

INNOVATING ENGINEERING EDUCATION, TO FACE THE KNOWLEDGE SOCIETY

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It is a miracle that curiosity survives formal education.
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ABSTRACT: The paper develops its title, explaining it in reverse order. Since the onset of the *Knowledge Society* is inescapable, whereas its details are yet fuzzy, the approach is pragmatic: the starting point is based on the general framework of the Lisbon objectives filtered through the contextual expectations of a Romanian university. On this groundwork, the paper core elaborates on diverse meanings of "*to face*" in an almost chronological order: "admit", "be in front of", "cope with". Then, a contentious issue is dealt with – as less biased as possible: "*Engineering Education*" is regarded as the area where a paradigm shift is both more influential and more urgent. Hence, "*Innovating*" is considered not just a means, it becomes a must. Among the conclusions: a) Universities should start a critical – but not hasty – revolution towards Life-Long Learning. (Because this problem involves moving the focus from managerial-strategic aspects to academic-tactical ones, the authors tackle the topic in a related paper.) b) To be affordable here and now, such a vital shift is beyond the reach of both traditional solutions and local approaches. Thus, the paper ends with specific proposals to boost regional cooperation aiming at the very words in its title.

1. INTRODUCTION. LISBON IS FAR AWAY

The paper aim is to explain, support, develop, and start to approach its very title. The starting point is based on the general framework of the Lisbon Strategy [27] filtered through the contextual expectations of a Romanian university. Thus, the target is challenging, moving, and far too complex (as both *multifaceted* and *convoluted*) to be approached within a single short-term undertaking. Hence, it is impossible to be dealt with in solely one paper. In fact, in the conceptual and temporal environment of this conference, there are five interconnected papers, corresponding somehow to five stages of a long-term endeavour.

The first paper related to this subject matter was a broad outline of "A Bumpy Ride towards Reform: Higher Education Challenges Journeying from Sibiu to Lisbon via Bologna", [16] where the author blended the educated guess of a manager with the "educated vision" of a doctoral advisor. On this groundwork, a kind of exploratory leap into the foreshadowing of the *Knowledge Society* (KS) was performed in [18], describing an ongoing task – unfortunately now partially frozen: "the first Romanian project to apply agent-oriented paradigms in open, uncertain, and dynamic industrial environments; thus, it appears as one of the first European attempts to adjust quality management to the Knowledge Society, via agent-orientation" [18]. (Both mentioned papers play the role of a prolegomenon for the present one.)

With regard to the two papers to be presented during this conference, in essence, this one is focused on managerial-strategic aspects (*what* kind of engineering education is needed), while the next (hereafter referred to as fourth paper) is focused on academic-tactical ones (*how* could the objectives be achieved). The last one, submitted to the World Conference on Educational Sciences (Istanbul, 2010, hereafter referred to as fifth paper) goes into details, illustrating the way of applying new paradigms in engineering as a whole and in engineering education (EE) in particular via modern artificial intelligence (the syllabus studied as case in point is for "Agent-orientation").

As a result, the rest of this paper is organised as follows: Section 2 presents the *rationale*, explaining the title and transforming it from a declarative sentence into an almost imperative one, setting thus the target. Section 3 is more specific because abridging *the history* it illustrates the main university assets: two research strands able to endorse the attempt. Section 4 suggests the *approach*: devising top-down, implementing bottom-up. Then, Section 5 – together with Section 2 representing the paper core – describes the *challenges*, making an inventory of the key paradoxes run into on the way to Lisbon. On the other hand, the next two sections have overoptimistic titles: "*Start*. The First Affordable Steps" (Section 6) and "*What Next*? A Possible Roadmap" (Section 7), respectively; in reality they are intended to catalyse the political will of the universities represented at this conference to both change mentalities and start off transdisciplinary collaboration in EE. Indeed, as Section 8 *concludes*: "cooperation becomes a must".

2. RATIONALE. EXPLAINING THE TITLE

Since the onset of the KS is inescapable – despite the fact that its features are yet fuzzy – it is considered as a premise. Therefore, the title is examined in reverse order.

Knowledge Society. The objectives put forward by the Lisbon Strategy [en.wikipedia.org/wiki/Lisbon_Strategy] are considered here as working definition for KS for eight reasons:

a) When it was set out by the European Council in March 2000, it yielded the most highly structured document portraying Knowledge Society [27].
b) All the way from diagnosis and analyse to target and strategy was dealt with in the documents it triggered; most of them are formally adopted as EU acts (e.g. , FP7 [6]).
c) The links to education are manifold, essential, adaptable, and ever more significant: "Universities therefore look for-

ward to playing a pivotal role in meeting the innovation goals set by the Lisbon Agenda" [9].

d) Almost as a corollary: this strategy built the framework for some "Pacts for Education", not only in Europe (e.g., in Germany the *Nationaler Pakt für Ausbildung und Fachkräftenachwuchs in Deutschland*, 2004 [www.en.inbas.com/projects/d_pro089_quib.html]), but worldwide: [24] "synthesises the Brazilian strategy towards a knowledge-based society and economy, the perception and the influence of European Union's Lisbon Strategy in the country, its impacts already visible and the possible future ones". "The knowledge dimension involves the current world situation in which knowledge is a differentiation factor of national development levels. This dimension will spread more and more over all human activities and should consider: education of quality; access to information for all; the rise in the capacity of scientific, technological and innovation knowledge creation; the interaction between popular and scientific knowledge" (the program for strategic planning *Brasil Três Tempos*, quoted in [24]).

e) In particular, the same principles are taken into account in the Romanian "National Pact for Education" [23].

f) More specific, this strategy was adapted and adopted explicitly by our university [16] [25].

g) Likewise, both research strands this paper is founded on – quality management and modern artificial intelligence – have vital roles in attaining the target. Thus, prefacing the report on the renewed Lisbon strategy, in December 2007, José Barroso asserted: "By re-launching the Lisbon strategy in 2005, and refocusing it on growth and jobs, Europe has come a long way. […] The Lisbon Strategy is the EU's vehicle for accompanying change. […] Here are a few examples of what we need to do together: reduce the number of early school leavers to ensure that no one is left behind in the age of globalisation; give Europe a new "fifth freedom", the free movement of knowledge, to allow Europe to capitalise on its creative potential; […] reinforce the education-research-innovation triangle, notably through the establishment and operation of the European Institute for Innovation and Technology (EIT) and the Joint Technology Initiatives (JTI)" [6].

h) At last, a very pragmatic reason: no research project ignoring the Lisbon objectives could aspire to EU funding: "FP7 was only launched at the end of 2006 […]. Annual work programmes are now issued in each summer, […], the 2010 work programmes were adopted by the Commission on 29-30 July 2009 and the first calls for proposals from these work programmes were published on 30 June 2009 […] Any transnational research activities can be funded within this programme. The following ten thematic priorities have been defined […]: 1. Health - 19% […] 3. Information and Communication Technologies - 28%. 4. Nanosciences, Nanotechnologies, Materials and new production technologies - 11% […] 7. Transport (including Aeronautics) - 13%" [en.wikipedia.org/wiki/Seventh_Framework_Programme].

To Face. From the diverse meanings of "*to face*" in [thefreedictionary.com/face], three connotations are relevant here in an almost chronological order: "To confront with complete awareness", "To overcome by confronting boldly or bravely", and "To bring or to be brought face to face with". In short, we have to *admit* now that soon we will *be in front of* the KS, and then we should *cope with*. (How we intend to cope with is presented in the fourth and in the fifth paper.)

Engineering Education is regarded as the area where a paradigm shift is both more influential and more urgent. On the other hand, since it is the very substance of this conference and, at the same time, a quite contentious issue, it is dealt with, in detail and as less biased as possible, in the fourth and in the fifth paper, where some solutions are proposed based on a "Robot-Portrait of a Postindustrial Engineer". As a result, here are investigated only aspects relevant to "*Education*" – mainly higher one. **"Universities and the Knowledge Society**: The central task is to equip Europe's populations – young and old – to play their part within the Knowledge Society, in which economic, social and cultural development depend primarily on the creation and dissemination of knowledge and skills" [9]. Universities strive to innovate "in particular through their commitment to the European Higher Education and the European Research Areas" [9]. "All over the world, but particularly in Europe, universities face an imperative need to adapt and adjust to a whole series of profound changes. These changes fall into five major categories: Increased demand for higher education […] The internationalization of education and research […] The proliferation of places where knowledge is produced […] The reorganization of knowledge […] The emergence of new expectations" [5].

Innovating. Section 4.3 of [6], having the title "Investing in knowledge and innovation", explains: "Under the new cohesion policy programmes, more than € 85 bn will be made available for investments in knowledge and innovation. […] Europe needs a "fifth freedom" – the freedom of knowledge – completing the four freedoms of movement of goods, services, people and capital. This "fifth freedom" should spur the EU's transition to an innovative, creative knowledge economy: […] information and communication technologies, driven by high-speed internet are key to raising productivity and stimulating innovation in Europe" [6]. In [27] the need for innovation is emphasized: "Europe needs strong universities (in the broadest sense) as "motors" in the knowledge triangle of education, research and innovation. […] European universities have gone through the second half of the 20th century without really calling into question the role or the nature of what they should be contributing to society. It is no more so. Universities also must change for good". Thus, "*Innovating*" is considered not just a means, it becomes a must.

In the end, the last sentences of the Lisbon Declaration: "Not just Europe, but the whole world, is becoming a "Knowledge Society" and the Lisbon Strategy, the creation of the European Higher Education and Research Areas, together with the efforts of national governments, will require constant reconsideration in order to meet the challenge which this presents. These are exciting times for universities as they contribute to innovation through teaching and learning, research and knowledge transfer. Europe's universities welcome the opportunity which this gives them to help to shape Europe's future" [9].

3. HISTORY. MERGING TWO RESEARCH STRANDS

The (pre)history of this undertaking stems from the pioneer-times context when "our university had begun in the late 1990s two separate research strands (that were then quite rare in Romania): quality management and modern artificial intelligence" [16]. Both started in 1997 - 1998, almost from tabula rasa (without experience, Google, explicit funding, research teams, logistics, and so on) and were developed each "in more than 30 papers/articles/books in the last decennium" [18]:

Quality Management. Research originated from the practical need to ensure ISO 9000 quality management [21] to the applications of the domain of parallel engineering [20] – then still in embryo in Romania and was first summarised in [19]. Quality management research was applied to education first for a Master Program [12]and then explicitly for e-learning (a decision support system for higher education institutions was described a year ago in [13], [17]). A major part of the research results was expounded in a recent monograph [22].

Modern Artificial Intelligence (practically, agent-orientation [1]). Research began in human-computer-interaction (HCI) [4], whereas the first explicit reference to agent-orientation was made in a chapter of [11]. Results until 2002 are given in [2]; later work (including also intelligent learning is referred to in [3]. More references are in the fourth and in the fifth paper.

From Convergence to Merging. After reaching maturity, the two strands "converged – without merging – into transdisciplinary research" [16] (in this regard a most relevant PhD thesis is [15]). "Recently – this time from an explicit Lisbon perspective – they began to fuse organically into research on the "3L" (Life-Long Learning) for the groundwork of a knowledge-based approach to affordable technological innovation […] The joint strand exploits the synergy emerging from coalescing the results achieved in both areas, proposing new approaches for decision support systems and testing them in improving decision making in a significant plant (in the domain of automotive engineering). For the new strand, other research is rather hard to find – since it is an obviously innovative undertaking in a transdisciplinary research niche" [18].

New Approach to Quality Management. It is most likely the key achievement of this research niche and was dealt with in Section 3 ("New Quality Management") of [18]. The approach will be reiterated in the next section, from the standpoint of this paper. Here just its very abridged history: from the very beginning "the trend toward anthropocentric systems distinguished by human-oriented interface, and based on cognitive ergonomics" [4] was taken into account based on cognitive models [7] and on the concept of *ecological validation* – having a broader meaning than that in cognitive psychology [14] where it comes from. Later it was applied in validating experimental models of interface agents (e.g., virtual therapist, virtual guitar player, agent with a more human-like sense of time): "The history (since 2003) includes more focused research regarding intelligent HCI embodied in agent-oriented interfaces (expressed or not as pseudoavatars)" [3].

4. APPROACH. DEVISING TOP-DOWN, IMPLEMENTING BOTTOM-UP

The double nature of the paper – position paper (following the target set up in [16]) and research paper (refining the results obtained in [18] and moving the focus from industrial engineering to EE) is now over. Thus, the approach is pragmatic: keep consistency with [18], reorient the investigation to deal with the new research topic, and impair redundancy. Therefore, the results of [18] – and to some extent its conclusions too – are used as starting point and scrutinized whether they could be reworked (focusing on EE) to serve the overall aim of the paper triad to be presented. On this groundwork, the span of this paper can be set up. On the other hand, this section should do more than offering an approach: the most promising, wide-ranging and adjustable results of [18], namely those described in Section 3 ("New Quality Management") must be revisited:

a) *Quality is hard to measure*. Since the quality of any educational process is much more elusive than that of an industrial application, all assertions are, even *a fortiori*, pertinent to EE. Moreover, the grades – standardized or not – are acknowledged to be among the most subjective "quality indicators".
b) *Quality is highly contextual*. Again all assertions are *a fortiori* relevant to EE. Just two amendments: b1) Despite the fact that human-centeredness was acknowledged – already in Socrates' times – as a key feature of any educational undertaking, no modern university is perceived by its stakeholders as "anthropocentric enough", while improving academic quality management is a cardinal concern for every Rector. b2) Strange enough, as regards teaching the shift was rather in the opposite direction: the highly contextual Socratic "*duologue*-based-maieutics" needed no grades.
c) *Quality is hard to describe*. Idem. Moreover, the educational environment is increasingly uncertain, firstly *because* it is very dynamic. Hence, education quality becomes more and more hard to describe because of its high time derivative. Indeed, how could students evaluate the quality of their education "when *past* quality becomes suddenly irrelevant, *present* quality is elusive, and *future* quality is unpredictable?" [18]. On the other hand, even for education conventional numerical quality indicators are still relevant for processes with a suitably high number of instances, where results have usable statistical significance.

Then, how to approach this seemingly uncontrollable educational process, when its very quality is so hard to pin down? The answer is below (again as comments to Section 3 in [18]).

Qualitative validation. Since any knowledge-based approach should be based on *cognitive ergonomics*, then even more so for an approach to education – a process cognitive *par excellence*. Likewise, any "Viet-kind approach" is inappropriate: "Qualitative validation consists in showing that a model is able to mimic available observed data. In population level biological models, the available data frequently represent a group status, such as pool testing, rather than the individual statuses. They are aggregated. Our objective was to explore an approach for qualitative validation of a model with aggregated data and to apply it to validate a stochastic model" [26].

Finally, to show that qualitative validation is inextricably linked to any educational process, three remarks: a) Medieval universities like Oxford or La Sorbonne established their high esteem during centuries, on a purely qualitative base – without *describing*, *contextualizing* or *measuring* the quality of the services provided. Why? Because quality – like beauty or any other elusive macro-feature – is firstly *perceived*, later *explained*. b) "How can we assess the potential effectiveness of yet not born skills (i.e., the quality of *learning*) measuring (often just by grades) the volume of knowledge acquired by the students (i.e., the quantity of *teaching*)? Primarily in education, quality should regain its prevailing role" [16]. c) Unavoidably, strategic planning (for instance, to win a war or to make a journey) is *architectural*, basically *holistic*, and *top-down*, whereas carrying it out (to prepare a battle or to start an excursion) is *structural*, basically *reductionistic*, and *bottom-up*. Otherwise – above all in higher education – it foreshadows failure. That explains the section title and defends its content.

5. CHALLENGES. NINE PARADOXES ON THE WAY TO LISBON

Why describe *challenges* by counting *paradoxes*? In fact they are hurdles perceived on a scale of nuances from intricacy or difficulty to trouble or even worry. However, the paradox is a statement "exhibiting inexplicable or contradictory aspects" [thefreedictionary.com/paradox]. In short, a challenge is in the real world but yet to come while a paradox is in our mind and by now. Thus, restating the problems by means of paradoxes (most of them have been already described as such in [16]) aims at:

a) Suggesting that the current "Scientific Zeitgeist" based on a quantitative "Kelvin way of thinking" [8] will be unable to coexist with the "Knowledge Society Zeitgeist" – yet unborn but already foreseeable. (The problem was extensively dealt with in [8], filtered through the sieve of "affordable technological innovation" in [18] and its huge consequences for EE will be elaborated upon in Section 3 "Speed of Change" vs. "Change of Needs" of the fourth paper.) Hence, the paradigm shift is *unavoidable*.
b) Implying that the way to unravel the paradoxes, proposed for each of them, is a pointer to a solution for adapting EE to KS and, on the other hand, showing that no effective solution is possible within the existing paradigms (indeed, if a solution could be thought of, why is the paradox still in force?) Hence, the paradigm shift is *urgent*.

Old Paradoxes. They regard mostly education as such and were pointed up in [16] because they are aggravated by KS; here, after quotes from [16], the impact of KS is emphasised.

- "In fact, the well-known policy of ″following the leader″ is not workable unless someone who has already drawn close to the final destination could give you a roadmap". There is no time to wait for best solutions from advanced Western universities, since KS is coming soon.
- The "″double truth″ of the divergence between inertial, conservative short-term objectives and dynamic, innovative long-term targets" is worsened by the diminishing interval from "short-term" to "long-term".
- A rather general paradox: "avoiding risks is a most risky policy". Indeed, ignoring the advent of KS involves risks unbearable for any university.

New Paradoxes. They regard education as such, but mainly EE because they are generated by KS features based on new engineering paradigms; here, they are abridged from [16] without comments, since their vital impact on EE is elaborated upon in Section 6 ("The Hurdle: Teacher and Learner Live in Different Times") of the fourth paper. (Likewise, the paradoxes relating predominantly to Information and Communication Technologies (ICTs) are dealt with in the fourth and in the fifth paper.)

- Despite its name, education in the KS would focus rather on *skills* than on *knowledge* because the global, easy accessible, Internet-based "Webliothek" is its key texture (in most nuances of the word). Hence, knowledge tends to become a utility whereas the real challenge is to be skilled enough to put knowledge to work.
- How can we *assess* the potential effectiveness of yet not born skills (i.e., the *quality* of learning) *measuring* (often just by grades) the volume of knowledge acquired by the students (i.e., the *quantity* of teaching)? Primarily in education, quality should regain its […] role.
- The last baffling paradox to cope with when heading towards "3L" stems from a kind of "temporal contradiction", i.e., how to organize institutional *teaching*, clearly limited in both time (corresponding to the Bologna degree framework) and objectives (corresponding to the focused curricula) to meet the expectations of a dynamic and indistinct environment, as implied by the concept of life-long *learning*.
- Our present object of work (teaching) is neither *present* nor *object*, since it aims at a *future*, quite far away, *process* (learning). Why should the teacher focus on *solving* (predictable) *problems*, when the learner should focus on *managing* (unpredictable) *situations*?
- We have to live with two still divergent conditions: a) The educator profile should move from teacher, to trainer, to catalyst (because the target moves swiftly from knowledge to skills). b) The "*e*-"prefix is inexorable (because of the "temporal contradiction" mentioned above. Acknowledging the hurdles in devising "e-teachers", how could we expect to devise better "e-catalysts"?
- How could be "computer-aided" an intellectual activity that is human-oriented par excellence?

6. START. THE FIRST AFFORDABLE STEPS

Here are only the *first* steps (namely those related to the position nature of this paper; those regarding 3L could not anticipate the fourth paper). They must be *affordable* since a key thesis of the entire undertaking is affordability – in the meaning implied by the first papers. Thus, a prerequisite of the "Ride towards Reform" [16] is to propose "a ″robot portrait″ of an affordable tourist-class roadmap to Lisbon […] on the groundwork of a knowledge-based approach to affordable technological innovation. (″Affordable″ is a sine qua non requirement for universities like ours.)" Likewise, [18] shows that "radical technological innovation is affordable (as time, cost and effort) in current industrial environments if it is based on new development paradigms – stemming from the Knowledge Society framework as outlined by the Lisbon objectives" and that "only powerful organizations could afford the hazard of exploratory research. For all others – universities included – the only affordable innovation was due to the predictable but limited yields of incremental research, achieved within established paradigms. On the contrary, during a period of severe funding shortage, the only affordable research is based on exploring new paradigms". In short, affordability, after being recognized as main part of the *problem*, should be now accepted as core part of the *solution*: here affordable steps means those not requiring explicit funding in the next two years.

Educational steps. The first three are inevitably sequential; the next three are either syllabi components or just alternatives.

- Gather the papers dealing with EE based on the Lisbon strategy into a book, together with similar papers asked from every Balkan country – as well as from EU officials. (First ideas for the title could be "*Engineering Education from Bologna to Lisbon*" or "*Engineering Facing the Knowledge Society*".) A less significant but faster alternative: selected papers from the Conference Proceedings could be the contents of a special issue of an ISI Journal.
- Improve on this groundwork the syllabus proposed in the fifth paper.
- Use that syllabus as model for related syllabi.
- Prepare a course-based master's program for *Master of Post-Industrial Engineering* focused on "ICT Paradigms for the Knowledge Society".
- Idem for "Quality Management for the Knowledge Society".

- Idem for "Engineering Education for the Knowledge Society". (Training the Trainers.)

Organizational steps. They are ranked in order of decreasing EU funding required:

- *FP7 proposal*. The FP7 Cooperation scheme promotes collaborative research projects in ten thematic areas. As shown in Section 2, the top priority area, *Information and Communication Technologies*, will get about 28% alone and, together with the following three areas, about 71% from the total funding [en.wikipedia.org/wiki/Seventh_Framework_Programme]. Thus, a well-defined and accurately formulated application proposal could be of noteworthy interest. A common organizational form could be a *Network of Excellence* – e.g., using as model *AgentLink* (European Coordination Action for Agent-based Computing).
- *COST Action (Workgroup)*. COST (European Cooperation in the field of Scientific and Technical Research) supports strongly such initiatives if they are well prepared, within available funding. If it is intended to become a separate Action, the proposal is expressed as a *Memory of Understanding* (MoU) to be signed at country level, while if it is only a Workgroup within an existing Action it is approved by the very Action.
- *No funding*. The following steps may have a more limited impact but need neither explicit funding nor explicit institutional structures inside every university involved in EE (the staff should work on volunteer basis):
    - *Institute BRCEE as organization*. Set up a permanent Balkan Region Conference on Engineering Education (BRCEE) having secretariat, website, and teleconference facilities.
    - *Appoint officers in charge*. To reach the Lisbon goals "each Member State must appoint a senior member of cabinet to be the sole representative in cabinet meetings in charge of the Lisbon Strategy as a ″Mr or Ms Lisbon″" [10]. In line with the principle of subsidiarity each university should appoint a senior faculty member (for instance, a Head of Department) in charge of the Lisbon strategy.
    - *Initiate a Delphi survey*. To be able to launch a realistic "Call to Cooperate in Engineering Education", the first questionnaires should focus on university potential to reach Lisbon educational objectives rather on describing ideas about potential features of the KS. Thus the first stages could be limited to gathering information for an opinion poll.

7. WHAT NEXT? A POSSIBLE ROADMAP

If the previous section content could be deemed to be overoptimistic – mainly when work has to be done without explicit funding – the title of this section seems at least an obvious overstatement. Indeed, "no one yet has clear milestones leads to Lisbon to share […]: we must embark for a foggy destination before knowing *how* to approach it, only to flee the danger of being approached by this very target before we are ready to accept it. Indeed, our ″Lisbon target″ […] must be arrived at before it could overwhelm us – since if we are not yet prepared to live and work in such a post-industrial society, the blessing could turn into a curse. In short, how to devise a to-do list without knowing what to do?" [16] (see also the first "*Old Paradox*" in Section 5). Hence, a roadmap is not just premature but appears as almost unworkable.

However, it seems important to sketch an – albeit very fuzzy – "robot portrait" of a roadmap (see also the previous section) firstly to show that the target is not a *fata morgana*. There are neither deadlines, nor evaluations whatsoever – without reliable information about funding it would be pointless. Thus, it is more forecasting than planning (that is the main rationale of the Delphi survey proposed before). In contrast, some milestones could be anticipated:

At first come the steps proposed in Section 6 – mainly a workable logistic infrastructure and the *Educational steps* – since they do not unquestionably require cooperation. Then the first Balkanic *Lisbon-oriented network* should be set up via the feedback to "Call to Cooperate in Engineering Education". After a positive response from universities from about seven or eight countries, EU sponsorship could be asked for – based also on the results of the Delphi investigation. In parallel, from the improved syllabi could be assembled curricula, commonly agreed upon. Afterwards the horizon is open.

In short, the outline above aims at reassuring us that Lisbon is reachable, albeit far – even before investigating closely the methods proposed in the fourth paper and improving the syllabus yielded by the case study in the fifth one.

8. CONCLUSIONS. COOPERATION BECOMES A MUST

In theory, the nature and context of this paper should involve conclusions organized on three echelons regarding: a) the paper standing for a research *per se*; b) the third account of an ongoing research undertaking covering a much wider scope; c) the paper as position paper on the topic of EE in the KS. In practice, such separation would be cumbersome, difficult to follow, partially redundant, and – above all – loosing the relevance of its holistic approach. Thus, the conclusions will skip over the first echelon, focus on the second, and comment shortly upon the third one.

- The *research topic*, as expressed in the paper title, is of paramount significance to any university – here and now. Moreover, it becomes urgent to deal with.
- The *rationale* is exposed comprehensively (covering premises, objectives, and context – from European to Romanian, to local) via X-raying the title and is defended by a recent and rich webliography.
- The *approach* is architectural, basically holistic, top-down, and based on advanced, state-of-the-art concepts like: niche transdisciplinary research merging synergistically vital strands explored before; open, uncertain, and dynamic environments; anthropocentric systems; cognitive ergonomics; life-long learning. The approach is also pragmatic, reorienting – with minimal redundancy – the investigation from industrial to educational environments.
- The *focus* is on managerial-strategic aspects, affordability, shifting to KS paradigms (e.g., "Just in Time", agent-orientation, qualitative validation of macro-features), and strategic planning. (The focus will move to academic-tactical aspects when implementation methods will be described in the fourth and fifth papers.)
- In short, the undertaking appears to be the first attempt in Romania to adjust quality management to KS and to apply consistently KS paradigms in exploratory research regarding EE.
- As regards the position-paper echelon there is a single conclusion: to attain the Lisbon objectives, cooperation becomes a must because the inexorable and vital paradigm shift is beyond the reach of both traditional solutions and local approaches. There is also a hope: the paper is convincing enough to boost the outlook for cooperation in embarking for Lisbon.

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