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## Emerald Article: Notes about COOL: analysis and highlights of complex view in education


C.A. de Oliveira

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C.A. de Oliveira
*INE-CTC-UFSC, Florianópolis, Brazil*

## Abstract

**Purpose** – The purpose of this paper is to present principles from the complex approach in education and describe some practical pedagogic experiences enhancing how "real world" perspectives have influenced and contributed to curriculum development.

**Design/methodology/approach** – Necessity of integration in terms of knowledge modeling is an historical trend in Engineering and Computer Sciences curricula. Integration of particular technical aspects with wide global aspects is a response to globalization demands. Globalization demands require new approaches, at both educational and teaching levels. Also, educational level embeds a wide range of pedagogical proposals or teaching proposals. Since the 1990s, Engineering and Computer Sciences curricula have emphasized, increasingly, the project-oriented approach in the Engineering field of knowledge and software engineering contents has migrated to beginners or freshman level in Computer Sciences courses. This approach is called the Complex Approach in education. COOL – "Comprehensive Object-Oriented Learning" – is an educational project mentored by Emeritus Professor Kristen Nygaard, from the Department of Informatics at Oslo University, which deals with the complex approach in education. Professor Nygaard passed away in 2002. This project was published in 2006 under the title of "Comprehensive Object-Oriented Learning: the Learner's Perspective". This paper analyses theoretical aspects in Nygaard's project and also compares aspects with the author's work teaching Object Oriented Modeling in Computer Sciences and Engineering, at Federal University of Santa Catarina – UFSC, Florianopolis, Brazil. The author's pedagogic proposal, developed on those contexts, since 1997, is supported by Nygaard theory and also by Edgar Morin "Complex Thought" theory adopted by UNESCO, titled Complex Thought cathedra.

**Findings** – Innovation, in terms of Engineering and Computer Sciences curriculum development, is deeply related to the complex approach educational paradigm. Consequently, innovation in terms of pedagogic practices is also deeply related to the complex approach perspective. Complex approach overpasses fragmented view of knowledge towards integrative view concerning curriculum development in technological areas.

**Research limitations/implications** – The comprehensive object-oriented learning presented here is applied to Computer Science and Engineering. However its development and application could impact other disciplines and education, especially in relation to technology integration in education.

**Originality/value** – The paper presents and discusses COOL as a concept and approach for enhanced learning, in a novel manner, taking account of theoretical underpinnings developed aligned to modern thinking.

**Keywords** Globalization, Higher education, Knowledge systems, Curricula, Object oriented learning, Comprehensive object oriented learning, Complex approach

**Paper type** Research paper

## 1. Introduction

Globalization phenomena create new demands in the field of research in terms of integrated focus, also in educational area. It is a natural but long and difficult way.

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In memory of Oslo University Emeritus Professor Kristen Nygaard (1933-2002), for his contribution to Computer Sciences and Education.

The problem is not at all about costs or even material necessity. The most important difficulty is the shift paradigm logic. Hegemonic cultures have followed fragmented specialized paradigm avoiding union of common values presents in all civilization models.

The informatics educational area constitutes an interesting case to explain this evolutionary and natural movement concerning knowledge approach toward integrative focus. The several informatics knowledge modeling paradigms traduce evolution in thought modeling. This evolution is not casual. It occurs parallel with increasing complexity external context. Informatics mission is to give answer, in terms of knowledge systems, under increasing complexity demands. The present paper, first of all, presents the historic evolution concerning knowledge representational paradigms. After this, it emphasizes the educational trend looking for the specific experience from comprehensive object-oriented learning – COOL project (Fjuk *et al.*, 2006; Groven *et al.*, 2003). In addition, the present paper associates COOL proposal with the "complex approach" criteria from UNESCO's "Edgar Morin Itinerant Cathedra of Complex Thought" that was supported by International Institute for Complex Thought (IIPC) (UNESCO, 2011; Morin, 1999). And, to finalize, COOL is associated with the author pedagogic experience at informatics and engineering undergraduate courses at Federal University of Santa Catarina (UFSC) since 1997 (de Oliveira, 2005).

## 2. Historical perspective from knowledge representational paradigms in engineering and computer sciences education – achieving the complex approach

Computer sciences and engineering academic curriculum have been modified, as times go by, in accordance with external context demands. It is visible in the case of technological development, the necessity to deal with increasing complexity. Complex problems can be called broad projects perspective, supported by thematic perspective knowledge focus (de Oliveira, 2005). Problems increasing complexity now enhances presence of parameters out of technological field. Engineering and computer professionals usually pay attention only to focal technical aspects and disdain external generic aspects which can deeply influence technical result. But globalization context parameters, including, for example, ecological and economic parameters, force everyone to pay attention to emergent demands. And also force everyone to use modeling methods in accordance with complex formulation. In this direction, nowadays academic curriculum regards carefully those demands in terms of knowledge modeling forcing presence from new and integrative approach in education. Table I illustrates evolution from knowledge representational paradigms along the last five decades (de Oliveira, 2005).

### *2.1 Sequential representational paradigm (1960-1970)*

During 1960s in the twentieth century, the typical knowledge representational paradigm in computer sciences modeling was the sequential paradigm. The traditional curriculum was usually represented by isolated disciplines which considers subjects of study from particular isolated focus to the whole vision. In those times, knowledge

| Period (decade) | 1960-1970 | 1970-1990 | Since 1990 |
|---|---|---|---|
| Modelling Knowledge Paradigm | Sequential | Structured | Object-oriented |

**Table I.** Knowledge representational paradigms along the time focus moved from subjects like mathematics, physics and computer sciences to engineering or informatics project subjects.

*2.2 Structured representational paradigm (1970-1990)*

During 1970s in the twentieth century, the typical knowledge representational paradigm was the structured paradigm. From the 1970s in the twentieth century, traditional curriculum trend has changed from very isolated focus toward integration of group of disciplines. This structured knowledge focus has promoted increasing association between disciplines, for example: assembly programming and machine architecture; introductory programming; and numerical analysis. In old times, curriculum disciplines were quite isolated and some subjects could appear twice in curriculum bound with individual issues. Under structured times, disciplines are organized to stay under a group of disciplines focus. For example, Assembly Language discipline, can teach about registers programming issues at the same time Architecture of Computers discipline studies the set of registers issues from a computer device.

*2.3 Object-oriented representational paradigm (since 1990)*

On the years 1990s began the third wave, the object-oriented paradigm. The traditional curriculum trend looks to the called Inverted Curriculum (Meyer, 1993). Curricular disciplines typical from professional level of study like software engineering and projects (in informatics courses), or engineering projects (in engineering courses), now, usually precede traditional beginners' level disciplines like maths and physics (Accreditation Board for Engineering and Technology, 2000; Farbrother, 2001; ACM/IEEE-CS, 2001).

## 3. COOL project – an educational proposal

COOL is a three years duration project funded by the Research Council of Norway. It started in the late autumn 2002. Unfortunately, his mentor, Prof Kristen Nygaard passed away before the project was due to start. The project, however, was implemented by his team workers between 2002 and 2005. It is launched by a consortium of several Norwegian research institutions, also supported by institutions in Aarhus, Denmark. It aggregates cooperation from several test sites around the world.

The contribution from COOL concerns a unifying process from object-oriented platform for informatics but also a learning landscape of pedagogical and organizational components to be used in education. Several cultures/languages have contributed to test sites like Spanish, South American, English, North American, Scandinavian.

The aim of COOL is to produce an introductory textbook added by multimedia material (Fjuk *et al.*, 2006). The COOL research concerns to "instructional competence and effects of the students" learning outcome and a computer system's performance. Primary research focus are: how learning is reflected in discourse and in the negotiation of common understanding; how cognitive process interact with social factors in the learning process; and, how ICTs and tools are actually used in these activities (Fjuk *et al.*, 2006, pp. 21).

*3.1 Origin from COOL project ideas – the earlier years sixties*

During 1960s in the twentieth century, the typical knowledge representational paradigm was the sequential, also titled imperative. But at the same time, two Norway professors, "Kristen Nygaard and Ole-Johan Dahl invented Simula compiler and language" (Fjuk *et al.*, 2006, pp. vii), already embedding object-oriented ideas. Prof Nygaard himself has preferred the term derived than invented when he use to talk about object-oriented criteria. He has used to affirm the criteria was already disposable in nature therefore instead of invention, better derivation express the spirit from object-oriented developed ideas. The principal computer languages supported by object-oriented criteria are: Simula, C, BETA, Java (Groven *et al.*, 2003). Nygaard has mentored the object-oriented criteria and Dahl has developed the Simula compiler. Both researchers together could mix theory and implementation in a harmonic way.

Object-orientation is coming more and more to be the present. If the engineering and computer sciences courses curriculum from 1980s in the past century and nowadays are compared, in terms of modeling approach, it is easy to find out the project view, in engineering area at beginners' level, substitutes focussed problems view. And, the software engineering view in computer sciences area substitutes the isolated informatics issues since the first year of university studies.

Of course there is a long way to arrive at a total object-oriented curriculum because it is not only the discipline parameters to be changed, but also the deep logic to think about educational models. Norway, in this sense is a privileged country because its culture already embeds high antroposophic focus. By the way, Nygaard had studied in his youth in a national antroposophic school, as he has commented to the author of the present paper.

*3.2 COOL proposal nowadays*

Object-oriented paradigm, is nowadays used through a variety of modeling and programming techniques. Following Dale (available at www.cs.utexas.edu/users/ndale), today 65 percent of participating institutions teach object orientation as a part of introductory courses in computer science education.

Federal University of Santa Catarina, Brazil also adopts object orientation since early years in informatics courses. de Oliveira (2005) has been teaching object-oriented modeling as the first computer programming paradigm since 1997, supported by a curricular changing. The chosen computer programming language was the object-oriented Pascal. Today it is adopted the Java computer programming language. Till 1997, UFSC has adopted structured modeling as the first glance in modeling paradigm at computer science under-graduated course.

## 4. Complex thought criteria in education

At the end of 1990s in the twentieth century, UNESCO President Federico Mayor invited Emeritus Researcher from Centre National de la Recherche Scientifique (CNRS), the sociologist, philosopher Edgar Morin, born in 1921, to synthesize reflections to constitute the start point to a future educational proposal. Morin works over a set of ideas called "complex thought" theory.

The educational ideas supported by complex thought approach, are resumed in the emblematic book titled: *Seven Complex Lessons in Education for the Future*. They are also treated by the UNESCO itinerant cathedra titled "Edgar Morin Itinerant Cathedra" (UNESCO, 2011; Morin, 1999).

Complex thought proposal embeds three core knowledge principles, or truism (see Table II). First knowledge principle: "pertinence of knowledge." Second knowledge principle: "integration of knowledge." Third knowledge principle: "inverted knowledge sequence" which means knowledge appears from generic to specific/specialized subjects. Those principles are modeling knowledge criteria present in all kinds of implementation under integrative focus, like the already presented object-oriented paradigm from informatics field of knowledge.

*4.1 Pertinence of knowledge*

Complex view automatically creates pertinent knowledge, also titled relevant knowledge. This perspective enables each one to be connected to the problem external context and answer all the questions about global solution unified with the technical issues. Technical issues now belong to the problem and are not, anymore, considered the problem itself. If you are conscious of the importance of the object you will fight for a result under this such kind of generic perspective. Following Morin (Morin, 1999), "complex is what is treated together with its wide context" and "knowledge pertinence," is a core intrinsic characteristic from complexity.

*4.2 Integration of knowledge*

By truism, integration of knowledge appears as an emergence from complex view following de Oliveira (2005). This is to say, if you treat knowledge subjects altogether, you force automatic integration, due to the necessity of the brain to synthesize what comes to be confused or difficult to understand. Under this focus, specific issues are not considered in opposition to generic ones, but both belong to the whole model. They are all treated together following a time process. It aggregates issues along a process. The process is just called knowledge integration.

*4.3 Inverted sequence of knowledge*

Considering pertinence, also called relevance of knowledge as a characteristics from complex knowledge approach, and, integration as an emergence from the complex approach process concerning knowledge, it surges a practical question. How to treat knowledge all together, specially at beginners' level? How possible is the integration of external contextual subject like social, economics, with specific and specialized subjects like technology and basic applied sciences? The answer points out the knowledge approach must change from fragmented to globalization focus proposals. Complex view, according to de Oliveira (2005) proposal can face this problem just presenting an increasing difficulty projects sequence considering global issues first and refining toward technical (e.g. engineering), or, specific (e.g. mathematics) subjects. The sequence follow simple problem to difficult one under a line of process. To achieve this vision since the first glance in education, it is necessary to create a sequence of projects belonging to the same subject such way the Project zero is simpler than Project one, and so on. The whole set of projects can be called meta-project.

## 5. COOL proposal at highlights of complex thought in education

COOL proposal (Fjuk *et al.*, 2006) weds with complex thought (Morin, 1999) in terms of common core principles. And also both wed with thematic-oriented approach (de Oliveira, 2005). In this sense, complex thought can be considered together with COOL project, and also with thematic-oriented approach as integrative educational proposals. They consider nature process, which embeds complex issues all together. Methods from object-oriented approach are useful to complex thought modeling independent from the product to be achieved. Final product can be a

**Table II.** Knowledge principles from complex thought theory

| | |
|---|---|
| Principle 1 | Pertinence of knowledge |
| Principle 2 | Integration of knowledge |
| Principle 3 | Sequence of knowledge from generic to specific |

computer information system, or even, a theoretical knowledge system without computer implementation at all. Following, they are discussed each one of the three complex thought theory principles facing COOL proposal in education. The pedagogic experience from UFSC University with object-oriented tool modeling tool at university beginners' level, wedding with educational complex thought approach promoted the called thematic-oriented methodology as a proposal in accordance with Nygaard and Morin ideas.

*5.1 About COOL and pertinence of knowledge*

Considering COOL basis is established under object-oriented view. It considers object as the unit of knowledge embedding both attributes (static issues) and methods (dynamic issues), definition of complexity of object can create pertinence of knowledge, or not. It all depends on the level of generality of the object/project focus. This aspect is related with the titled "abstract operation zero" from object-oriented modeling. This operation expresses the level of generality of the adopted knowledge model. The chosen abstraction model is intrinsic related with the level of generality to be considered. Resuming, if you treat a project under wide context focus, knowledge subjects associated with such kind of project turns to be in a natural way pertinent. If you treat projects under fragmented knowledge focus, the punctual objective subjects associated with such a kind of project do not favor creation of pertinence. COOL by its pedagogic spirit and by its modeling tool support has the potentiality to create pertinence of knowledge in educational environment.

*5.2 About COOL and integration of knowledge*

Object-oriented representational paradigm is focussed in complex systems. For this reason it embeds potentiality to achieve integration of knowledge principle. After a choice for a wide level of abstraction (operation zero) in the sense of vertical hierarchy of knowledge, the object-oriented focus supports the called "operation one." Operation one is related with model vertical hierarchy. Operation one refers to the generalization × specialization aspect. It permits knowledge treatment vertical sense. The possibility of knowledge organization vertical sense favors the emergence of properties like "reusability of knowledge," a known concept in object-oriented modeling area. Another case is the possibility of creation of knowledge synthesis traduced by the known "abstract classes." "Abstract classes" born when the system growth arrive to the necessity of system reorganization toward simplification through vertical movement of the units of knowledge.

*5.3 About COOL and inverted sequence of knowledge*

Object-Oriented paradigm "recognizes epistemologic and ontologic issues on human development. Human development is complex and inherently interdisciplinary" (Fjuk *et al.*, 2006, pp. viii). But in the day-by-day activities it outcomes several practical pedagogic questions like: how to treat with complex approach all together also in introductory level? Meyer educational proposal under object-oriented tool support (Meyer, 1993) proposes to answer this question. de Oliveira's (2005) educational proposal under object-oriented tool support also pretends to answer this question considering that it is possible to treat complexity since introductory level. If projects follow the direction from generic to detail knowledge focus, it is possible to manipulate complexity at beginners' level. And, also, if it is built a sequence of projects under the same theme, permitting to deal with increasing difficulty, it is possible to deal easy with complexity.

## 6. COOL and practical pedagogic experiences from federal university of Santa Catarina under "real-world" perspective

The author experience (de Oliveira, 2008, 1998), in informatics teaching at department of Informatics – INE from UFSC with project-oriented focus in introductory computer sciences disciplines denotes how important is to integrate different courses spirit, even in technological areas or with high-knowledge affinity areas. The pedagogic experience concerns to sanitary engineering course and computer sciences courses teaching. In the computer sciences introductory computer programming discipline, some subjects are usual to be proposed as information systems subjects: restaurant enterprise; DVD enterprise; stock-department enterprise, etc. At the same discipline (computer sciences introductory programming), but now referring to sanitary engineering course, typical subjects to be proposed as information systems are: climate impact to agriculture; urban garbage collection; Hg pollution in rivers; urban water control, etc. What is remarkable is the wide, also called real-world themes when they migrate from sanitary engineering field of knowledge to computer science field causes an impact in terms of harmony between computer concepts needed to program and the case example. Usually, computer science area dedicates itself to develop and implement information systems. Computer sciences has a potent complex modeling tool titled object-oriented tool. Unifying real-world knowledge focus, with complex tool, both areas can profit together. After this experience, teaching complex tool concepts in a wide complex theme becomes much more natural. And theoretical concepts comprehension by students was increased. Before this experience it was not easy to present such kind of philosophic concepts of complex systems to beginner level computer sciences students.

## 7. Conclusions

Innovations under COOL proposal: innovation, in terms of Engineering and Computer Sciences curriculum development is not always related with new technological devices. Revolution can come from the way knowledge is treated to give technological responses under societal demands concerning globalization phenomena. Consequently, innovation in terms of pedagogic practices is also deep related with complex approach knowledge perspective.

Innovation under complex thought proposal: innovation signification is also to overpass fragmented view of knowledge toward integrative view concerning curriculum development in all knowledge areas and of course at technological areas too.

Putting all together: Complete educational environment involves people, machine and knowledge approach all together. Curriculum development is a core educational issue but it must be integrated with other parameters, like complex teaching environment approach to increment potentiality of positive results in education.

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**Corresponding author**
C.A. de Oliveira can be contacted at: clara@inf.ufsc.br