

# THE RENAISSANCE ENGINEER AND CDIO

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## **ABSTRACT**

The aim is to promote more real trans-discipline education in various engineering programs. The scopes are to encourage and recommend many engineering renaissance initiatives and reforms by several CDIO campuses and yes by going further than intra-disciplinary and/or traditional multidisciplinary approaches respecting border discipline. In order to better serve our green society, we need wider educational and professional perspectives for the future generations of engineers to face their new problems in our complex international world. We need a more global professional with a holistic approach able to work in different trans-disciplinary teams and in different languages. They will build together a sustainable planet in our period of new renaissance. We need a revolution on our campuses from both management and teaching staff (including their union and syndicates) to drastically change their traditional methods and thinking to serve better their students with the right balance education. Trans-disciplinary is one of the solution available for all these engineers of tomorrow needing a stronger social sciences curriculum at graduation and not only some camouflage crump. We need a constant and serious deep educational reform to make all the required changes now, if we really want to graduate more sustainable and global engineers. In the end, sadly maybe, we do prefer to protect the old guard again and our personal interests. Are we ready or not to be reborn and participate in all the educational challenges of the new renaissance? Some maybe are just looking for their retirement pension ahead and do not want to rock the boat. We need more renaissance engineers with trans-disciplinary methods and skills techniques for a symbiotic synthesis for all the new challenges of this century and the CDIO syllabus could help us..

## **KEYWORDS**

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Trans-disciplinary, global, sustainable, pedagogy, holistic, education, transformation, reform, balance, diversity, generalist, renaissance.

<The ideal engineer is a composite ...He is not a scientist, he is not a mathematician, he is not a sociologist or a writer; but he may use the knowledge and techniques of any of all of these disciplines in solving engineering problems.> [1]

## **INGÉNIEURS DE LA RENAISSANCE & CDIO**

<Renaissance> meaning in the French language is clear: it could be translated as reborn again. It is not related to any faith to the best of my knowledge; however at said period in Europe the churches were facing already many problems. It was a great period for changes because of the great works of engineers, architects and artists. They did accomplish several <chefs d'œuvres> in the medieval times and not only in Italy but all across Europe. This new century offers again to our engineers more green challenges and opportunities. We could work together all across our blue planet with other professionals to have a new renaissance but we must be better prepared with a wider education and master the holistic thinking for a more sustainable environment.

CDIO initiative is a great collaboration of persons and institutions with innovative vision looking for a renaissance of the engineer profession on all continents. I do believe that generally speaking the proper engineering curriculum is not completely reached yet because we do not give a fair space and enough weight to the social sciences in my opinion. The formation of most engineers could be better balanced on most of the campuses. Some engineering professors are often in an ivory tower protected by strong unions and syndicates and more or less interested in serious educational reforms. Many of us still have no proper formation in pedagogy and others are more interested in research than teaching. The students now want coaches, mentors and not professors highly specialized imposing their old notes and slides with boring power points presentations. They want to work with international teams of instructors from the industry, from others campuses and yes why not with non engineers professors. I do agree with nice modern laboratories and well equipped technical tools; this is excellent but in their learning process the future engineers need also good working environment and less scientific space to complete their university formation in many social sciences, literature, philosophy, etc...They need preferably the daily exposures with students from other departments, faculties and work on complex projects with others schools even campuses at distance if necessary. It is a lot easier today with cheap technology; the multimedia (like Skype) is also available for better communications. When I read the CDIO official syllabus, I did see some improvements in all four sections to increase the social sciences content in the curriculum. However when I did read the twelve CDIO standards, I disagreed with deference with the selection of the seven mandatory's standards. I still do prefer the supplementary five non essentials standards. They are keys for me and not only mere best practices in engineering education .The more important are the standards on the enhancement of faculty teaching skills and the introduction to engineering. My students always prefer to work in groups with open ended problems; so we need to educate our professors with more pedagogical skills. We should encourage CDIO

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experiences and initiatives on all continents for the progress of engineering education; it is one of the right good steps to build a renaissance engineer curriculum for the future.

I did begin my research on renaissance engineering education and the aims of CDIO. After several lectures, I did find many international authors with different educational recommendations. I was inspired by Doctor Shirley Ann Jackson's wisdom on the web in her outstanding address on the twenty second of July 2004 at the National Academy of Engineers (NAE) for the National Education Summit in Washington. Her speech title was Engineering the Renaissance for the conference NAE Engineer of 2020. She was the president of Rensselaer Polytechnic Institute at the time and she rightly said to the engineer audience:

A true liberal education should include the hard and soft sciences, the fines arts, literature and, in our century evolving forms of entertainment, information, education, and cultural awareness.  
[2]

I did serve with many universities (engineering department) and/or polytechnics for more than twenty years as a professor/senior researcher. I did see most of the time that the hard sciences do have usually more than 90 % of the curriculum space at prime time and the left over was for the soft sciences if time permits...of course. Maybe the soft skills are still a second class education for some engineering professors; it is really sad because we need more balanced engineers. I could also testify that my own daughter did complete after her degree in software engineering a second seemingly unrelated bachelor degree in communications by interests and that my own son recently after graduating from Mc Gill University in mechanical engineering decided to complete his master in Finance at the London School of Economy. Like many others students, they were not only looking for the engineer education and formation; they do not want to practice as traditional engineers. We have to respect the choices of all students and not impose our professional views. I do recall that more than twenty per cent of my MBA class was engineers looking for non technical education to be more polyvalent and better managers.

In IEEE Transactions on Education, you could find an excellent summary on the renaissance engineering by Professor Vicki P. Rainey. She does insist on trans-disciplinary education shifts for engineers. The context of the engineering problems is now more important today in our society and we need to work more with other professionals from the global community. We must prepare our students for a life of constant learning and the importance of the human aspect in all their works. Their education must be looked in a strategic context including the social aspects of student life.[3] The renaissance engineer programs and CDIO official syllabus offer them more alternatives in their engineer training with a wider vision but we could more trans-disciplinary by increasing the real weight of non technical courses in all engineer programs. Often the complimentary courses offer is so few that it is creating an imbalance in favor of technical and scientific courses. Most of the engineering schedule does also privilege the hard courses. On some campuses some academic staff still creates an unfriendly environment for non-technical activities instead of promoting a fair balance for their students.

A nice tentative for a new curriculum was done by professors Moore and Voltmer in a very good article entitled <Curriculum for an Engineering Renaissance>; the authors stress the importance of the soft skills in the engineer education. They suggest excellent recommendations to improve the professional formation of engineers with critical thinking, ethics, liberal studies and independent learning. We must insist on the imagination and creativity in our engineering programs with strong non technical components like humanistic studies and liberal arts. Their curricula for 2013 for electrical and computer engineering is a lot better balanced; it is called <Engineering renaissance>. I hope they will be able to sell that to all their partners in their

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engineering faculty to create such a winner atmosphere to reduce the internal competition, infighting, departmental compartmentalization. The key is to return to the original mission of the engineers to serve our society on the move and for their real needs and not for the interests of the teaching staff or the department looking for bigger budgets to build up an academic empire.[4] We could have similar more balanced curriculum in all engineering programs.

The renaissance engineer concept is well present on all continents. A British colleague brought some interesting ideas from physics in his article: <The Renaissance engineer: ideas from physics>. This is a good article in the European Journal of Engineering Education bringing new suggestions also with an interdisciplinary approach. I still prefer a more aggressive agenda with a strong trans-disciplinary menu. I do agree with him: we still need some specialists but we need to offer also a solid generalist formation with the flexible spirit of the renaissance engineer of tomorrow [5]

The e-learning with the lifelong education is necessary to keep us up to date as new renaissance engineers. The multidisciplinary aspect is now a reality and is also more present because knowledge grows and the engineering discipline splits easily with the evolution and the technology. The law of progress is dynamic according to Professor Mervyn. E. Jones in his article: <The renaissance engineer: a reality for the 21st century?>. He does mention in his third section the dichotomies in teaching and learning with transferable competencies. We need to use a diversity of technologies and strategies to reach out our students and more so in continuing professional development because of their rich experience. It is a real potential to customize our educational services with the right vehicle and preferably at low costs while maintaining high quality to better reach out. He did recall the key point on how much resources are available to educate the renaissance engineers. [6]The management of our institutions may make some unpopular decisions and even sadly must face some confrontation with the professors unions and syndicates if they are not interested in major education reforms, improvements and transformations for the benefit of their students. Some engineering professors could have a hard time to adjust to all the new needs and work closely with non engineers for a trans-disciplinary approach across all programs. We (the professors) need to work together in one pluridisciplinary course even if we are not all engineers in a common project with different teams of students preferably from various departments. We could design new courses preferably and if possible in different multidisciplinary programs ideally (even at distance if necessary). It is a meta-fusion of disciplines by integrating tools and methods for the benefits of our students.

<The renaissance engineer: educating engineers in a post-9/11 world> written by professor Adnan Akay is also an excellent contribution to the new role of engineering today in this new century. He insists on broadening the scope of engineer curriculum and mentions that some time the research aspect is too important in their university formation. The growth of cross discipline is well mentioned and he does confirm that the sole technology knowledge is no longer sufficient in today realities. This is a very good contribution on the education of the renaissance engineering that could inspire us for many years [7]

In Asia (Malaysia, Japan) and in Australia, there are also several relevant authors on many articles on the concept of renaissance engineering, like professor Errol Lawson and his article <An Examination of the Social Systems of Engineering Projects based on the French capital concepts of Bourdieu> très pertinent. [8]

Lastly, I should also mention an excellent article from south of our border entitled: < An arts, sciences and engineering education and research initiative for experiential media> sponsored

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by the American Society for Engineering Education and IEEE education society by professors Rikakis. He does recommend multi paths researches and combining disciplines at their junctions with an extensive interdisciplinary network. He does raise the evaluation impact. [9]

We could be proud to see that many engineers and non-engineers are still working together for a new renaissance in education even with all the difficulties. We are often too proud of our professions, institutions, traditions, customs, academic circles, unions, clubs etc. that we are de facto blind. It is very sad that some of us do refuse the fantastic challenge to be reborn again as a new renaissance professional. We do not have to speak any Italian or Latin. We just have to listen more carefully to our artistic soul and be a bit more philosophical in order to be a better polyvalent educator for today's needs. We still need engineers with a generalist approach open to an applied sustainability and a balanced focus in social sciences. The engineers should be always open to innovation, diversity and transformation to meet the actual needs of our society. We need an integrated learning method to adapt rapidly to all the new changes required in short times to face our new engineering risks. We could also benefit of the wisdom of more female students for a more human engineering perspective in a renaissance spirit.

< If engineering is to be practiced as a profession, and not just a technical craft, engineers must learn to harmonize natural sciences with human values and social organization. To do this we must begin to look at engineering as a social science and to teach, practice, and present engineering in this context.> [10]

## **TRANS-DISCIPLINARY & ENGINEERS**

La transdisciplinarité, c'est plus que la multidisciplinarité traditionnelle et l'intra-disciplinarité réunies ensemble.

We are lucky that for more than 15 years several campuses offered various trans-disciplinary programs on all continents. We need more and more universities and technology institutes to follow their leadership. Our students deserve more choices to serve the new engineering needs of our society. Interdisciplinary is the link between different disciplines. It is the integration and fusion of various knowledges around one problem. The holistic result really crosses boundaries and reduces the silo effect toward a common goal. It is not an intra-disciplinary analysis and it is a lot more than a series of multidisciplinary or interdisciplinary projects respecting carefully the limits of each discipline. We need to transcend the traditional subject borders and destroy our internal Berlin wall protecting our professional turf to be really trans-disciplinary.

The meta-discipline required the blending of disciplines in a dynamic way like a joint research with a global perspective. It is a real merger of wisdom, traditions, customs, methods, analysis, models, informations, and skills toward a common target. We need to work together in respect for a symbiotic amalgamation of education disciplines. The engineering sciences are well at the center of multidisciplinarity in most projects and researches because we do encourage creativity. We need more polyvalent engineers who are flexible, innovative, team players and open minded to all disciplines including soft skills. The renaissance engineer likes entrepreneurship, military engineering, feminism, literature, spirituality, ecology, management,

law, biology, foreign languages and could be a member of engineer without frontiers if he or she wants.

The key of the challenge is the progressive integration of trans-disciplinary programs with the right open minded staff and multimedia equipments. The techniques and methods are already used in very successful programs across the planet. Many existing programs do already cover the process, design and systems with a cross-discipline team of coaches and international mentors. We do not need more professors but dynamic instructors and guides. Such advanced educational activities are progressing on at least twenty-three major international campuses according to the last survey by the Texas Technical College of Engineering in 2010 on the web site of the Academy of trans-disciplinary learning and advanced studies (Atlas) [11]

You will find many relevant examples in different countries.

In United States, with professors Ertas, Tanik, Rainey and Maxwell in their article <Transformation of higher education: the transdisciplinary approach in engineering>[12] , professor Menoni with the article <Introducing a Transdisciplinary Approach in Studies regarding Risk Assessment and Management in Educational Programs for Environmental Engineers and Planners> [13] and professors Shuman, Besterfield-Sacre , McGourty with their key article on The ABET Professional skills – Can they be taught ? Can they be assessed? [14]

In Denmark,with professor Jakobsen et al in the article <Transdisciplinary variation in Engineering curricula. Problems and means for solution (a polyparadigmatic curriculum). [15]

In Japan, with professors Tadashi, Hisazumi, Hisahito, Agerico, Satoshi, Trans-disciplinary graduate and refresher programs for education, research and training in the fields of nanoscience and nanotechnology .[16]

In Australia, with professor Toft with her article <Virtuous reality: The development of safe design through transdisciplinary teams,> [17]

In Germany, with professor Mollinga in his article <Towards the transdisciplinary engineer: Incorporating ecology, equity and democracy concerns into water professionals, attitudes, skills and knowledge.>[18] and the wunderbar workshop on global engineering education in 2000 in the nice border city of Aix- La -Chapelle where Charlemagne did create mandatory school.[19]

I did of course make a difficult selection to demonstrate that the concept is spread internationally and really without frontiers of states and disciplines. The wind of trans-disciplinary already reaches the entire blue planet for a better governance and quality of life irrespective of cultures, languages and faiths. The important is the heart and not the age of the engineers with the right mind willing to work closely in a new renaissance era with a trans-disciplinary attitude. We need now meta-coaches and international mentors to become renaissance professors again in order to guide the future meta-engineers of manana. The medieval times give us a critical leading role in many sciences, literature and arts. Now, it is our time; we could build together that new synthesis with our modern techniques and tools. Our era of integration and combinatorics did replace progressively the mature Cartesian-Mechanistic period according to professors Ertas, Tanik and Maxwell in their multi bene article <Transdisciplinary Engineering Education and Research Model> a must for all professors of engineering or not. They rightly insist on the great value of trans-disciplinary in improving overall research quality, productivity, and the education of students to build, maintain and manage the next generation of enterprises as well as their products and services.[20]

It is sad that I know only few languages because I am convinced that I am missing a lot of wisdom from many cultures like China or India on trans-discipline. We could work together for a better sustainable world like in the medieval times to develop together more linkages.

The constant interactions between disciplines are the success of the multidisciplinary approach; we need new protocols and methods to stretch across the old disciplines. Our society with our communications technology available could increase the exchanges and connections for a better interaction among different disciplines. The quality assurance of engineering of today could increase with a trans-disciplinary approach because we do add better global risk management aspects in our services and products with an international team of different disciplines working together for the same target. The process, design, systems, metrics must be developed with a trans-disciplinary methodology with the integration of different knowledge and information's from the industry and from the academics world. The technological development of this century must be combined with several other disciplines in an integrated approach for a real trans-disciplinary education for the benefits of our students and society.

I must also recommend the very good article of professor Skates with the title: <Interdisciplinary project working in engineering education.> [21] This article detailed all the implementation steps required for a successful engineering program with a trans-disciplinary education approach. Several examples of integration projects are demonstrated by different teams. He does confirm again the excellent benefits of such approach for our students for a more successful engineering career. It does encourage more innovative and critical thinking. It does open the door for non engineering students to engineering skills and for all to appreciate the wealth of the team concept. I sincerely hope that more campuses will offer such new alternative soon. We do have already too many old costly engineering programs not meeting the new needs of our society. The limited resources of each campus are for the benefits of our respective students in theory at least. I hope that the annual budget is not de facto controlled by a weak management under the influence of some powerful professors and/or researchers with their own private agenda... We must make the right choice now because the resources are limited and should reduce duplication of services. Some students could prefer smaller campuses with quality of a balanced life and not be a white collar slave on a big campus research center working too closely with some industries in topics of interests only to some professors or their grant providers.

I do believe sadly that many of us do need a refresher on pedagogy, ethics and equity but we are all humans in nature and have egocentric attitudes from time to time. We should look across all disciplines like a holistic synthesizer with a critical mind but always open to some new wisdom. Our duty is to increase the interconnections between disciplines and transcends the knowledge and information. The renaissance engineer must be polyvalent and have a meta-level (many disciplines), knowledge and international perspective. The level of intertwined links must be increased among disciplines for a better integrated engineering knowledge.

## **CONCLUSION**

The restructuring of engineering programs could be done with the right academic staff under a wise management to implement a transdisciplinary program across the campus. The problems of the real life are there to be solved by team players from different disciplines working closely

together in multidisciplinary way. The necessary integration is always some successful compromises and maybe you need a good mediator with discernment. You need to find some champions to realize all the changes and to transform the atmosphere deeply. The important is to go beyond the intra-disciplinary aspects and to create a real multidisciplinary environment with an integrated trans-disciplinary program across your campus or make an alliance if it is better in your local strategy. It is a captivating challenge and yes it will create some turbulence like in the medieval time but you will be among the re-born engineers for a new Renaissance era. We need to serve primarily our students and to be always liable and accountable to our society in providing excellent and pertinent education and research to future engineers and non engineers.

Lastly I am able to testify as a non engineer to be proud to teach together with a team of dedicated engineers willing to have an integrated approach to education on our campus at Polytechnique de Montréal. Of course the CDIO syllabus is a good start to implement gradually a real renaissance engineering program in concreto across any campus. We could conceive, design, implement and operate more reformed engineering programs in the spirit of the new renaissance with more social sciences activities like some community service experiences. The solution is a common ontology in a new creative synthesis of disciplines on the same problem or project. Yes I do believe strongly in the trans-disciplinary approach for a better engineering education in this century like in the renaissance times for our students.

<Engineering education can be seen as an emerging discipline but more usefully as a merging of other disciplines>[22]

Ciao, mille gratie.

Louis Haeck, DCL (Mc Gill University)



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