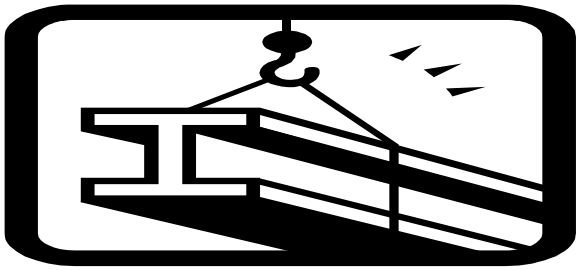

FIGURE 3
INNER CONTEXT: CIVIL ENGINEERING COMPETENCES

Knowledge Level 3 - Less Generality Level: Figure 3 suggests inner aspects of Knowledge Management in Civil Engineering field. It deals with knowledge acquisition and transference and professional competences in specific engineering tasks. Technical task competence is considered the visible part of competence. Competence, broad view, must include comprehension about socio-emotional, economics, ethics and ecologic subjects. Technical competence represents concrete results. At same time, it hides a lot of strategic aspects.

ANALYSIS OF CIVIL ENGINEERING THEME UNDER INTEGRATIVE VIEW IN EDUCATION

The illustrated research theme (Brazil-Portugal Comparative Study of Management of Knowledge in Civil Engineering) is adequate to be implemented in integrative knowledge modeling because it is enough generic.

The proposed thematic modeling considers two kinds of knowledge subjects: generic subjects and particular subjects.

Generic subjects can be: economics, ecologic, rights, ethics. They can refer to ecological impact, legislation, lost construction material, and so on. It is remarkable that some of those subjects will not generate implemented or numerical concrete results. However, if they are recognized as belonging to knowledge model, it favors new knowledge vision emergence.

Particular subjects can be: enterprise data about construction and construction management and other concrete issues. They refer to the day by day enterprise performance and they can usually be converted in typical engineering concrete numerical results. Both knowledge subjects categories together contribute to build new knowledge models.

The proposed Civil Engineering theme offers a wide range of possibilities in terms of knowledge model. Engineering feeling about knowledge usually embeds economics and the security parameters, but sometimes it lacks strategic, management and human behavior parameters. Integration of knowledge domains favors extrapolation of technological filter amplifying problem vision. The proposed theme offers can be implemented in engineering curriculum under integrative knowledge view.

INTEGRATIVE VIEW IN ENGINEERING AND COMPUTER SCIENCES CURRICULUM

The knowledge integrative view referring to engineering curriculum can be summarized, as follows:

- **Traditional Engineering and Computer Sciences Curriculum**: discipline oriented focus. Disciplines approach from specialized issues towards broad subjects. Typical engineering curriculum is divided in two sets of disciplines: basic disciplines and professional disciplines. Typical entry level courses disciplines are maths, physics, informatics and so on. Typical professional disciplines are subjects of engineering technical implementation like projects and industrial operations. Professional disciplines occurs a posteriori, after basic knowledge is already learnt.
- **Integrative Engineering and Computer Sciences Curriculum**: project/theme oriented focus. Disciplines or projects explore sophisticated issues all together since the fresh man curriculum level. Integrative curriculum is titled by Meyer, [24] as "inverted curriculum". It refers to informatics courses. On this approach, technical

implementations are converted in a projects sequence. Wide flexibility of projects can be chosen in accordance with each course or cultural demand.

Some experiences all over the word refer to thematic approach in engineering curricula [2],[25],[26]. It can be found this approach out of engineering scope, for example in Medicine courses. Health subject, can, for example, discuss public health and family social-emotional problems before touch specific problem like disease.

STEPS FROM THEMATIC ORIENTED TEACHING PRACTICE IMPLEMENTATION

Thematic view proposal implementation in education concerns the following steps, [27]:

0. Prepare context for integrative education in curriculum level- planning the course with members

Training people in the initial phase is important to achieve positive results. Training people involves two pedagogic aspects. First aspect is to train people in collective activities, hierarchy of work, and inter personal skills. Second aspect is to train people in knowledge modeling. Choosing an adequate modeling tool is adequate to take advantages of global vision. It is high recommended to use a modeling tool. In this direction, Computer Sciences specialized field can offer a good tool to support integrative reasoning. Good outcomes from integrative approach depend on this initial stage called stage zero. Next steps refer to theme implementation in teaching practice.

I. Prepare initial discussion about thematic view

First week plan – It is important to share with students how the integrative vision works and what is expected from the individuals and from teams of students. Teachers and students must acquire detailed information and comprehension about the educational methodology.

Presenting thematic context – the thematic is presented in accordance with curricula proposal. State of the art is presented including all kinds of subjects in accordance with personal trend of each member of educational environment. From art to history, from ecology to rights and ethics, all can be jointed.

Understanding integrative view philosophy – the theme is explored under two concepts. Concept one is simplicity. Concept two is complexity. First version of thematic knowledge model has high level of abstraction in terms of concrete technical implementation. By the other side, it contains all kind of generic information. This version could be called the most simple (concrete issues) but the most complex (generic issues). Posterior versions from thematic model are more and more refined in terms of concrete details.

II. Defining life cycle for themes and projects

Philosophy of work must be clear – students must conceptual differentiate theme from concrete projects.

III. Exploring theme domain by defining a sequence of projects representing the unique theme

Taking advantage of exploring a complex theme – each project is considered complete by itself and it can be treated as an isolated product. Each project version belongs to a sequence of projects linked by the generic theme (project version one till project version n).

Movement of knowledge process acquisition is always from generic (complex) to specialized parts in terms of context, increasing difficulty, as time goes by, according to curricular demands.

IV. Defining documentation format

Taking advantage from different kinds of documentation – each project contain high number of information. Some information, called open information, have apparently low sense in terms of final technical results. But, open information is very useful to increase student conscience about educational process and thematic comprehension. It is convenient to develop a documentation format registering the history of each version. Some technical information to memorize are: methods names, kinds of variables, structures of data and other specificities. Some contextual information to memorize are: outer context and inner context for each solved problem. In teaching environment it is useful to develop a pedagogic memory (under students learning point of view) and project technical memory (under supposed external users point of view).

V. Defining activities format

Taking advantage of exploring a complex theme in terms of academic activities – the complex theme is ideal to generate a lot of work and a lot of information. Team work activity is an ideal activity format giving to student a real idea of a wide theme. Time is saved by knowledge reuse or by exchange different knowledge between groups of students.

VI. Defining instrumentation format

Combination of different pedagogic instruments is suggested to achieving different mind reasoning styles. Pedagogic instrument can be, for instance, internet wire, chats, personal discussions, draft, writing texts, etc.

VII. Defining evaluation format

Evaluation is a very sensible point if pedagogic process is interpreted under integrative or complex view. Evaluated event is substituted by evaluated process. Academic learning process is substituted by life learning process. Oliveira presents and analyzes evaluation process in education under complex approach in ICEE 2005[15].

ADVANTAGES OF INTEGRATIVE VIEW IN ENGINEERING AND COMPUTER SCIENCE CURRICULUM

The engineering field context: Nowadays, global demands and also professional concurrence aspects force development towards union of academic technical competence with management and socio emotional competences. Traditional engineering skills concern to high technical competence.

Socio-collective and other management competences must to be integrated with the technical one.

The Computer science filed context: both engineering and computer science context search for a new professional profile. In addition, it faces as long as time goes by, more and more complex knowledge systems. A big task in informatics is modeling complex systems with specific characteristics using complex modeling tools. Integrative knowledge view is in accordance with those tools demands and facilitates teaching theoretical principles of those tools implementation.

Integrative oriented curriculum or even traditional oriented curriculum can implement thematic view. Results will be always positive [12], [15]. Potentiality of good outcomes will increase if integrative view extrapolates isolated disciplines to be inserted in a whole curriculum spirit. This is important to express because every school can practice integrative view independent from culture or available educational tools.

CONCLUSIONS

The core aspects referring to thematic view in curriculum development can be summarized as follows:

- **On formal education**: in past times education was usually centered on teacher or student or in methodologies. The integrative tendency considers complex knowledge model as the center of educational axis because the regard from their members (teachers, students and support workers) will converge to outer academic context respecting a natural hierarchy. Integrative knowledge paradigm applied to formal education enables emergence of sustainable world solutions.
- **On migration of research experiences under "real world" perspective to curriculum development:** broad themes central focus is useful to think about new curriculum development and new profile on technological careers.
- **On Curriculum development in response to globalization challenges:** engineering and computer science courses can contribute different way to migration towards integrative view in education. Engineering field brings real world themes and informatics field brings knowledge modeling tool to treat real world contexts.
- **On Students motivation:** Students belong to a connected world. Brain reasoning is deep influenced by the way reality is presented. Academic knowledge is "pertinent" if it is aligned with the global world demands, embedding integrated aspects. Integrative knowledge approach contributes to pertinent knowledge development.
- **On Training people:** integrative view changes the logic of educational practice and its positive results depends on getting partners to share the new way to be built in education. Teacher training is necessary because inner assent by members (teachers, support workers, students) is a core condition.
- **Challenge for the future**: curricular structure can profit from broad themes. Today many experiences have took place isolated way, in disciplines under traditional curricula. Potentiality of results will increase if the whole curricula of engineering and computer science courses follow integrative view. Reinforcing knowledge theoretical aspects is necessary to overpass educational crisis.

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