Lifelong Learning Programme

Improving Teaching Effectiveness in Chemical Engineering Education

ITEACH

Decision Making Matrix

Deliverable 3.1.

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Contents

Executive summary

With the development of the European market, the panorama of students and teaching methods are changing: other logics, other methods, other goals. Training centers in chemical engineering are put in front of new control processes and focused more and more responsibilities on results rather on the means to get them.

More and more, in fact, the society defines the legitimacy of the Chemical Engineering teaching on the basis of socially and economically results which have to be useful for today and tomorrow. iTeach must provide robust performance indicators of Chemical Engineering training centers and of teaching effectiveness. This exercise is part of the modes of governance because it aims at transforming boring and complex data and into "eloquent" and clearly legible figures.

Two frameworks are then developed :

- The first one deals with the assessment of a whole training center and includes more of 150 parameters, gathered in 7 global indicators taking into account the specificity of the activities in Chemical Engineering. It has been proposed after following a preliminary work developed at ENSIC Nancy - France, one of the iTeach partners. It is thus assumed that science follows a normal distribution, whose variables are described by central (average) and dispersion (standard deviation) parameters. Then, the measured variables can be the subject of appropriate mathematical treatment... Unstable, divergent thinking specific and 'revolutionary' are therefore not yet envisaged, because requiring the exchange of proposals with all of our European partners.
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- The second one deals with the evaluation of a single teaching unit and is based on a literature analysis of different methods developed for assessment of teaching effectiveness. The impact of the formation, its relevance, the notions of transfer, acquisitions, competencies are in particular considered. The proposed framework is then based on 6 metrics, that can be assessed through questionnaires completed by different stakeholders involved in the teaching process : students, graduates, academics and employers.

The assessment of performance is both **measurement** (since associated with quantification), **meaning** (because it must be interested in the meanings by the interpretation of the measurements), **decision** (indicators represent what efforts should be accomplished to achieve “excellence”).

The document is preceded by a preamble defining a number of characteristics of the complex relationships between teaching activities, and their environments and translation in terms of indicators, followed by a proposal which has been discussed and approved by the iTeach EU partners.

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1. Introduction

This report provides the summary of the criteria to be used for the selection of the most appropriate methods of assessment of the effectiveness of core knowledge and competency delivery. It describes the results of the multi-objective analysis, indicating the methods to be included in the proposed assessment frameworks.

Two frameworks will be developed: one for the evaluation of the effectiveness of a whole formation, and a second one for the evaluation of a single teaching unit. This report contains thus two major parties, related to the development of the two frameworks.

2. Evaluation of a training center in Chemical Engineering

2.1. Introduction

World has moved from a situation where the expectations of the individuals had a basic dimension to an environment where the obtained rewards give rise to new needs. These lead to problems (risks, ethics, supplies, global warming, health, well-being, etc.) likely to give birth to social dissatisfaction, which should be often answered by a technical approach. Identify and try to formulate these emerging problems and societal issues is all the more necessary that the distinguishing feature of a large part of the demands and needs is to be based on dissatisfaction. This does not mean that there exists, for the public, rationally preferable solutions. Therefore, those who are at the source of innovation in the processes of transformation of matter and energy have to consider realistic alternatives which will give meaning to the will of technical progress in society, which will lead to quality and enthusiastic jobs, etc. However, and this is obvious, the limits of knowledge and the complexity of the systems can lead to flawed proposals.

This consideration therefore, imposes a forecasting approach on the part of the training centers in chemical engineering (ChemEngng) to define the issues, the new objectives and the way to achieve them (Westmorland, 2008; Daniels, 2012, Babymaz et al., 2013), and the strategy of educational choice including new forms of learning for students and the choice of partners to develop the appropriate effectiveness of teaching.

2.1.1. A general vision

To set pedagogical priorities, for a formation strategy in ChemEngng, is a challenge which, to our knowledge, has not been explored for a long time. It seems that a dual approach is to follow (Costa, Moggridge, Saraiva, 2006; Perkins, 2002) :

- The first can be used to prove that the current knowledge and methodologies, despite scientific imperfections of some theoretical foundations and "fragility" of certain scientific and technical knowledge, yet allow credible application objectives. Engineers and students of ChemEngng are well placed in the industries and have general knowledge allowing facing the changes. Wanting to strengthen this ability and the image of the discipline is however desired by many partners. It is risky, because it is possible to come to dead ends, to the impossibility

to change the course of things, etc. However, it must address these problems which, ahead of the international competition, become urgent (MD. Noor, 2004; Rosen, 2009).
- The second, recorded in longest terms, should aim at expanding our means of understanding new phenomena, to develop new processes, etc. in relation to the (mastered) evolution of the world and of learning processes.

2.1.2. Tactics

Formation/Training strategic choices in ChemEngng should be guided by societal objectives and some anticipation of the evolution of knowledge. On the other hand, the tactics defines the choice of issues depending on internal and local criteria (to the community, the teaching unit, and the teacher-researcher), taking into account possible partners that could join research, the human and financial environment, to define and enhance the legitimacy of ChemEngng formations.

It is on this basis, that this work has been undertaken by the authors in the frame of the European contract iTeach (Improving Teaching Effectiveness in Chemical Engineering Education, 2013) accepted by the European Union within the 'Lifelong learning Programme'. It aims at trying to define the learning outcomes necessary for the development and the legitimization of the ChemEngng domain, their envisaged developments and, in this context, to propose indicators to compare, as a first step, the positioning on a "mapping" of the ChemEngng Formations at a European comparison level.

The method is based on the work of the "International Ranking Expert Group" (IREG, 2011), which, in the "Berlin Principles" defined quality rankings based on good practice which are summarized below:

- Set clear goals,
- Use transparency in the method,
- Select appropriate and valid indicators,
- Make the weights assigned to different indicators prominent and limit changes to them
- Recognize the diversity of formations.

Indicators are here used as a variable that can be measured and that seeks to represent as closely as possible a given concept referring to the state of the object to be measured (Lazarsfeld, 1971). The properties of the indicator must always be compared with the properties that the concept is supposed to possess, comparison based on intuition and knowledge of the object or on other measures of this concept (Gringras, 2013).

2.2. General Context

The objectives of ChemEngng training centers are to be based on a scientific approach, centered on the appropriation of knowledge and focused on society (its needs, health, products) and therefore to develop, in the field of processes engineering, a systemic approach to design, produce and operate systems of transformation of mass and energy more efficient, more safe, more communicative, more economic, more environmentally friendly, etc. (García-Serna, Perez-Barrigon, Cocero, 2007).

These goals fit into a strategy which is:

- To acquire basic concepts and technologies,

- To be present on the front of the knowledge and bringing new innovative projects,
- To meet the challenges of society in the ChemEngng field.

To achieve these goals, interdisciplinarity, the merging of disciplines (avoidance of too disjointed knowledge) internally, but also with industries and academic and institutional partners, should be increased. Pooling disciplines is not without confronting them : Chemistry, physics, mathematics and modeling, automatics, signal and communication processing, human and social sciences, fluids mechanics, reaction engineering, heterogeneous environments, etc. The list is probably longer.

Confront the disciplines must be done in a common approach:

- To understand, model and observe by experiments and simulation,
- To design and build : specify starting from the expressed needs and up requirements to the component and system,
- To control, optimize and manage the complexity related to mobility, to the big data and networks,
- To generate new applications.

So that a teaching should be efficient, it must be based on a coherent framework that pedagogically translates into a logical core, allowing students to acquire the basic notions. However, it should also promote and support innovation (even pedagogical), which cannot be done without risks, and requires dynamic teaching and teachers. Innovation is related to a notion of breach of scientific tradition and it is necessary to consider how preparing students to the (permanent) process of change. It is therefore necessary to 'convert' and bring a part of teachers, and industrial partners, to associate them with this approach.

This approach can be put to evil by "refractory people" becoming unable to participate in the dynamic activity of teaching, necessary for the best performance of the school. It is a worrying factor in certain activities of formations, running too inside 'disciplinary fields' and recognized themes (which have or had their legitimacy). Arguments about potential risks, analysed or not, collected by teachers engaged in a new action, can naturally strengthen the positions of rejection for the change. Eventually, this represents a real problem: the brand image of the school changes, impossibility of changing formations, forms of conservatism, etc.

This is why questions arise : how to clear off the collective work those who will take the initial risks allowing the development of new combinations ? How to support these non-conformists scientific and pedagogical innovation factors that induce the necessary teaching evolution ? How to take into account the originality, the creativity, the ability to rebuild a formation, at least for a definite time ?

Generally, innovators and creative people manifest themselves in situations where uncertainty is sufficient to develop a scientific and/or technical skill that is 'legally' not vested. Moreover, will it have funding (and especially people) to take the risk of a new approach that can also be interdisciplinary ? Without this uncertainty, normal situation in research, but less in teaching, cannot be transformed into creativity. These financial and management aspects can limit creativity and risk taking, especially if they are not strongly supported. The school management must have reflexive and united partners who anticipate and support the change, which are not only in the 'values' and in the hierarchical logics and ordinary careers... Synthetic and analytical intellectual abilities which are involved in the act of innovation are to be found in any part of the following qualities :

- Capacity for the identification and definition of ideas for a future,
- Revisits formations,
- Searching for information related to a project,
- Searching for similarities: analogies, metaphors, comparisons,
- Self-motivation, agreement and firm support from the management for risk-taking,
- Selective combination : grouping of information enabling the realization of the idea, and even its evolution,
- "Divergent" thinking: generation of a field of emerging possibilities,
- Responsible self-assessment,
- Agreement for the questioning, trust in the hierarchy,
- Accept the error and use feedback for improvement (REX),
- Piloting shared for the entire school dynamics.

The economic calculation of a formation and of its objectives puts a proposal for formation costs measured with the inputs financial system (salaries, support, infrastructure, etc.). A public economic calculation must in principle be rooted in a coherent theoretical vision of the formation, conditions of the integration of diploma students and the 'sustainability' of their employment, flow of personnel and students, links with other partners, department's leadership, its influence and its attractiveness (for different audiences), etc. The implementation of standards, repositories or indicators corresponds to the description of an organized system, and its production, more or less standardized (with the risk of a too reductive simplification not allowing to take into account interdependencies and recursive of teaching activities : employment, balance of payments, brand image and attractiveness, etc.). This may mean that there is in Europe (the European project framework), but more broadly in the Occident, a form of dominant thought "legitimate" which might tend to establish itself as a non-questionable truth. iTeach must wonder about this important point to determine whether to propose clone programmes of each other within the EU or whether, on the contrary, the specificity must prevail. Yet once raises the question of the position of the cursor in between these two extremes. (Estermann, Bedi, Claeys-Kulik, 2013).

The difficulty of managing changes in teaching structures leads to worry about a growing tension between an adaptation to constraints (in-depth relevance, creativity, competition) and coherence (traditional activities that have made the reputation of the quality of the formation). This reality involves far-reaching consequences because some elements, rapidly presented above, illustrate the fact that demand is imposed and that the reality is another, at least in part today. But what will happen tomorrow ?

School teachers want probably not being "trapped" by a control in the form of an illusory objectivity, nor subject to doubt, or to the discussion. Indeed, in a complex system, involving the training of engineers, design of efficiency cannot be reduced to a single method, both in-house and with respect to different instances (evaluation, managing, piloting, funding, etc.) than externally (attractiveness, hierarchical positioning, jobs, career, etc.). Similarly, it is probably difficult to believe that the "best" estimate is that the "cost-benefit" assessment is the highest at the time "t".

However, specialization or the readability of a ChemEngng programme should result in principle in:

- A better clarity in way of acquisition of knowledge,
- Increased communication and influence,
- Customized productivity,
- Modern way of teaching, to meet current and future,

- Alternative training, but allowing the confrontation with European Countries, and even more widely world competitors,
- A match between stands for creativity, design and production support...

The transformation of ChemEngng programmes could be the result of a desire for guidance to (still) be set in terms of objectives. Should we expect creative incentives from other developed countries which could, in the international competition, give the impression that "we" regress ? We can understand the interest of stakeholders to use in iTeach a model applicable to the formation of specialized engineers' policy and to apply it to enable international comparisons and schedules based on easily quantifiable indicators (to a scale calendaring).

It should be noted that, in fact, a ChemEngng training center should respond to a model of flexibility, more adaptive (in relation to the societal needs and to the competences and some willingness of students – towards an "à la carte" training ?), as related to the rapid evolution of the environment. In these conditions, the time factor is a fundamental parameter in the development of international competition. Indeed, it is to consider the management of all the teaching activities of the laboratory "ChemEngng Programme" to consistently optimize them so that they are able to provide to the company a product-service with all the attributes to which the public places value (Rey, 2014). There is therefore a need to review goals of the formation in issues of deepening societal relations, representing an adapted form to these strategic exit criteria, as well as engage prospective reflections for action. It is then obvious that the uncertainty of the environment of ChemEngng programmes should probably lead teams to reconfigure to adapt to both organization and 'offers '. It is only on this condition that structures will :

- Do not be overcome by more adaptive foreign ChemEngng training centers,
- Deal effectively with changes in value systems that must orient their instructional, science and technology strategies,
- Anticipate creatively about future scientific and societal needs.

However, such ability to change must be based on a number of stable elements which must be representative of the performance gained (concept of competitive advantage, control of critical knowledge, adapted teaching and recruitment, control of links with other partners, pooling of shares, etc.). Then the "calculation" of effectiveness must be redesigned to take into account this reality entered in time, by combining organizational aspects leading to the maintenance and/or strengthening of the educational performance of the teachings of the formation.

If the concept of performance is a real common word, it should characterize by a set of skills for collective action:

- Control, steering and intelligent management,
- Use of published knowledge (bibliography and competitive),
- Coherence and diversity of teachers,
- Coherence and diversity of students (from a complete monochromic vision to a full adaptable recruitment, function of the local goals of the training in Chemical Engineering),
- Relevance and originality,
- Recognition of interdisciplinary and coordination between teachers,
- Integration and differentiation.

It is clear that only evaluation, determination of criteria for effectiveness evaluation and the development of corresponding indicators can allow checking the property based approaches for improvement / reorientation of teaching activities (highlighting progress and sources of problems). In a domain whose dynamics must be permanent, the specificity of the teaching activities cannot be satisfied with transposed methods from those used in "simple" production activities. There is therefore need to reveal the complex process of ChemEngng training centers, the sequence of these, their characteristics and related issues before proposing indicators leading to an analysis matching the training strategy. Moreover, we do not underestimate the pitfalls where could lead the implementation of inappropriate indicators with possible perverse effects of different origins. Indeed, if the interest in the establishment of efficiency or performance criteria is legitimate to enhance the decision support process, indicators should just serve to measure the achievement of objectives and measure the essential elements. But they shall in no event substitute for these objectives.

It should be noted moreover that a ChemEngng training center unit is not an island disconnected from the real world. It interacts with its environment and, for example, pedagogical, scientific or technical direction that blew a lock, from another ChemEngng school, can have a considerable influence on the developments to be programmed. These forms of sometimes critical interdependencies are not enough taken into account in the analysis.

It is thus, in iTeach, to achieve quantifiable data, actual ratings, which will be “agglomerated”. "Ratings" should be used wisely to avoid inappropriate dissemination that may modify the behavior of a number of players folding computational rule and not to the true mission of the ChemEngng departments. If it seems normal to access to reduced information to help the decision, taking into account the whole comprehensive information about teaching remains fundamental. Indeed, we should be aware of risk of damage to the teachings and students : damage in the image, or material harm, knowing that it will be difficult to establish a causal link between a wrong analysis of the situation and possible prejudice. So that means conservative and wary use of the information on the one hand, a co-construction of the indicators with other European training centers, on the other hand. Indeed, it must be understood that it does not exist for the authors of this draft document any predetermined quantitative method in the concerned field. It is then necessary to take account of the opinion of external managers in relying on a few broad measurable determinants.

Thus, rather than undergo imposed rules, a way taking into account the criteria presented above, with a broader spectrum of activities of the formations than "simple" descriptions of the disciplines taught, and more qualitative aspects, is proposed. Trying to combine teaching and measurable funding, to collective interpretations, it must be possible to reach meaning indicators. In the following work for the development of teaching efficiency, we have tried to take into account the difficulty of the exercise for training centers modestly prepared for this type of analysis, yet essential for the necessary management of any organization. In this spirit, it is hoped to rely on simple and practical as principles:

- Understandable by the ChemEngng formations involved in the iTeach project,
- Measurable, quantifiable in quality and quantity (according to the issues),
- Reasonable,
- Temporal (duration of a few years).

In the corresponding initial process, choices were made. They probably deserve to exist, but can / must be the subject of developments to adapt the reflection (for use). In any event, it should be remembered, an indicator of efficiency or of performance is only a contributing element of a broader package associated with the performance of a ChemEngng training center.

2.3. Definition of a set of indicators. Decision Matrix

The discussion between the French members led to the proposal of a number of parameters, with 6 main indicators. They must be integrated at various scales (weighting to define on an initial basis, within the iTeach project) into different parameters of influence, presented below. In a second report (D3.2.) proposals for ways of calculation of different indicators will be proposed.

Note: every information has a variable importance depending on the selected objectives : it appears thus, that it is not possible to estimate *a priori* the 'weight' of information that will be included in the indicators. Inside iTeach project, it should be possible to define an "averaged" ChemEngng Formation that society can expect in terms of innovation and engineering activity. This being so, it will be useful to use this base to examine how a formation can be distinguished from any others, defining the specific brand image of a ChemEngng training center and to initiate correlation studies between specificity, attractiveness, salary, etc.

However, if all cannot (yet) be weighted, a large number of elements that will be requested in the surveys can be the subject of a weighting. In this preliminary report, we first did not quantify any of the parameters, but only indicated in the following decision matrix if and for which global indicator it should be taken into account. It is indicated by "?" themes that seemed difficult to evaluate, and which should be subject to discussion. The scale of values and quantification of the weight to use in the calculation of an indicator will then be described in the second report D.3.2.

The six indicators we first defined are the following:

- Pedagogy,
- Revision process, quality
- Innovation - Relation with research,
- Relations with industry,
- Consistency with Learning Outcomes,
- Attractiveness.

Once these indicators developed, it will then be possible to propose a "mapping" of different existing ChemEngng training centers, allowing to identify their strengths and weaknesses

2.3.1. Pedagogy

It is clear that no pedagogical method should be compulsory regarding any other… The importance remains on the interactivity and the diversity of the teaching methods, on the reflections regarding their effectiveness, their relation with student culture, and their flexible adaptations in relation with the current evolutions of the learners, the industrial, social and scientific expectations.

The first draft version of the parameters that should be included in the definition of indicators is thus detailed. The decision concerning the way and where the parameter is taking into account is proposed.

2.3.1.1. Financial aspects / political or strategical management

Theme	Decision
Cost of education per student (5 years)	Has to be taken into account, in a same manner for every formation. It will be in the denominator of the global indicator
Report of the public-private financial contributions	No at present, difficult to assess ?
Average salary of graduate students	Employment
Adaptation of the project in line with the economic reality in the ChemEngng field; consistency with the "learning outcomes".	LO (Learning Outcomes)
Goal of the formation: General Engineering (1), specialized (2), technical (3)	LO
Operational presence of a Steering Committee	Quality
Foresight and anticipation of developments in terms of formation	Quality
"Disciplinary" educational framing	LO

2.3.1.2. Human qualities to promote/skills

Theme	Decision
Extensive formation or opening knowledge adapted to the management of projects	LO
Degree of autonomy of teachers	No, difficult to assess
Degree of autonomy of the students	No, difficult to assess
Capacity of abstraction and reasoning by analogy	LO
Creativity, innovation, divergent thinking	LO
Project management	LO
Management of compromise, interdisciplinarity	LO
Entrepreneurship training	LO
Teaching through research	Research
Associative involvement (students)	Attractiveness
Involvement of students in the following formations	
Development of culture	No
Humanities	No
Maintaining excellence in time	Quality

2.3.1.3. Achievements in terms of learning outcomes/methods of teaching

Axis	Decision
Number of hours of formation (over 5 years)	300 ECTS
Classical teaching	Pedagogy
Participatory/interactive teaching	Pedagogy
Teaching materials	Pedagogy
Work home-prepared.	Pedagogy
Self-training and e-learning	Pedagogy
Internships	
Number of weeks of internship/student	LO
Average duration (days)	LO
% internships to foreign/year (Eurydice, 2013)	LO
Interdisciplinarity	LO
Projects	Pedagogy
Number of projects	Pedagogy
Average duration (days)	Pedagogy
% projects related to industrial	Industry
Master-thesis; training through research	Research
Scientific and technological conferences: number/year	Research & Industry
Visits to companies, research laboratories and development industries: number	Research & Industry

2.3.1.4. Assessment/Quantification

Domain	Decision
Assessment of lessons	Pedagogy & Quality
By whom should teachers be evaluated (students (1), branch (2), University (3), (4) Department, Board of Directors (5), (6) educational Committee, several (7))	Quality
Course preparation time	Pedagogy ?
Existence of an office on site	Pedagogy
Existence of a working email address	Pedagogy
Availability	Pedagogy
Teacher training	Quality
Evolution of the formations in the duration (content, modes)	Quality
Humanities/human relations	Quality
Pedagogical competence	Quality
Periodicity of the evaluation	Quality
Return/impact of the evaluations on students	Quality
Return/impact of the evaluations on faculty	Quality
Control by the management of the number of teachers	Quality
Part of the teachers in permanent position	Pedagogy
Unemployment rate in 6 months after graduation	Employment

Existence of an external communication cell	Attractiveness
Number of persons	Attractiveness
Number of annual benefits	Attractiveness
Number of students / teachers	Pedagogy
Number of hours teached by industrials	Industry
Number of hours teached by researchers	Innovation
Number of students postponed	Pedagogy
Number of hours for an ECTS ?	Pedagogy
Educational advisors	Pedagogy
Industrial advisors	Industry

The use of instrument to increase teaching effectiveness and quality has also to be taken into account : Students need some time, interest, and motivation to understand how a particular course is involved in the whole formation ! The utilisation of some questionnaires, such as SEEQ could also be promoted ?

2.3.2. Revision process – Qualtity

Theme	Decision
Executive management leadership ability	How ?
Executive management financial ability	???
Existence of an operational Steering Committee	Yes
Distribution of members	
Industrial	Yes
Internal teachers	Yes
External teachers	Yes
Students	Yes
Number of sectors represented	Yes
Number of researchers	Yes
Frequency of meetings	Yes
Alumni position in the Council	Yes
Existence of a forward thinking	Yes
Estimation of the potential of mobilization of teachers in developments	Yes
Estimation of the potential of mobilization of industrial developments in	Yes
Estimation of the positive developments of image (and associated hiring) related to strategic changes in training	???

2.3.3. Innovation; links with proximity research

Theme	Decision
Influence of local research department on the anticipation	Quality
Influence of research units	Quality
Number of researchers publishing / number of persons in the department	Yes
Number of patents / year in the laboratories	Yes

Joint research with business units	Yes
Creations of startups	Industry
Volume of the research contracts with companies	Yes
Junior enterprise and innovation support	Industry

2.3.4. Relations with Industry

Theme	Decision
Graduates with stable employment after six months of graduation	Employment ?
Graduates with a steady job 10 years after graduation	Employment
Additional formation after graduation	Employment
Additional research formation after graduation	Employment
Influence of the Alumni on the placement association	Employment
Average starting salary	Employment
Average salary after 10 years	Employment
Level of responsibility	Employment
Job sectors	Employment

2.3.5. Consistency with Learning outcomes

Axis	Decision
Number of teaching hours (over 5 years) and consistency with the disciplinary fields (A/B/C/D/E/F)	Yes
Traditional teaching	Pedagogy
Participatory/interactive teaching	Pedagogy
Teaching materials	Pedagogy
Work home-prepared.	Pedagogy
Self-training and e-learning	Pedagogy
Internships	
Number of weeks of internship/student	Yes
Average duration (days)	Yes
% internships to foreign/year	Yes
Interdisciplinarity	
Projects	Pedagogy
Number of projects	Pedagogy
Average duration (days)	Pedagogy
% projects related to industrial	Industry
Master-thesis; formation through research	Innovation
Scientific and technological conferences: number/year	Industry & Innovation
Visits to companies, research laboratories and development industries: number	Industry & Innovation

Adding also some Skills and Competencies Student Outcomes, taken from the World Council of Chemical Engineering :

Ability to solve problems, Ability to analyse information, Ability to gather information, Self-learning ability, Ability to identify and formulate problems, Ability to work effectively as a member of a team, Ability to communicate effectively, Appreciation of an interdisciplinary approach.

Or such as :

(a) An ability to apply knowledge of mathematics, science, and engineering
(b) An ability to design and conduct experiments, as well as to analyse and interpret data
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) An ability to function on multidisciplinary teams
(e) An ability to identify, formulate, and solve engineering problems
(f) An understanding of professional and ethical responsibility
(g) An ability to communicate effectively
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) A recognition of the need for, and an ability to engage in life-long learning
(j) A knowledge of contemporary issues
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

REFERENCE : Engineering Accreditation Commission (EAC) Criterion 3. Student Outcomes: Criteria for Accrediting Engineering Programs.

These may also be taken from industrial target competencies, according to the feedback we may receive…

2.3.6. Attractiveness

Theme	Decision
Number of applicants / number of places	Yes
Understanding of relevance and attractiveness of the ChemEngng field	Yes
Legitimacy of the formation on a promising area of social utility	?
Influence (presence of scientists, laboratory quality, doctors honoris causa training, books, videos)	??
National ranking	Yes
International ranking	Yes
Comparison of salaries in the educational competition	Yes
Number of foreign students	Yes
Number of nationalities represented	Yes
Number of internationally available places	Yes
Management communication	Yes
Other forms of communication	Yes

Registration fee / cost of school/year	Yes
Quality of the buildings	Yes
Modernity of educational equipment	???
Housing facilities	Yes
Enhancement of community life	Yes
Influence of the alumni association	Yes
Influence of the location	Yes
Courses in english ?	Yes

2.3.7. Conclusion

Such an approach gives an overview of the aspects that could be taken into account for a robust proposal of indicators that could allow assessing the definition and estimation of teaching efficiency in Chemical Engineering. These reduced indicators and parameters have, of course, been discussed between the partners of the iTeach project, and will be clearly validated after the results of the WP4 "Pilot Implementation". Their quantification or weighting will also be subjected to discussions within the partners and will be detailed in the second report D.3.2.

2.4. The proposed parameters & indicators

The final proposed indicators follow almost the same frame as that initially defined in the former paragraph. The names of some of them have just been modified, in order to have more consistent and more robust indicators… At the same time, according to industrial feedback, a distinction between relation with industry and employment has been added, since most of the graduates are to be employed in industry.

Finally, the global indicators for assessing the effectiveness of a whole formation are seven in number, and listed below:

- Pedagogy,
- Learning outcomes (or LO)
- Attractiveness,
- Relation with research,
- Relation with industry
- Employment,
- Quality.

Those indicators include several parameters, which are to be defined in relation with the indicator they are supposed to reflect, and quantified.

2.4.1. Pedagogy

Teaching	
	Hours (or ECTS) of classical lectures
	Hours (or ECTS) of tutorials
	Hours (or ECTS) of labs
	Hours (or ECTS) of Problem & Project Based Learnings
	Hours (or ECTS) of NTICs
Use of feedback questionnaires, such as SEEQ ?	
	Learning
	Enthousiasm
	Organization (including course materials)
	Group interaction
	Individual rapport
	Breadth
	Examinations
	Assignments
	Overall
	Use of response to feedback questionnaires, such as SEEQ ?
Number of teaching hours for an ECTS	
Total hours of formation	
Percentage of students postponed	
Availability for teaching	
	Office on site
	Email adress
	Percentage of time for teaching
	Number of students/teachers
	Percentage of permanent academics
	Continuous professional development for academics
	Academic tutors

The SEEQ questionnaire is given in appendix 1.

2.4.2. Learning Outcomes

EFCE Learning outcomes	
Fundamentals of sciences and natural sciences	
	Mathematics
	Physics
	Chemistry
	Computer sciences
	Numerical methods
Chemical engineering fundamentals	
	Mass and energy balances
	Thermodynamics
	Fluid dynamics
	Heat & mass transfer
	Chemical reaction engineering
	Separations,
	Biomolecular and biological engineering
Chemical engineering applications	
	Basic process & product engineering
	Health, Safety & Environment
	Analytical techniques
Non-technical subjects / Skills	
	Social Sciences and management
	Languages
First cycle Internship	
Extension of scientific subjects	
Advanced cursus, chemical engineering deepening	
	Advanced Chemical engineering
	Product design
	Biotechnological processes
	Process management
Second cycle Internship	
Accreditation (CTI, IChemE…)	
ECTS of Active formations	
Learning outcomes of the formation clearly articulated	
ECTS of Foreign internships	
	or foreign formation
Skill & Competences	
	Ability to gather information
	Ability to analyse information
	Self-learning ability
	Ability to identify and formulate problems
	Ability to solve problems
	Ability to work effectively as a member of a team

	Ability to communicate effectively
	Appreciation of an interdisciplinary approach

2.4.3. Attractiveness

Number of applicants/place	
Registration fee/mean salary	
Housing facilities	
Size of the city	
Monthly housing budget/mean salary	
Existence of a marketing department	
Number of employees	
Implementations	
	Booklets
	Web
	Media
	Industrial or recruitment fairs
Participation of the students	
	In quality
	In attractivity
	In associations
	In communication
Percentage of foreign students	
International exchange agreements	
Courses in English	
National ranking	
International ranking	
Influence / existence of alumni association	
Average marks of incoming students	
Social mixity	
	Percentage of students that receive financial scholarships
Percentage of men/women	

2.4.4. Relation with research

ECTS of Research internship	
Advanced courses delivered by researchers conferences	
Visits to laboratories	
Number of hours (ECTS) by researchers	
ECTS of innovation project	
Percentage of research active staff/number of academics in the department	
Number of patents /year	
Joint research with business units	
Creation of start-ups	
Volume of research contracts/mean salary	
Number of dual diplomas/degrees agreements	
	National
	International
Percentage of students having a double master (with foreign universities)	
Percentage of Graduates making a PhD	

2.4.5. Relation with Industry

ECTS of Industrial internship	
Industrial advisors	
Number of visiting lectures delivered by Industrialists	
Visits to companies	
Number of hours (ECTS) by industrials	
ECTS of industrial project	
Apprenticeship Formations	
Percentage of students in apprenticeship formations	
Percentage of students that create their company	
Number of industrialists in the steering committee	
Number of industrial chairs	
Existence of industrials open days	
	Number of industrial sectors represented
Junior enterprise	
Hiring sectors	
	Basic Chemistry
	Specialty chemistry
	Energy
	Engineering
	Pharmaceuticals
	Agro & Bio industries
	Environment
Job position	

	Production
	Research
	Design engineer
	Technical assistant
	HSE & Quality

2.4.6. Employment

Average salary of graduates/mean salary	
Time to find a job (month)	
Unemployment rate after 6 month	
Influence of alumni association	
Percentage of additional formation after graduation	
Percentage of additional research formation after graduation	
Average salary 10 years after graduation/mean salary	
Percentage of steady job 10 years after graduation	
Level of responsibility after 10 years	
	Project manager
	Head of service
	Expert
	Sales manager
	Plant manager
	Executive officer
	Research director
	Director of company
	Director of Human resources
	Professor
Geographic hiring areas	
	Outside the country of formation
	in Europe
	in the rest of the world

2.4.7. Quality

Existence of a steering committee	
Distribution of members	
	Industrial
	Number of sectors represented
	External teachers
	Internal teachers
	Students
	Researchers
	Alumni
Frequency of meetings	
Existence of a forward thinking	
Frequency of formations evolution/year	
Control of the number of teachers	
Evaluation of teaching	
	Frequency of evaluations/year
	Evaluation of pedagogical competences
	Evaluation of teaching materials
	Evaluation of scientific & technical contents
	Evaluation of skills & competences contents
	Return of evaluation to the students
Academic staff development regularly monitored	
Existence of an educational committee	
Existence of a direction board	
	Industrials
	Teachers
	Students
	Politics

2.4.8. Conclusion

This first part of the report details thus the development process of the framework for the assessment of effectiveness of a whole formation. The indicators and parameters have been validated by the consortium, and their quantification will be detailed in the second report D.3.2.

3. Evaluation of a single teaching unit

After having developed a range of indicators to assess some whole formations in chemical and/or processes engineering, the discussions with the consortium partners led the authors of the previous part of the report to also propose ways to assess specific formations, or teaching units, knowing that there are interdependencies between cultures, pedagogies, thematics, etc. These elements are discussed in this second part, to attempt to respond the request.

The classic and most widespread evaluation bears mostly on disciplinary knowledge and know-how (Olds, Moskal and Miller (2005)). The "real skills" or transversal skills (as they are sometimes called), that is to say, the methodological or relational skills, those related to the development of the project or problem solving are often assumed to be purchased through of a device of the active method. They "sweat" of the device, but they are rarely evaluated. Should we conclude that the famous skills acquired by students result of "accidental education" both in terms of acquisition and validation (Bachy, Lebrun and Smidts (2010))? That is the challenge of this reflection, presented below.

3.1. What are we talking about?

Usually, teachers evaluate their students at the end of the course, and this evaluation helps to control what the students have learned. Photography more than videography, the assessor's interest is focused on the content of learning, rather than on the process. For AERES (2014), some major criteria form the basis of the external evaluation of a used multi-criteria rating system (Phillips, 1997) : the quality of the educational project, the results concerning to professional integration or further education and the quality of the steering of the education. Moreover, the involvement of professional workers is especially important for the professional formations and the formation of the engineers.

With the purpose of understanding the elements of the formation context, Warr, Bird and Rackham (1970) proposed a model based on the evaluation of the context, the evaluation of the resources or input, the evaluation of the reactions, and the evaluation of the results or output. The originality of this model lies in the addition of two steps : on one hand, the evaluation of the available resources (in terms of time, means and knowledge) and on the other hand, the evaluation of context that allows the identification of the formation needs (Gilbert and Gillet, 2010).

But in the context of iTeach, several other forms of evaluation can be proposed and carried out on the subject:

- The evaluation of the students' skills;
- Evaluation of the achievements during or in the end of the teaching unit (classical situation: with an exam);
- The evaluation of teaching effectiveness (for example, by a survey carried out by the direction or the pedagogical team of the university among the students);
- The ability to transfer skills in application terms (for example with practical work or industrial internships). Then it is not the same people (teachers or industrial) who analyze this ability;
- The impact on the field that allows to estimate the potential of the formation in terms of innovation, transformation of organizations, etc.

If the second and third items fall certainly within the formation objectives, it is finally the ability to occupy a position in society that should be the subject of attention of the evaluators (Brinkerhoff (2004); Sandana and Arya (2003)). But, there can be an impact, without exception, only if students were able to implement what they have learned (Unifat, 2015).

3.2. Evaluation of the impacts

At the end, it is possible to estimate in the short term whether a student integrated in the socio-economic world is capable to achieve specific objectives (for example during an industrial internship). However, even if formations with no direct or indirect links with the target application are not taken into account, there are a number of difficulties, which are detailed below in this evaluation of the impact:

- How can we be sure that the target is well defined? How can we be sure that the "path" to achieve this goal is unimodal ? How to estimate the ability of the formation to be able to answer "tomorrow" to questions that we are not asking today (creativity and innovation, for example) ? How to define specific and robust indicators for this analysis ?
- How do we manage the evaluation in the case, partially discussed above, of a multifactorial impact with not entirely clear effects, but which will result in the development of confidence in the ability of the graduated students to respond satisfactorily to the expectations (often multiple and evolving/changing) of the company ?
- A third difficulty is the possibility to isolate the impact that is actually due to the formation. Are we actually capable of, on the same subject, with "identical" students, in the same company (by overcoming relational human factors) making a comparison between a student formed in a given subject, while the other, other things being equal, would not have been ? How would these evaluations resist a change in the internship subject or in the company's technical activity ?

Therefore, it is very difficult to demonstrate the ineffectiveness (or the opposite) of a formation. However, we can question if it is possible to integrate all of the questions mentioned above in a systemic perspective, such as that shown in Figure 1 (Gérard (2003)). In this figure, the management has identified, according to its goals, objectives of development, for example the global effect expected in the industry (production, R & D, technical sales, research, management ?).

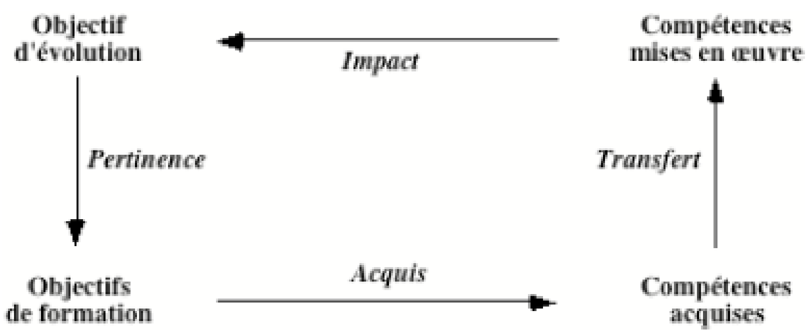


Figure 1: Goals of the evolution of a formation

How to define the most appropriate formation objectives? The skills that we will try to make students develop or acquire. The relevance of formation objectives is, obviously, a very important step. So it is possible, as a first approximation, to assume that the impact of a formation is defined as a kind of product of the following elements : quality objectives; educational effectiveness; quality of the transfer of the acquired skills.

3.2.1. The relevance

The relevance of the formation, evaluated a priori, is directly related to the analysis of the estimated needs (relationship of the teachers with the profession, prospective approaches, etc.) in :

- Defining the expected impact on the field when finishing the studies in the future;
- Defining the most appropriate types of action to achieve the educational goals (flexibility of the teachers, hiring staff, new technologies (for example MOOC's (Blass and Hayward (2014); and Djebara Dubrac (2015), Lawton (2014), Sorensen (2013)), organizational changes, changes in the timetables, etc.);
- Optimizing the students' profiles, both individually and collectively to achieve the objectives (rather than the opposite).

Such an approach, as shown in Figure 2, may be adequate at the time of its design, but may suffer a form of obsolescence for different reasons (market developments, technology, forms of receiving messages from students, etc.), which leads to periodically reassess the adequacy of formation, sometimes a delicate process when teachers hold their position ...

Figure 2 : Achieving the relevance

Apart from this aspect, some indicators are contextualized and specific for one formation: the European framework imposes rules of duration and methods of evaluation of the students, etc. Others may be proposed; these are, in an unlimited way, the following elements :

- Analysis of the needs by the profession (in a large way : management, hierarchical responsible, beneficiaries, etc. and shared by several of these categories);
- Comparison with other competing units of formation;
- Analysis of the supposed evolutions in the economic environment;
- Etc.

In addition, for graduated students, it will be possible to use questionnaires (anonymous?) of "satisfaction" to evaluate the adequacy of the formation (with the risk of emotional factors relative of a teacher and his teaching methods) and identify some indicators such as:

- The satisfaction of the formation objectives;
- The appropriate achievement of objectives;
- The educational performance;
- The assessment by the students of a good use of the knowledge taught;
- The satisfaction on the part of the teacher, of the training objectives;
- His ability to, if necessary, make it change.

3.2.2. Evaluation of the transfer

The complexity of the industrial implications makes this way of evaluation difficult and a little robust. It could be considered, at the end of the studies, and after some time (one year? three?) to ask the students and former students to answer a questionnaire answering questions like the following in relation to their skill level (for example, with a score from 1 to 4, by positioning themselves on three registers : before their studies, after; by estimating the importance of it, if the student had studied all subjects except this particular one):

- To plan and manage the projects of the discipline;
- To control the processes;
- To develop activity programs and work plans for employees;
- To evaluate the projects;
- To manage the teams;
- To control the R & D of the field;
- To be able to do research, innovation;
- Etc.

It is only a semi-quantitative approach, but it allows to associate alumni to the young students. Therefore, it is essentially a process to help the decision for a specific formation (which is also realized according to the intellectual, cultural and social qualities of students that integrate general education).

3.2.3. Evaluation of the acquisitions

With methods of the type 'problem solving', case of study or development of a project, students become more involved. They set up learning strategies that will also involve organizational skills, project management, critical thinking. If a part of this activity can be done during guided exercise sessions and practical work, the performance of an industrial internship is a good opportunity to test in full scale the capacity of a student, at the end of its specific studies, to transfer knowledge. So the student can present evidence of learning. He shares personal productions (report, self-assessment grid, layout, ...) with this partners and with the teacher, who can, along with an industrial partner, make a better evaluation of the transfer capacities. However, among the complexity and the number of internship subjects, it is possible to find situations where:

- The acquisitions of the specialized formation have little connection with the reality of the field; it's the whole formation that comes to be assessed*;*

- The company does not have a clear idea of the educational framework used in the formation of the trainee;
- Etc.

The use of questionnaires can be a way to overcome these challenges by answering questions as:

- Which parts of your formation has been useful during this internship?
- Which ones do you consider will be useful in the future ?
- Which ones do you consider unnecessary ?
- Etc.

The association with the internship assessments (with the advice of industry leader's internships) is a means to estimate the quality of the transfers.

All these operations allow, provided it falls within the concerns of a teaching team, to develop the formation given to the students.

3.2.4. Evaluation of the competencies:

It is necessary to identify and to measure a progression in the formation, and to measure a result of learning (Tardif (2006)). Few teachers are used to evaluate a progression in learning, because the specificity resides on the fact that it is necessary to determine some criteria and target levels. This suggests, therefore, the development of devices to reach the acquisition of competencies. Indeed, we know that the pedagogical objectives are defined as the abilities to use the content (Anderson and Krathwohl (2001)), and the skills (according Jonnaert (2002)), are generally referred to a set of elements that the subject can mobilize and coordinate to deal with a situation successfully.

The notion of competence can be defined as an implementation of the knowledge, skills and competencies, know-how or know how to manage in a given situation; a competency is always contextualized in a specific situation. This implementation assumes that the student mobilizes effectively a series of resources (social and cognitive skills) relevant for the situation. Beyond this mobilization of resources, he must also select those that allowed him to be, in his opinion, the most effective as possible in the situation. He will also have to coordinate the acquired knowledge even if, initially, a person mobilizes a lot of resources, he will only have to use those that are relevant to the situation and not redundant. Thus, in addition to mobilizing, the activities of selection and coordination of resources are equally important. Using these resources, this person should treat successfully the tasks required by the considered problematic.

We understand the double aspect of the evaluation in the context of active methods, that is, on one hand, to verify whether, during formation, the student selects and uses its resources properly and on the other hand, if he can solve a task successfully. The teacher should be able to collect evidence of learning and progress of the student thanks to the indicators, comparing them to some criteria, to measure skills and competencies. For indicators, we expect all evidence demonstrating learning and growth, and criteria, which allows the teacher to decide whether a student has reached an expected level and if the result is satisfactory. The teacher can set the criteria by reference to the steps it deems necessary for learning (Bachy, Lebrun and Smidts (2010)).

Questions remain on the degree of confidence according to the results observed (notion of validity) and on the choice of the tool and measurement that allows to make it (concept of reliability). The choice of measuring instruments is important to point and collect data and collect indicators. Tardif (2006) offers nine basic principles to develop an evaluation system of the acquisitions of students through an active learning:

- To report a progression;
- Think competencies;
- To determine the mobilized resources;
- To determine the available resources;
- To identify situations;
- To document the trajectory;
- To report the autonomy;
- To employ multiple criteria;
- To integrate individual differences.

3.3. Evaluation of a teaching unit by the students

According to Malassigne (2007), there are four types of knowledge in interaction in a formation (see Figure 3):

- Distributed (acquired during the formation);
- Applied (practiced);
- Acquired (implemented and validated in real situations);
- Used (knowledge requiring no more support).

These different forms can be evaluated (see also Nicol (2009)) and serve in the decision to continue or modify a subject, based at least in part on a self-evaluation made by the students. This but is, to Garavan and O'Cinneide (1994), to find the right balance among these interrelated elements.

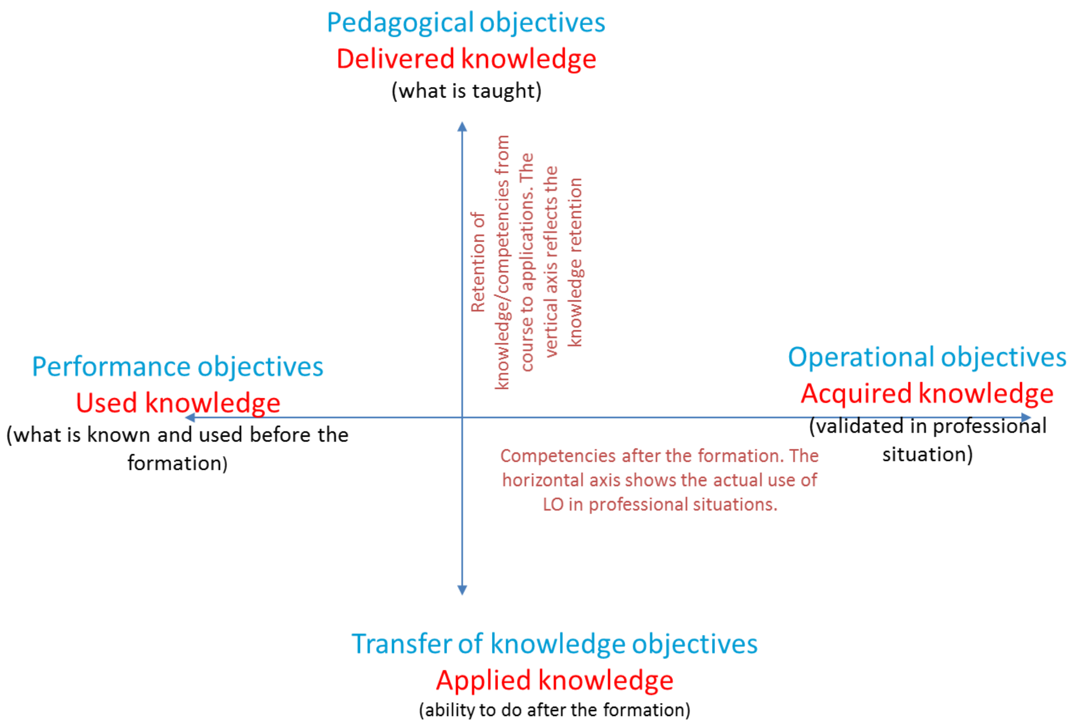


Figure 3: Types of knowledge involved in formation.

Traditional guidelines can be offered to have student's assessment of a course (FAO (2015)). They are presented below:

How have the students enjoyed (the) session (s)?

- One or more parts or the entire course;
- Positioning in the whole formation.

Which are the principles, facts and techniques that were assimilated?

- Written evaluation questions, oral questions, competency tests;
- General of the formation.

What changes in the future professional behavior will be allowed by the formation?

- Attractiveness for a specific job in the industries (of processes) taking account the formation;
- General attractiveness of the global given formation;

Which were the results of the formation that allowed improvement of the performance of your work?

- Some types of the formation's results are easy to measure;
- Those who are not will be considered as positive.

General opinion about:

- Interest of the subject for my future profession;

- Clarity of teaching unit objectives;
- Education level required;
- Coverage of the subject;
- Assigned time;
- Teaching methods;
- Links with other taught subjects.

All the elements presented form Figure 4, taken from "International organization of the Francophonie" (2015).

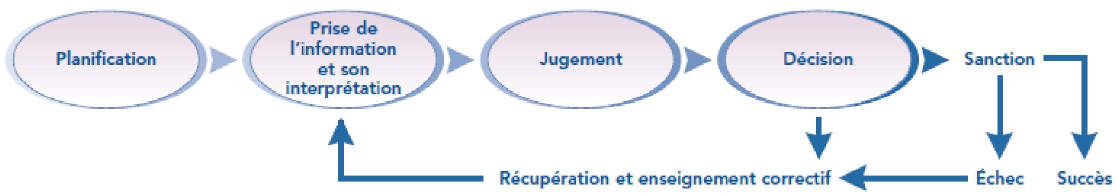


Figure 4: Elements to consider to evaluate a specific formation

The evaluation depends, in fact, as indicated by the same reference and in Figures 5, 6 and 7, of the interlocutors : the student, the teacher, the management (which should involve the companies that will hire the graduated students).

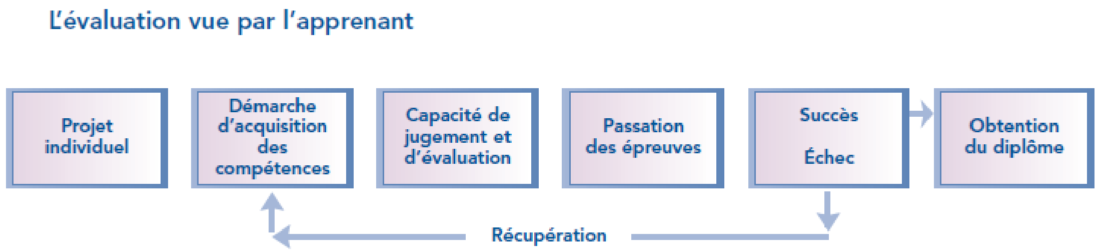


Figure 5: Evaluation seen by the student.

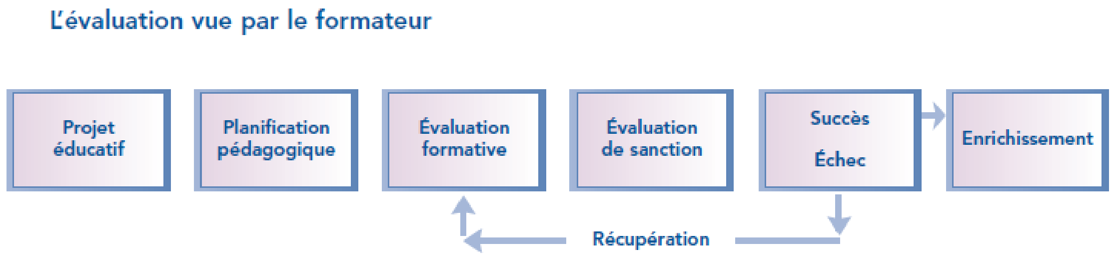


Figure 6: Evaluation seen by the teacher.

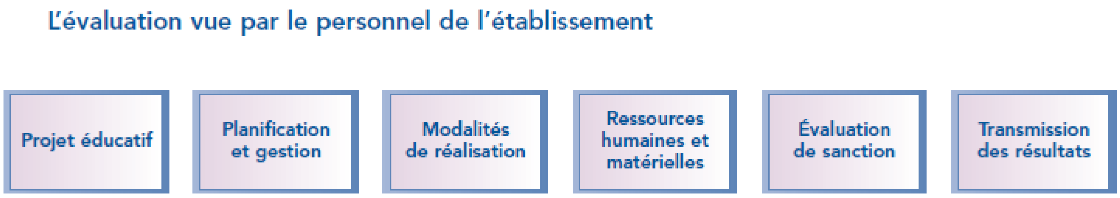


Figure 7: Evaluation seen by the management.

3.4. Interdependences among teaching units

The situation of the interdependences is crucial to evaluate the importance and effectiveness of a specific teaching unit. To illustrate this, we have selected some examples.

3.4.1. Example of a foreign language

We can consider that during the learning phases, usually given in the language of the country, the importance of mastering a foreign language is not especially useful to achieve the scientific and technological objectives *(*excepted the knowledge and understanding of international literature). Therefore, there is only a modest dependence among of this type of learning and the rest of the educational units. However, for the *industrials* who *are likely* to hire young students graduated in chemical engineering (which mainly evolve in international companies), a good knowledge of certain languages is essential for a career. The knowledge of this impact is therefore an important element in this example.

3.4.2. Example of the chemical reaction engineering

This teaching unit needs a set of knowledge about chemical kinetics, "classic" chemical engineering, mathematics, etc. There are obviously interdependent, since the achievement of the objectives can only be meaningful if the students have learnt and understood the basics of the aforementioned disciplines. However, the truly interesting question regarding this example is : is one student of a good level, able to learn by himself by means of documents (books, *polycopiés*, etc.), education via internet (MOOCs), etc. This reveals an important part of definition of the formations, necessary for a given student. Again, for a unit of formation, the knowledge of this cohort (and its abilities to deal with theoretical knowledge) is another parameter to consider.

3.4.3. The cost estimation

In the study of the definition of the costs of an industrial plant, from the business plan to the application on the field, some knowledge is required : forecast of the supplies and its costs, maintenance, salaries, organization, processes to implement, cost of the materials and the systems, security, operating in degraded mode, etc. The debate about the interdependencies between knowledge becomes wider. But then another question arises : should we introduce teaching units in this kind of subject, whose industrial and economic importance in chemical engineering is essential for a good decision support in basic training? Could we not rather consider this type of formation as lifelong learning, and taught as continuing education ?

Therefore, we made appear in these remarks several new elements far from how teaching should be conducted, but about its subsidiarity, its added value with respect to a given objective in the general formation in chemical engineering. The analysis of interest (its attractiveness) of a specific formation is thus of different interdependent partners : the future student (with the French example of a lack of interest in the scientific disciplines), the teaching staff and its management, and the future employer.

Based on all these remarks we have tried to propose a framework of indicators, to try to evaluate a relevant formation for the "production" of those specialists in chemical engineering that the industry is looking for, by responding the industry's current and future needs.

3.5. Towards the effectiveness metrics of a single teaching unit

After reflections and decisions, several classes of indicators, or Metrics, can then be released from comments made from the literature bibliographic analysis for a specialized formation, or a teaching unit.

All the metrics will be assessed through surveys, or questionnaires, to different populations concerned by the teaching unit : students; graduate chemical engineering students; teachers (including the one giving the course) and pedagogical team; hiring sectors of graduate students or employers.

The questionnaires might be rated using Likert scales (5 : very important ; 4: important; 3 : average; 2 : modestly helpful; 1: accessory; 0 : useless) according to weights that should be discussed within the consortium, and that will be detailed in the second report D.3.2.

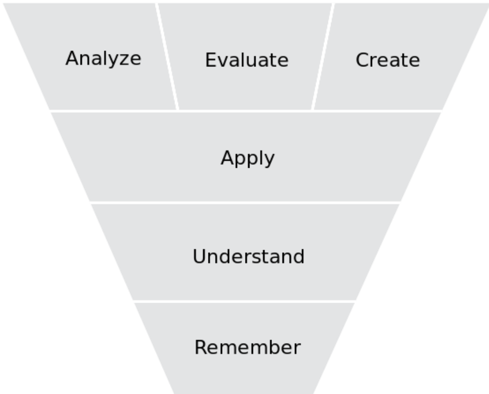
3.5.1. Strategic nature of the formation

- Analysis of the needs made by pedagogical team or steering committee (what are the needs that this course should cover, does-it cover them ?),
- Prospective approach (evolution of the needs, what are the future needs that this course will have to cover, national and international labor markets, evolution of the students' culture, etc.),
- Comparison with other competing formation units; Benchmarking (what is the study program of this specific subject in a competing university, which needs do they cover that our university does not and why),
- Strategic Thinking,
- Capacity of adaptation of the specialized formation (flexibility of the teachers, for example, would it be possible to change the way of teaching the subject, which advantages should it have ?),
- Reflecting about how this teaching unit fits into the attractiveness of the formation towards future students,
- Estimation of the importance of the teaching unit if the student had followed all the other teaching units, except this one in particular,
- Links of the formation with the reality of the field (if this is possible).

3.5.2. Overall relevance of the proposed formation

The relevance of a formation, evaluated a priori (previous metric), is directly related to the analysis of the estimated needs (relationship of teachers with the profession, prospective approaches, etc.) in:

- Expected impact in the field of departure of the formation in the future,
- Relations with other formation's teaching units (interdependencies),
- Reflections on the most appropriate action types to achieve the educational goals and Learning Outcomes, in relation with the Bloom's Taxonomy (Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation) for example,



- Optimization of the students' profiles, both individually and collectively, to achieve the stated objectives, in relation with the Felder's Learning Styles (Active and Reflective learners, Sensing and Intuitive learners, Visual and Verbal learners, Sequential and Global learners),
- Selection to enter, prerequisite (the current prerequisites are Essential (5), Necesary (4), Recommended (3), Helpful (2) or Not Really Necessary (1), to understand and pass the subject,
- Duration, level,
- Position in the program.

3.5.3. Pedagogical relevance of the proposed formation

Several basic principles can be used to elaborate an educational device for a teaching unit of formation:

- Definition in terms of Learning Outcomes,
- To report a progression; Evaluation of the acquisitions
- The document and the progression, How the progression is done according to the required Learning Outcomes ? Depending on the different learning style, and the required level... This might be referred to the Bloom Taxonomy:

	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Course						

Classroom sessions						
Labs						
Self-learning						
Projects						
Others ?						

- The mobilized and available resources
- The level of autonomy of the students
- The integration of individual differences, or Learning Styles

3.5.4. Perception of educational relevance of the formation proposed by the students

- Assessment of the quality of the teaching unit of formation: of some parts or of the entire course;
- Understanding the relevance of the topic for my future profession
- Clarity of teaching unit objectives
- Education level required
- Broadness
- Time allowed
- Teaching methods implemented
- Relevance of the links with other taught subjects

3.5.5. Evaluation of acquisitions

- Faculty of transfer during courses, classroom sessions, projects (if applicable), self-learning and practical work;
- Reached cognitive domains :
    - Knowledge (Exhibit memory of previously-learned materials by recalling facts, terms, basic concepts and answers)
    - Comprehension (Demonstrative understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas)
    - Application (Using new knowledge. Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way)
    - Analysis (Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations)
    - Synthesis (Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions)
    - Evaluation (Present and defend opinions by making judgments about information, validity of ideas or quality of work based on a set of criteria)
- During industrial internships (including expected feedback from the students):

- How much of your formation has been useful during this internship?
- Which parts do you consider useful for the future?
- Which parts do you consider unnecessary?

3.5.6. Evaluation of the transfer

For the person that hires a student after his studies in chemical engineering, it is important to be able to estimate, after hiring, the following elements. In fact, it is based on the general knowledge of the quality of the education, that the *industrials* choose a specific engineering school or university (branding);

- Control of concepts,
- Ability to extend the concepts to new problems,
- Knowledge and understanding,
- Engineering analysis and design,
- Investigations and practice,
- Ability to do research, to participate in innovation
- Transferable skills

During industrial internships (including expected feedback from the students):

- How much of your formation has been useful during this internship?
- Which parts do you consider useful for the future?
- Which parts do you consider unnecessary?

3.5.7. Conclusion

This first classification of metrics for the assessment of effectiveness of a teaching unit has been the object of multiple discussions within the consortium. A second version was developed, and used for a first evaluation of teaching effectiveness of a common course of Chemical Reaction Engineering according to different pedagogical approaches. This will be detailed in the second report D.3.2.

4. Conclusion

This first report aims at detailing the development processes of the two frameworks for the evaluation of effectiveness for a whole formation, and for a single teaching unit. All the presented subjects made the objects of internal discussions, intermediate reports, decisions… within the consortium, that are difficult to reproduce here in details.

The final versions of the two frameworks, and the quantifications of each parameters, will be detailed in the following report D.3.2.

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6. Appendix

What is SEEQ?

SEEQ is an instrument used to obtain student feedback on teaching quality and effectiveness.

SEEQ comprises items grouped into nine dimensions of teaching (learning, enthusiasm, organization, group interaction, individual rapport, breadth, examinations, assignments, and overall) allowing faculty to pin-point specific areas of teaching quality.

SEEQ is an easy way to obtain feedback on teaching with demonstrated effectiveness in improving teaching quality and students' learning experience. It also increases student involvement in the education process.

It is a professional evaluation summary that will facilitate recognition of outstanding teaching and can be included in a Teaching Portfolio for those applying for promotion, tenure or accelerated incremental progression.

Reliability/Validity of SEEQ

The SEEQ instrument has been exhaustively researched. Statistical tests repeated over 13 years (with responses from approximately 50,000 courses and almost 1 million students in a wide range of disciplines at both the undergraduate and graduate levels) have shown that SEEQ is both valid and reliable[1, 2].

[1] Marsh, H., & Hocevar, D. (1991). Students' evaluations of teaching effectiveness: The stability of mean ratings of the same teachers over a 13-year period. Teaching & Teacher Education, 7, 303-314.

[2] Marsh, H., & Roche, L. (1997). Making students' evaluations of teaching effectiveness effective: The critical issues of validity, bias, and utility. American Psychologist, 52 (11), 1187-1197.

SEEQ Questions

SEEQ consists of 32 standardized questions (#1-32), 10 student/course characteristic questions (#33-42), and 1 open-ended question for general comments/feedback (#43).

The SEEQ questions are available in the Questions section of this website.

Who developed SEEQ?

SEEQ was developed by Herbert W. Marsh of the University of Western Sydney in the late 1970's and initially published in the British Journal of Educational Psychology in 1982.

The SEEQ instrument is a public instrument which is free of charge. Permission to use the SEEQ instrument at the U of S was granted by the developer.

What can SEEQ be used for?

SEEQ can be used for:

· Formative evaluation: questions #1-29 provide diagnostic feedback for faculty about the effectiveness of their teaching that will be useful in improvement of teaching.

· Summative evaluation: questions #30-32 provide a measure of overall teaching effectiveness that can be used in personnel decisions because they are the most reliable indicators.

· An outcome or a process description for research on teaching

Questions

The following questions are available for the 200801 pilot:

the standard SEEQ questions (#1-32)
additional questions on student and course characteristics (#33-42)
an open-ended feedback/comments question (#43)

The issue of using additional questions will be reviewed by the SEEQ Implementation Advisory Committee along with other decisions that will impact the delivery of SEEQ in fall 2008.

Student Evaluation of Educational Quality Instrument

Use the following to evaluate the first 29 statements: (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree)

Learning:

1. I have found the course intellectually challenging and stimulating.
2. I have learned something which I consider valuable.
3. My interest in the subject has increased as a consequence of this course.
4. I have learned and understood the subject materials of this course.

Enthusiasm:

5. Instructor was enthusiastic about teaching the course.
6. Instructor was dynamic and energetic in conducting the course.
7. Instructor enhanced presentations with the use of humour.
8. Instructor's style of presentation held my interest during class.

Organization:

9. Instructor's explanations were clear.
10. Course materials were well prepared and carefully explained.
11. Proposed objectives agreed with those actually taught so I knew where course was going.
12. Instructor gave lectures that facilitated taking notes.

Group Interaction:

13. Students were encouraged to participate in class discussions.
14. Students were invited to share their ideas and knowledge.
15. Students were encouraged to ask questions and were given meaningful answers.
16. Students were encouraged to express their own ideas and/or question the instructor.

Individual Rapport:

17. Instructor was friendly towards individual students.

18. Instructor made students feel welcome in seeking help/advice in or outside of class.
19. Instructor had a genuine interest in individual students.
20. Instructor was adequately accessible to students during office hours or after class.

Breadth:

21. Instructor contrasted the implications of various theories.
22. Instructor presented the background or origin of ideas/concepts developed in class.
23. Instructor presented points of view other than his/her own when appropriate.
24. Instructor adequately discussed current developments in the field.

Examinations:

25. Feedback on examinations/graded materials was valuable.
26. Methods of evaluating student work were fair and appropriate.
27. Examinations/graded materials tested course content as emphasized by the instructor.

Assignments:

28. Required readings/texts were valuable.
29. Readings, homework, laboratories contributed to appreciation and understanding of subject.

Overall: (N/A, Very Poor, Poor, Average, Good, Very Good)

30. Compared with other courses I have had at the U of S, I would say this course is:
31. Compared with other instructors I have had at the U of S, I would say this instructor is:
32. As an overall rating, I would say this instructor is:

Student and Course Characteristics:

33. Course difficulty, relative to other courses, was: (Very easy, Easy, Average, Difficult, Very Difficult, N/A)
34. Course workload, relative to other courses was: (Very light, Light, Average, Heavy, Very heavy, N/A)
35. Course pace was: (Too slow, Slow, About right, Fast, Too fast, N/A)
36. Hours/week required outside of class: (0, 1 to 5, 6 to 10, 11 to 15, 16 to 20, More than 20)

37. Level of interest in the subject prior to this course was: (Very low, Low, Medium, High, Very high, N/A)
38. Overall average at U of S. Leave blank if not yet established: (Less than 50%, 50 to 59%, 60 to 69%, 70 to 79%, 80 to 89%, 90 to 100%)
39. Expected grade in the course: (Less than 50%, 50 to 59%, 60 to 69%, 70 to 79%, 80 to 89%, 90 to 100%)
40. Reason for taking the course. Select the one which is best: (Required for Major, Elective for Major, Degree Requirement, Minor or Related Field, General Interest Only, Other)
41. Year in program: (First, Second, Third, Fourth, Fifth, Sixth or more)
42. Year in University: (First, Second, Third, Fourth, Fifth, Sixth or more)

Comments/Feedback:

43. Please provide any additional comments or feedback: