Lifelong Learning Programme

iTeach

IMPROVING TEACHING EFFECTIVENESS IN CHEMICAL ENGINEERING EDUCATION

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Newcastle University

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PROJECT OBJECTIVES

- Develop a framework which will support the assessment of teaching effectiveness in delivering not only core chemical engineering knowledge, but also core employability competencies in a range of geographical and educational context.

- More details on www.iteach-chemeng.eu

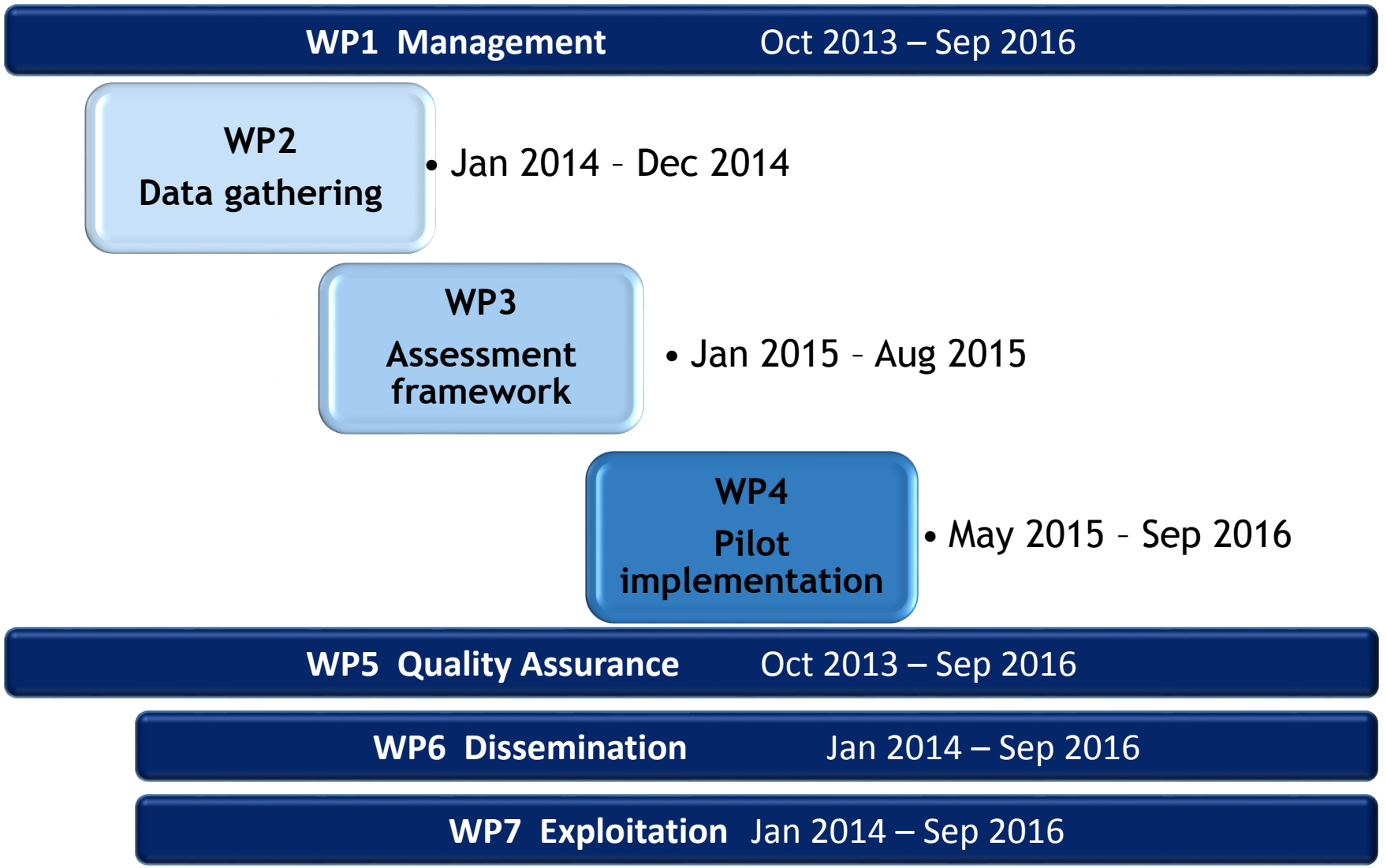
CONSORTIUM PARTNERS

16 associate partners formally signed up, representing professional institutions, employers, HEIs

PROJECT OUTLINES

1. Review the learning outcomes of a chemical engineering training,
2. Promote closer involvement of employer organisations in chemical engineering curriculum by carrying out focus groups,
3. Establish state-of-the art in assessing the effectiveness of teaching of chemical engineering skills and knowledge,
4. Define various indicators of the effectiveness of teaching in chemical engineering higher education,
5. Investigate in more depth methods of effectively acquiring employability competencies,
6. Use decision making technology and multi-objective optimization to identify the most appropriate evaluation methods,
7. Test the framework at partner institutions focusing on various pedagogic methodologies.

PROJECT OVERVIEW

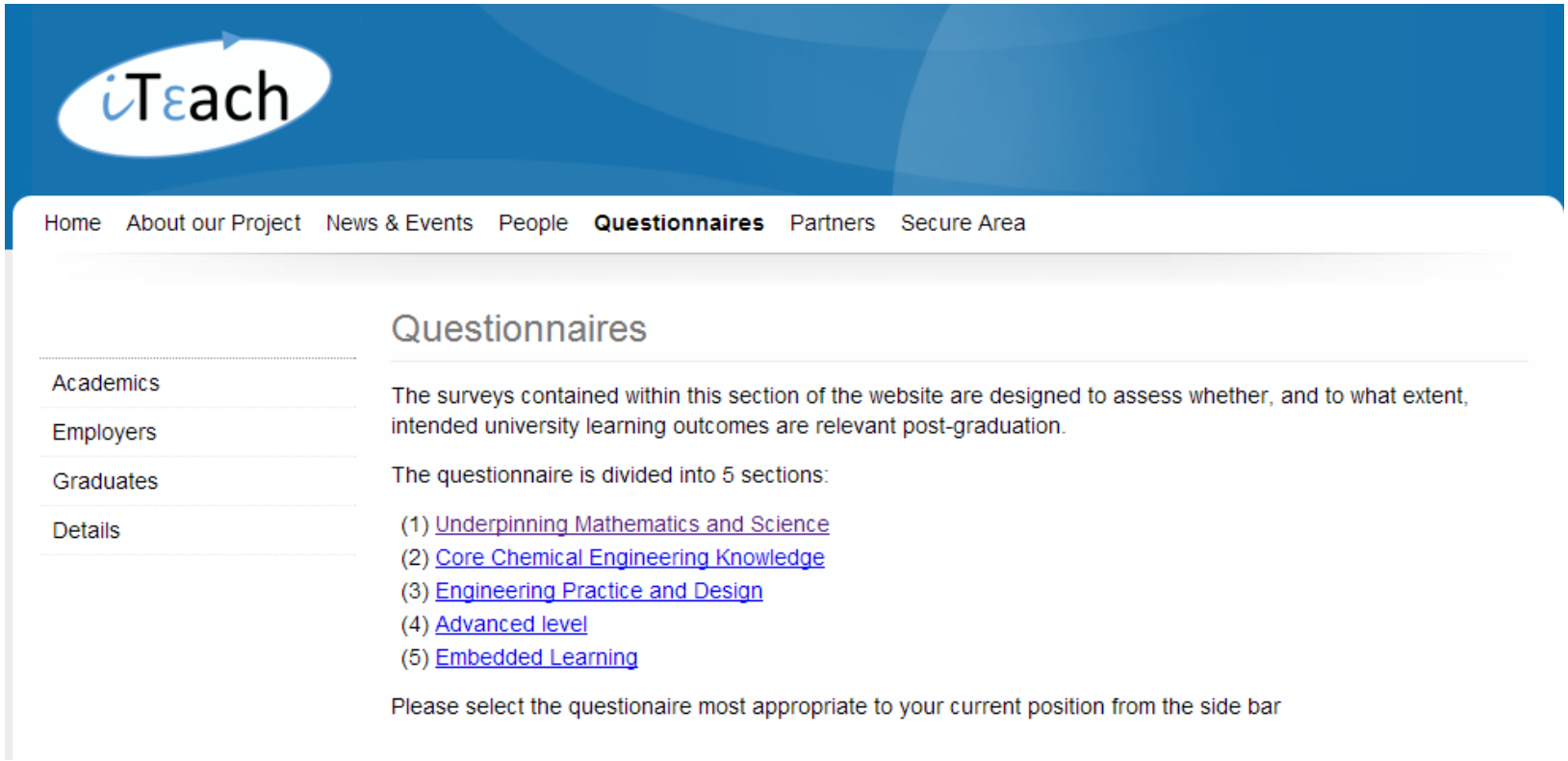


WP 2 : DATA GATHERING

1. Review the learning outcomes of a chemical engineering training,
2. Promote closer involvement of employer organisations in chemical engineering curriculum by carrying out focus groups,
3. Establish state-of-the art in assessing the effectiveness of teaching of chemical engineering skills and knowledge,

WP2 : DATA COLLECTION

- Gathering information on the current state-of-the-art in measuring effectiveness of teaching and perceptions from academics, employers and recent graduates



WP2 : DATA COLLECTION

IChemE

Accredit
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and assess

ENGINEERS

ENGINEERS
AUSTRALIA

STAGE 1 COMPETENCY STANDARD FOR PROFESSIONAL ENGINEER

ROLE DESCRIPTION - THE MATURE, PROFESSIONAL ENGINEER

The following characterises the senior practice role that the mature Professional Engineer may be expected to fulfil and has been extracted from the role portrayed in the *Engineers Australia - Chartered Status Handbook*. This is the expectation of the development of the engineer who on graduation satisfied the Stage 1 Competency Standard for Professional Engineer.

Professional Engineers are required to take responsibility for engineering projects and programs in the most far-reaching sense. This includes the reliable functioning of all materials, components, sub-systems and technologies used; their integration to form a complete, sustainable and self-consistent system; and all interactions between the technical system and the context within which it functions. The latter includes understanding the requirements of clients, wide ranging stakeholders and of society as a whole; working to optimise social, environmental and economic outcomes over the full lifetime of the engineering product or program; interacting effectively with other disciplines, professions and people; and ensuring that the engineering contribution is properly integrated into the totality of the undertaking. Professional Engineers are responsible for interpreting technological possibilities to society, business and government; and for ensuring as far as possible that policy decisions are properly informed by such possibilities and consequences, and that costs, risks and limitations are properly understood as the desirable outcomes.

Professional Engineers are responsible for bringing knowledge to bear from multiple sources to develop solutions to complex problems and issues, for ensuring that technical and non-technical considerations are properly integrated, and for managing risk as well as sustainability issues. While the outcomes of engineering have physical forms, the work of Professional Engineers is predominantly intellectual in nature. In a technical sense, Professional Engineers are primarily concerned with the advancement of technologies and with the development of new technologies and their applications through innovation, creativity and change. Professional Engineers may conduct research concerned with advancing the science of engineering and with developing new principles and technologies within a broad engineering discipline. Alternatively, they may contribute to continual improvement in the practice of engineering, and in devising and updating the codes and standards that govern it.

Professional Engineers have a particular responsibility for ensuring that all aspects of a project are soundly based in theory and fundamental principle, and for understanding clearly how new developments relate to established practice and experience and to other disciplines with which they may interact. One hallmark of a professional is the capacity to break new ground in an informed, responsible and sustainable fashion.

Professional Engineers may lead or manage teams appropriate to these activities, and may establish their own companies or move into senior management roles in engineering and related enterprises.

WP2 : DATA ANALYSIS

Univariate statistical analysis

- a high degree of consistency (geographically) in terms of the significance of learning outcomes and employment competencies.

Predominant method of delivering

- traditional lectures
- alternative project/case based and practical approaches - the delivery of employability competencies.

WP2 : DATA ANALYSIS

Multivariate data analysis - slight difference in the responses of the employers vs academics and graduates.

- The different perceptions of the importance of the engineering practice and design knowledge,
- the differences in the underpinning and core CE knowledge and advanced CE knowledge at masters level,
- some differences in the employability competencies.

WP2 : DATA ANALYSIS

Current effectiveness measures:

- Academics

- Industry

WP2 : DATA ANALYSIS

The initial results used for focus group discussions

- The analysis of transcripts from focus groups re-enforced the initial findings of the questionnaires.
- Concerns regarding the validity and the robustness of the current methods of assessing the effectiveness of delivery highlighted
- No specific suggestions for better means were stated

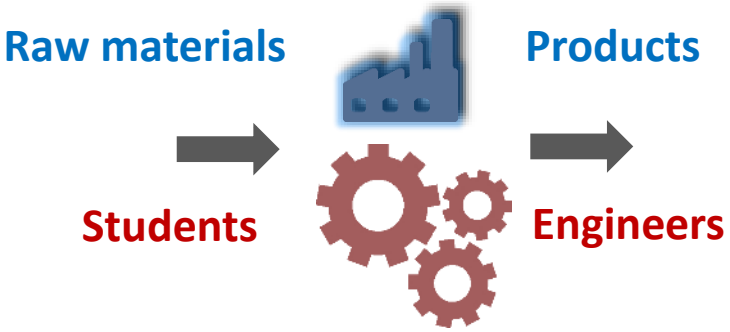
- Extensive lit review also carried out

WP 3 : ASSESSMENT FRAMEWORK

4. Define various indicators of the effectiveness of teaching in chemical engineering higher education,
5. Investigate in more depth methods of effectively acquiring employability competencies,
6. Use decision making technology and multi-objective optimization to identify the most appropriate evaluation methods,

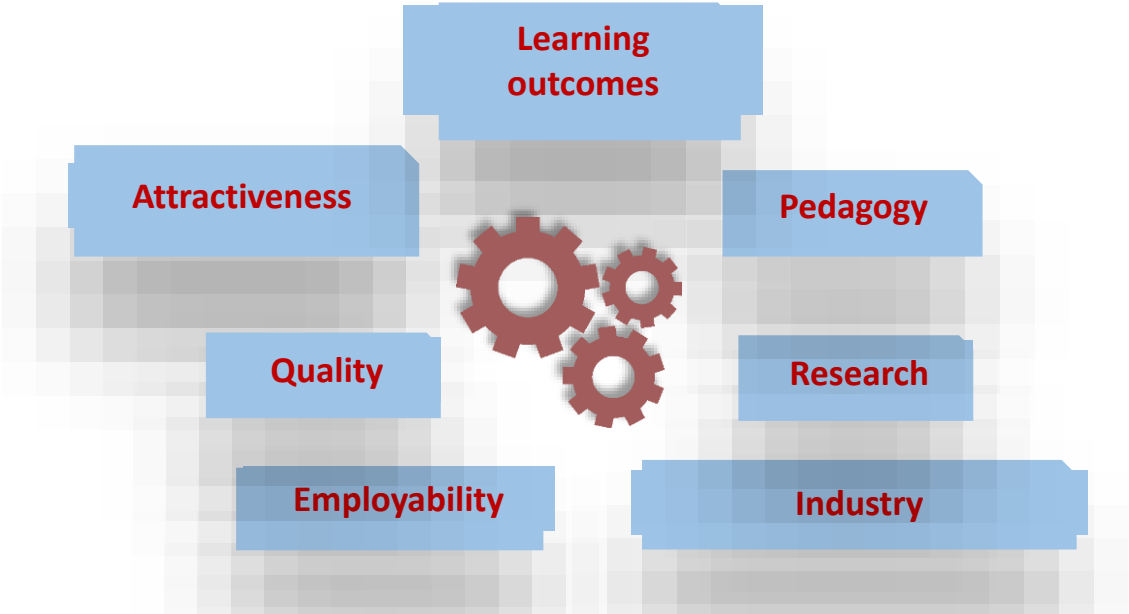
EVALUATION OF A WHOLE FORMATION

Chemical Industry and Chemical Engineering Education



Using WP2 Results, Data analysis, Literature results, Discussions with Stakeholders, Decision matrix…

Definition of 160 parameters, gathered in 7 global indicators :

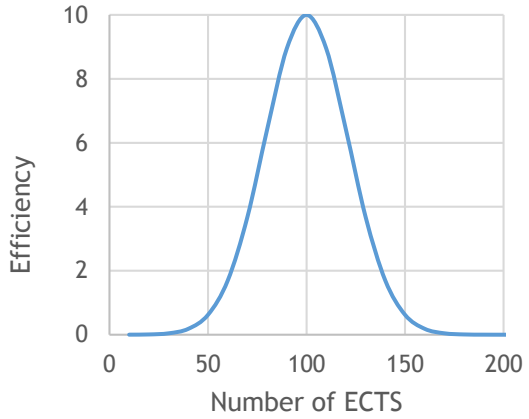


EVALUATION OF A WHOLE FORMATION

Quantification of each parameter : Discussions within the consortium, with stakeholders, recommendations of the EFCE…

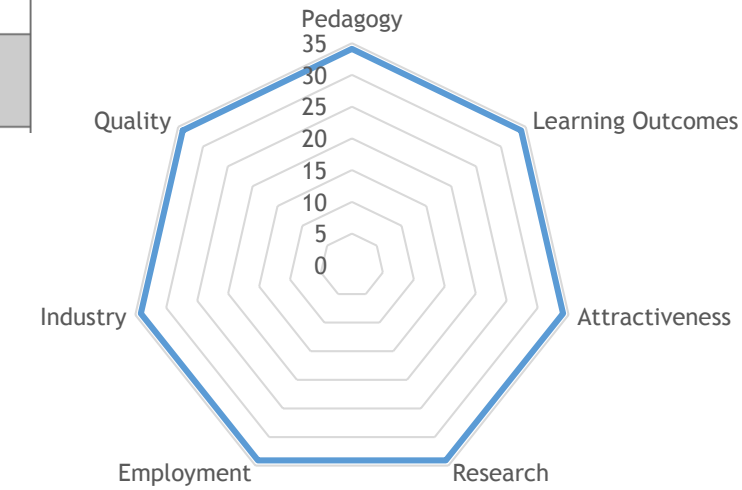
Example, for pedagogy :

Teaching		Mean value	Standard Deviation	Score
	ECTS of classical lectures	100	30	$e = 10 \exp\left(-\left(\frac{v-\mu}{\sigma}\right)^2\right)$
	ECTS of tutorials	50	30	$e = 10 \exp\left(-\left(\frac{v-\mu}{\sigma}\right)^2\right)$
	ECTS of labs	50	30	$e = 10 \exp\left(-\left(\frac{v-\mu}{\sigma}\right)^2\right)$
	ECTS of Problem & Project Based Learnings	50	30	$e = 10 \exp\left(-\left(\frac{v-\mu}{\sigma}\right)^2\right)$
	ECTS of NTICs	50	30	$e = 10 \exp\left(-\left(\frac{v-\mu}{\sigma}\right)^2\right)$



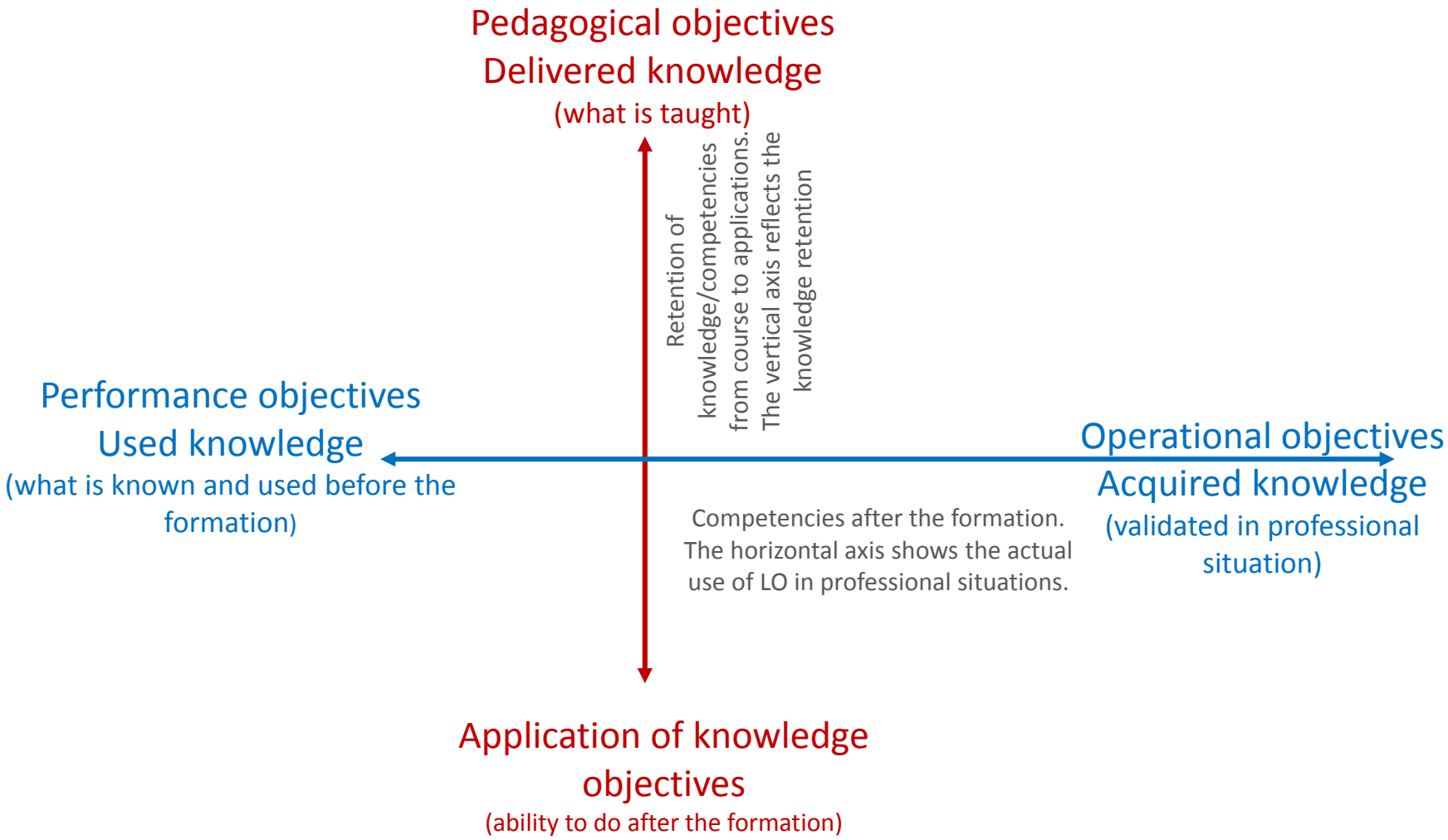
Score of each indicator (on 300) divided by the cost of formation, related to the national average salary.

Definition of radar plots, allowing improvements



EVALUATION OF A SINGLE MODULE

Based on the different types of knowledges involved in formation



EVALUATION OF A SINGLE MODULE

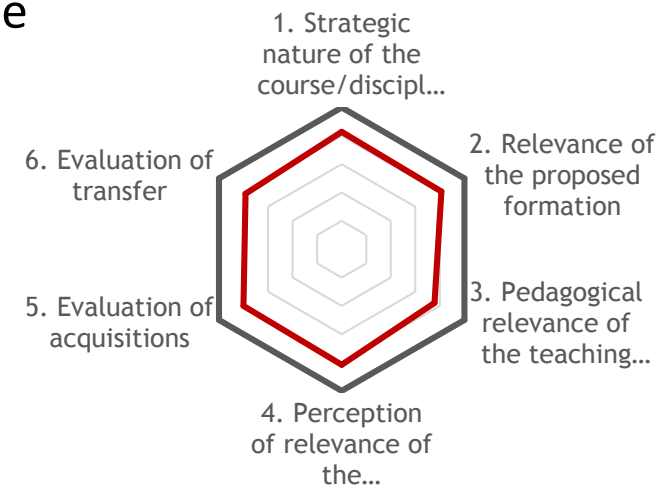
Definition of 6 metrics,

- M_1 : Strategic nature of the course/discipline,
- M_2 : Relevance of the proposed formation,
- M_3 : Pedagogical relevance of the teaching approach,
- M_4 : Perception of relevance of the pedagogical approach,
- M_5 : Evaluation of acquisitions,
- M_6 : Evaluation of transfer

Assessed by different stakeholders using Lickert scale

- **Academics,**
- **Graduates,**
- **Students,**
- **Employers**

According to different weights.



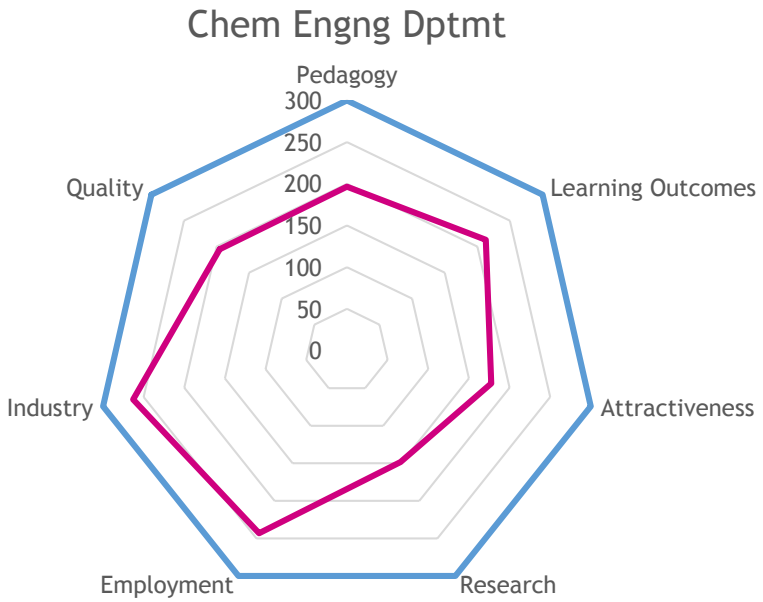
WP 4 : PILOT IMPLEMENTATION

7. Test the framework at partner institutions focusing on various pedagogic methodologies.

EVALUATION OF A WHOLE FORMATION

Application of the framework to an *anonymous* Chemical Engineering Formation

Calculation of scores (on 300) of each global indicator, not related to the average cost and salary.



Gives an indication of improvements areas :

Relations with Research, Attractiveness

Gives also an indication of strengths :

Relations with Industry, Employment

Difficulty in assessing all the 160 parameters…

EVALUATION OF A SINGLE MODULE (1/5)

Applied to the course of **Chemical Reaction Engineering I** (basic CRE) in different countries, using different pedagogical approaches :

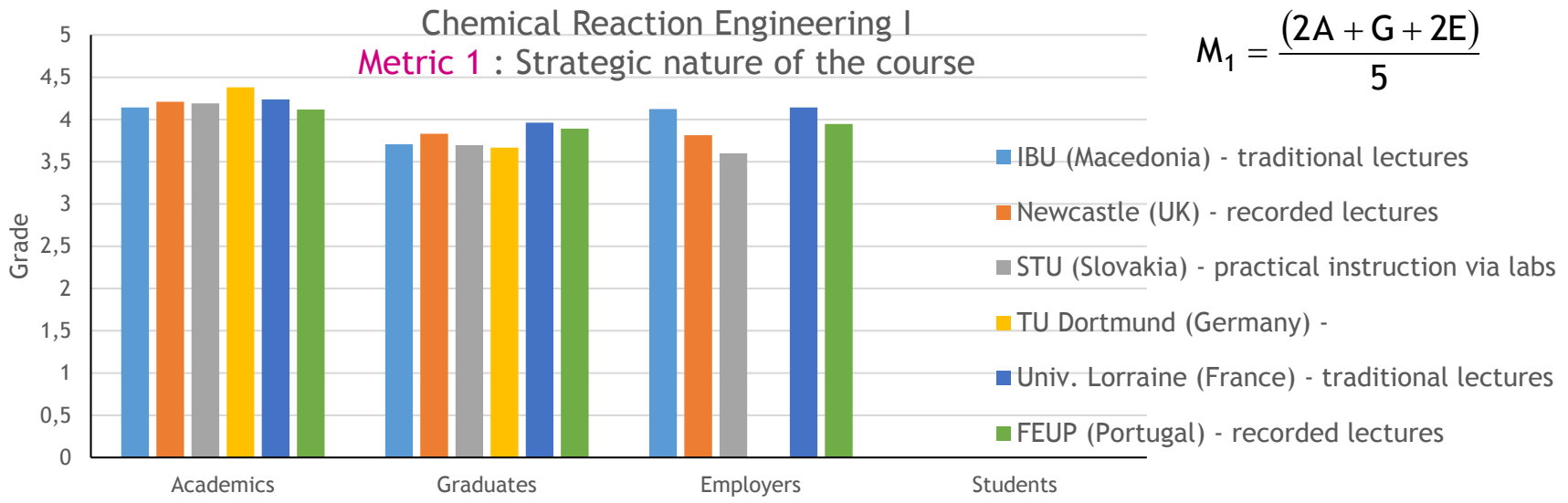
- P1(UNEW) – recorded lectures, problem based learning
- P2 (UL) – problem based learning, traditional lectures
- P3 (IBU) – work-based learning, traditional lectures
- P4 (FEUP) – recorded lectures, practical instruction via labs
- P5 (STU) – traditional lectures, practical instruction via labs
- P6 (TUDO) - work-based learning, problem based learning

Metrics assessed by different (national) stakeholders using Lickert scale

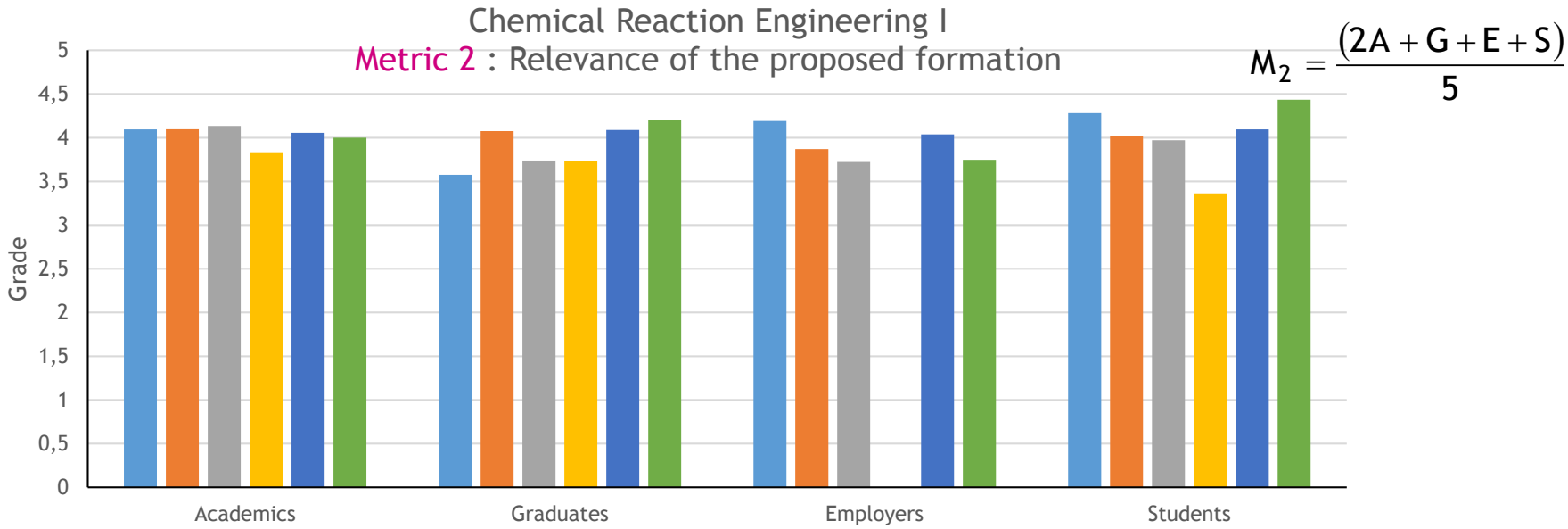
- Academics,
- Graduates,
- Students,
- Employers

1 : Strongly disagree
2 : Disagree
3 : Neither agree or disagree
4 : Agree
5 : Strongly agree

EVALUATION OF A SINGLE MODULE (2/5)



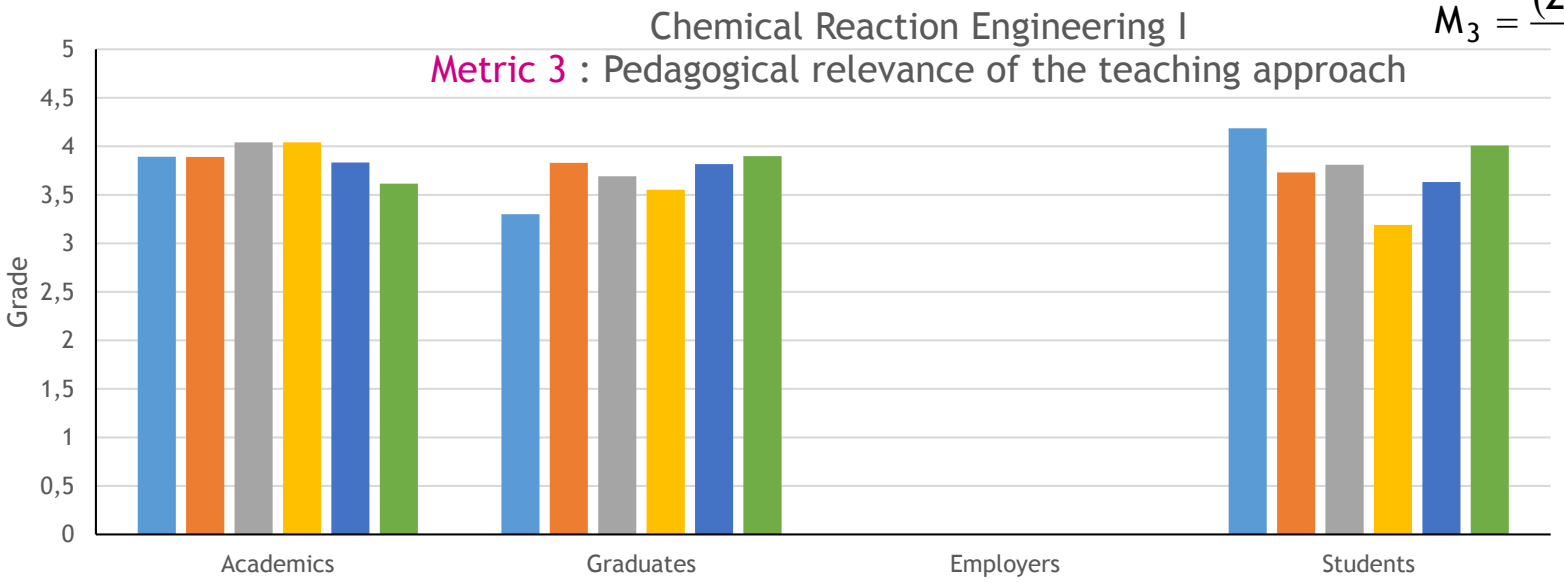
$$M_1 = \frac{(2A + G + 2E)}{5}$$



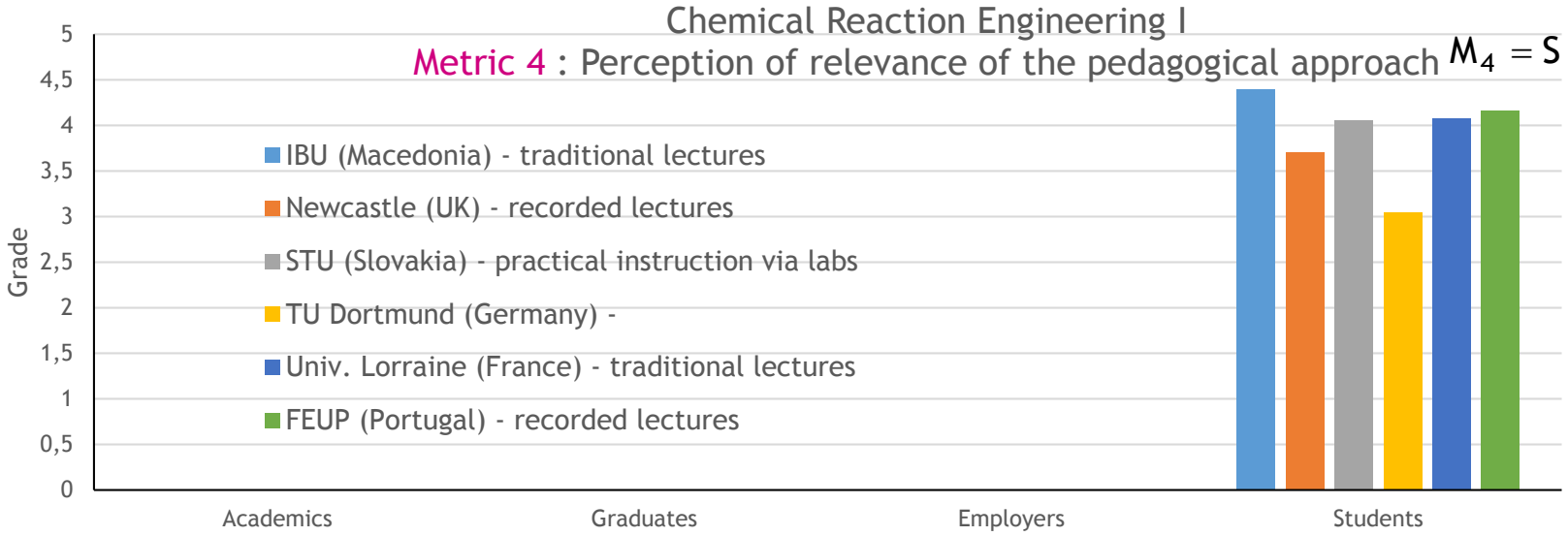
$$M_2 = \frac{(2A + G + E + S)}{5}$$

EVALUATION OF A SINGLE MODULE (3/5)

$$M_3 = \frac{(2A + 2G + S)}{5}$$

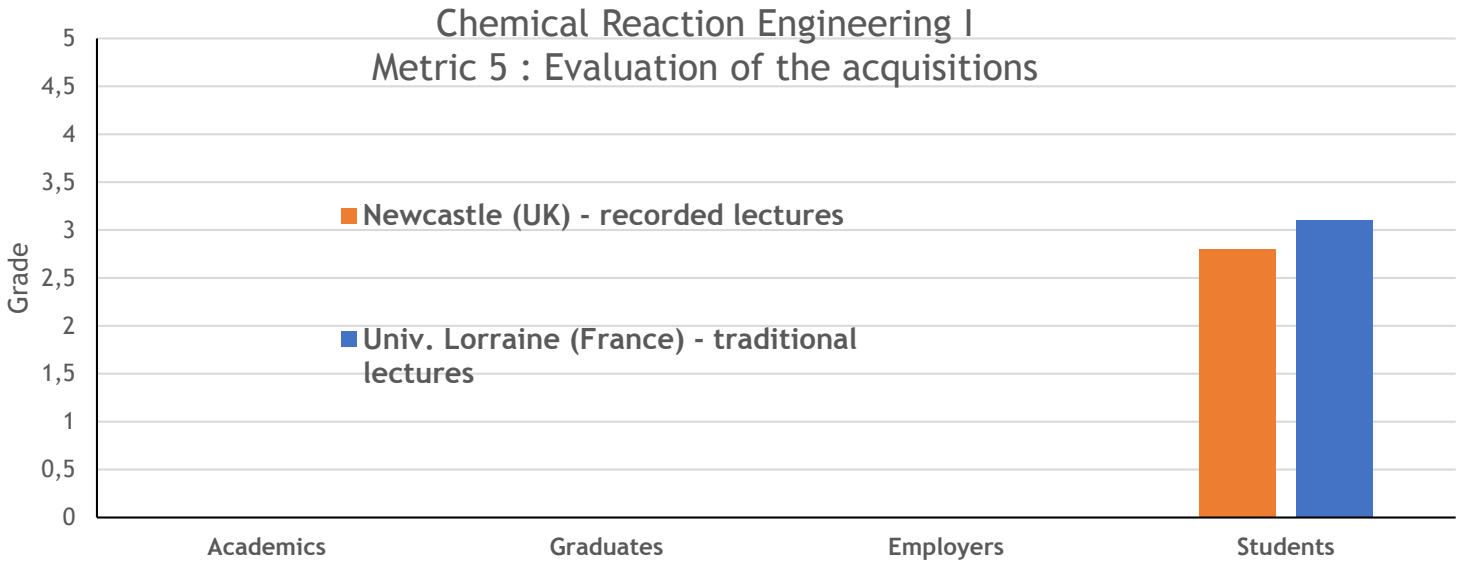


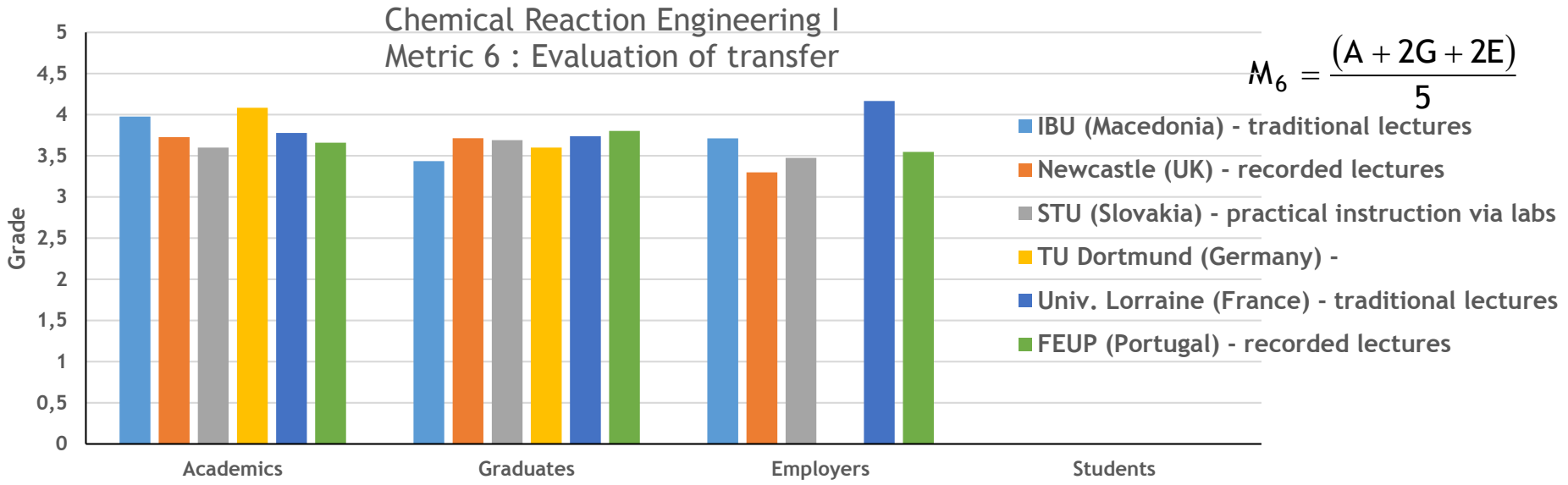
$$M_4 = S$$



EVALUATION OF A SINGLE MODULE (4/5)

$$M_5 = S$$

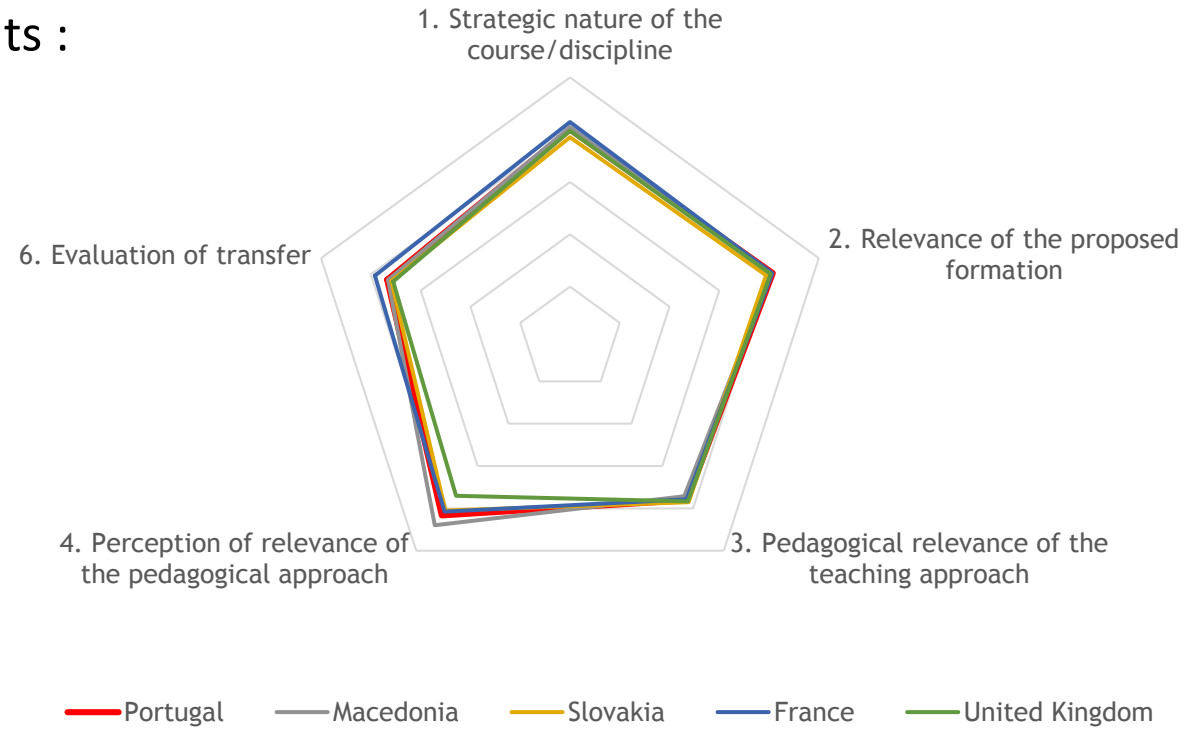




$$M_6 = \frac{(A + 2G + 2E)}{5}$$

EVALUATION OF A SINGLE MODULE (5/5)

Global results :



Germany : too small database

No major differences among the partner institutions
CRE classified in all Metrics as Good/Important

Great difficulties in receiving feedback to our surveys…
Only students were "forced" (in face to face positions) to fulfill the (paper) surveys.

EVALUATION OF DIFFERENT MODULES

Application of the framework to the evaluation of different modules and different pedagogical approaches, in a same university, for the same cohort of students

CRE I, in traditional teaching : Courses, tutorials and final exam

CRE II, in Project Based Learning : Design of a catalytic reactor, final defense of the project

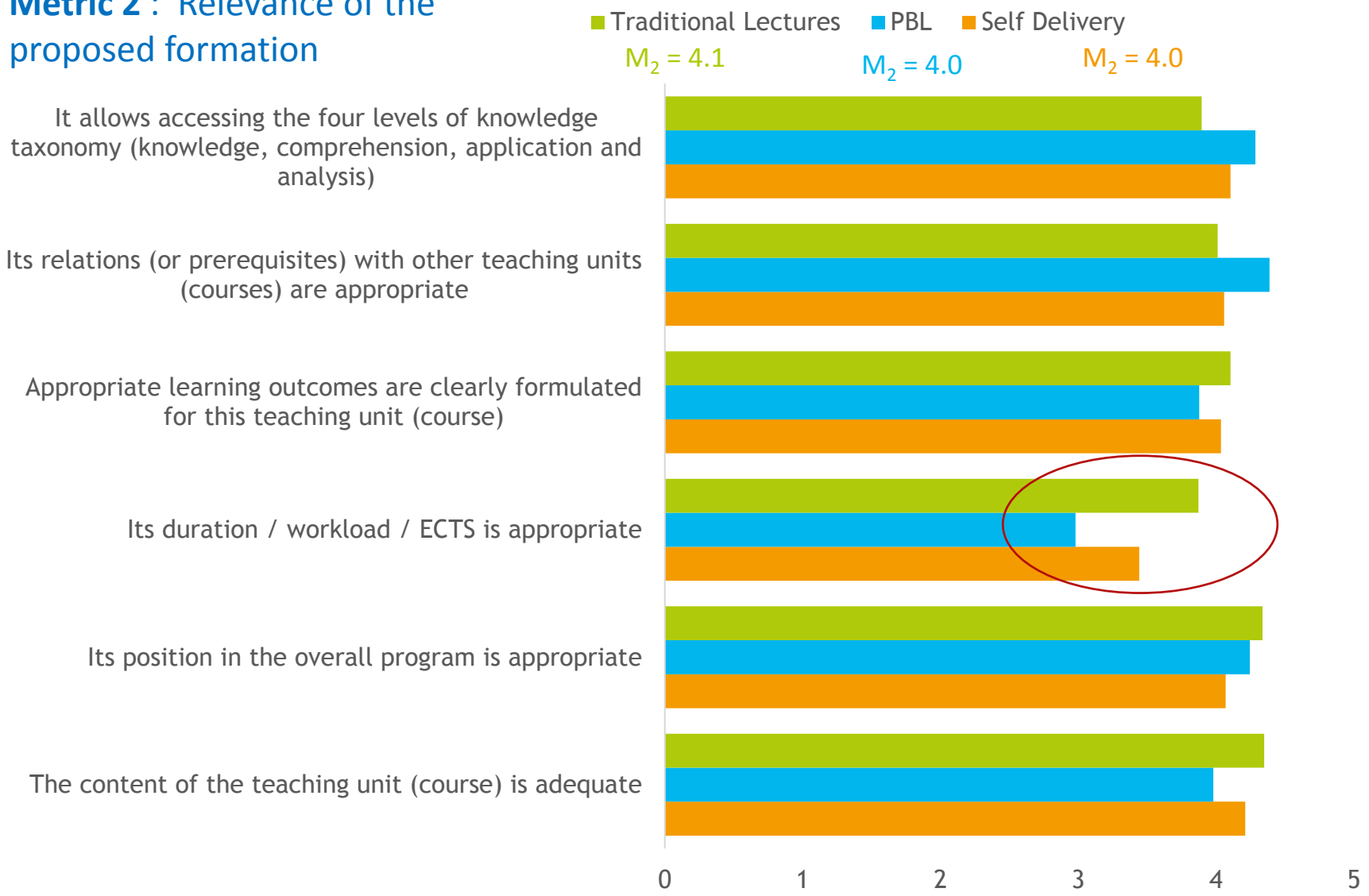
Heat Exchangers in self-delivery : Autoformation, and then Problem Based Learning applied to the design of an heat exchanger

Only students feedback described : Comparison of their detailed results for Metrics 2, 3, 4 & 5.

- ~~M1 : Strategic nature of the course/discipline~~,
- M2 : Relevance of the proposed formation,
- M3 : Pedagogical relevance of the teaching approach,
- M4 : Perception of relevance of the pedagogical approach,
- M5 : Evaluation of acquisitions,
- ~~M6 Evaluation of transfer~~

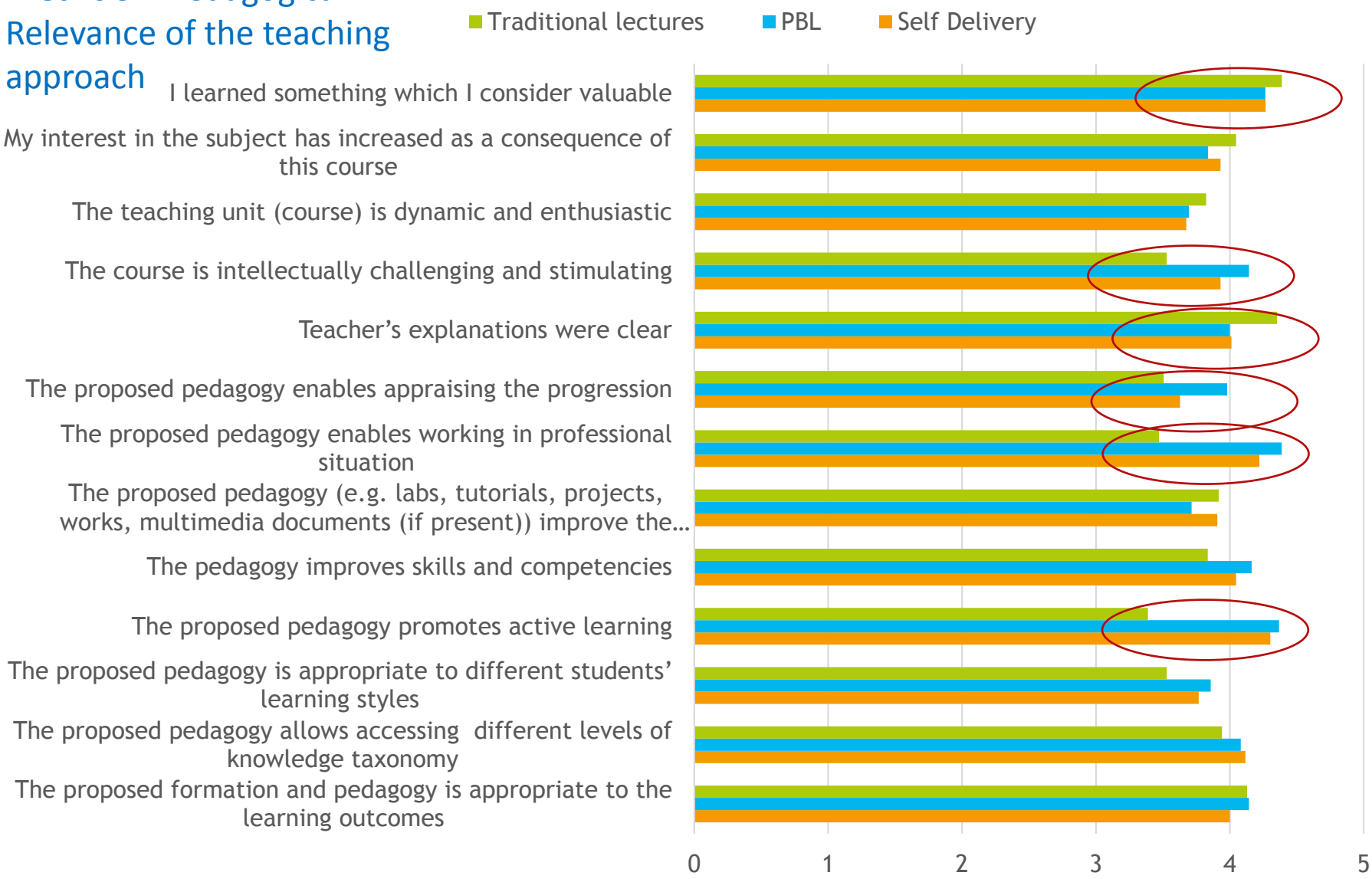
EVALUATION OF DIFFERENT MODULES

Metric 2 : Relevance of the proposed formation



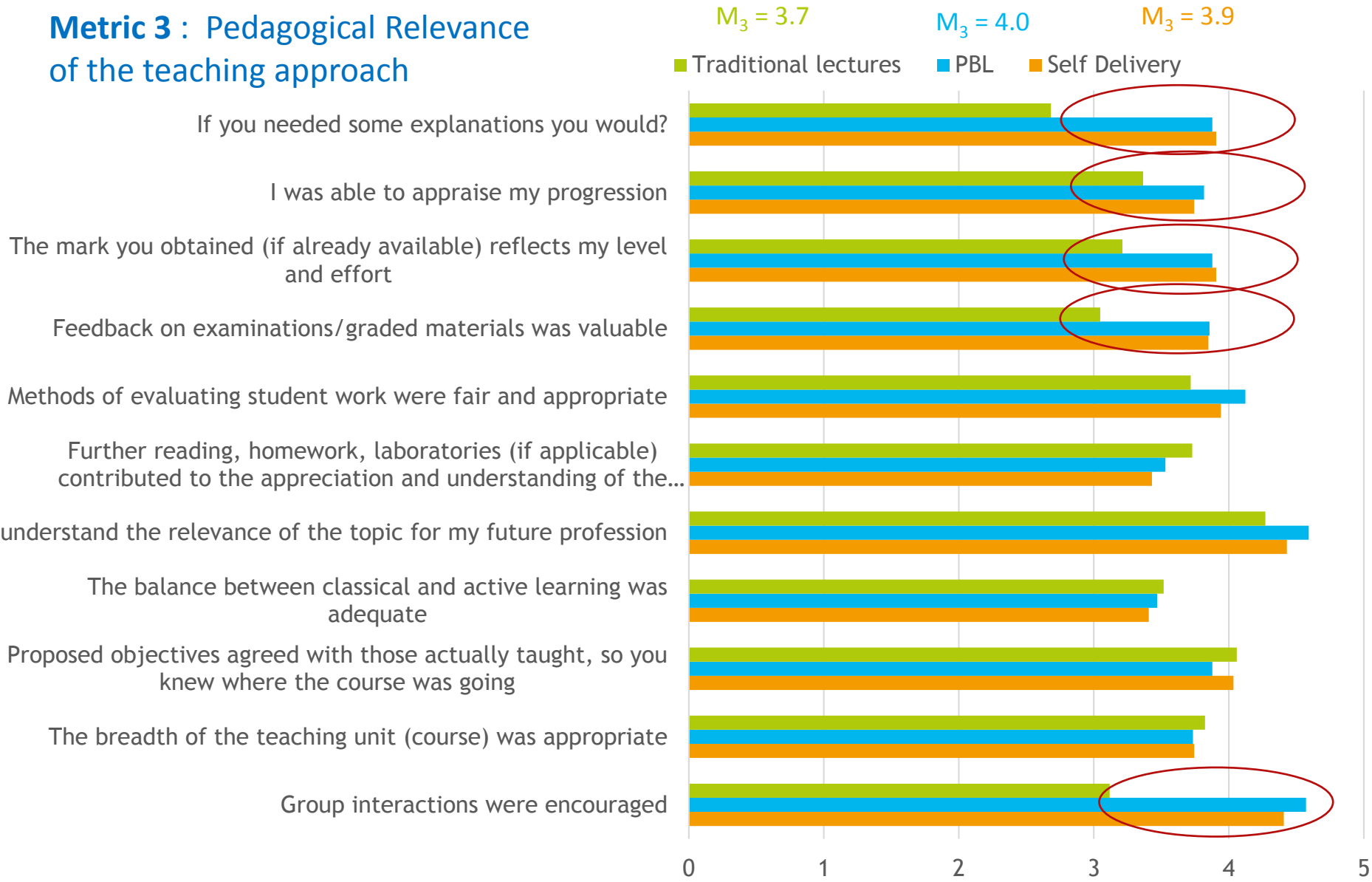
EVALUATION OF DIFFERENT MODULES

Metric 3 : Pedagogical Relevance of the teaching approach



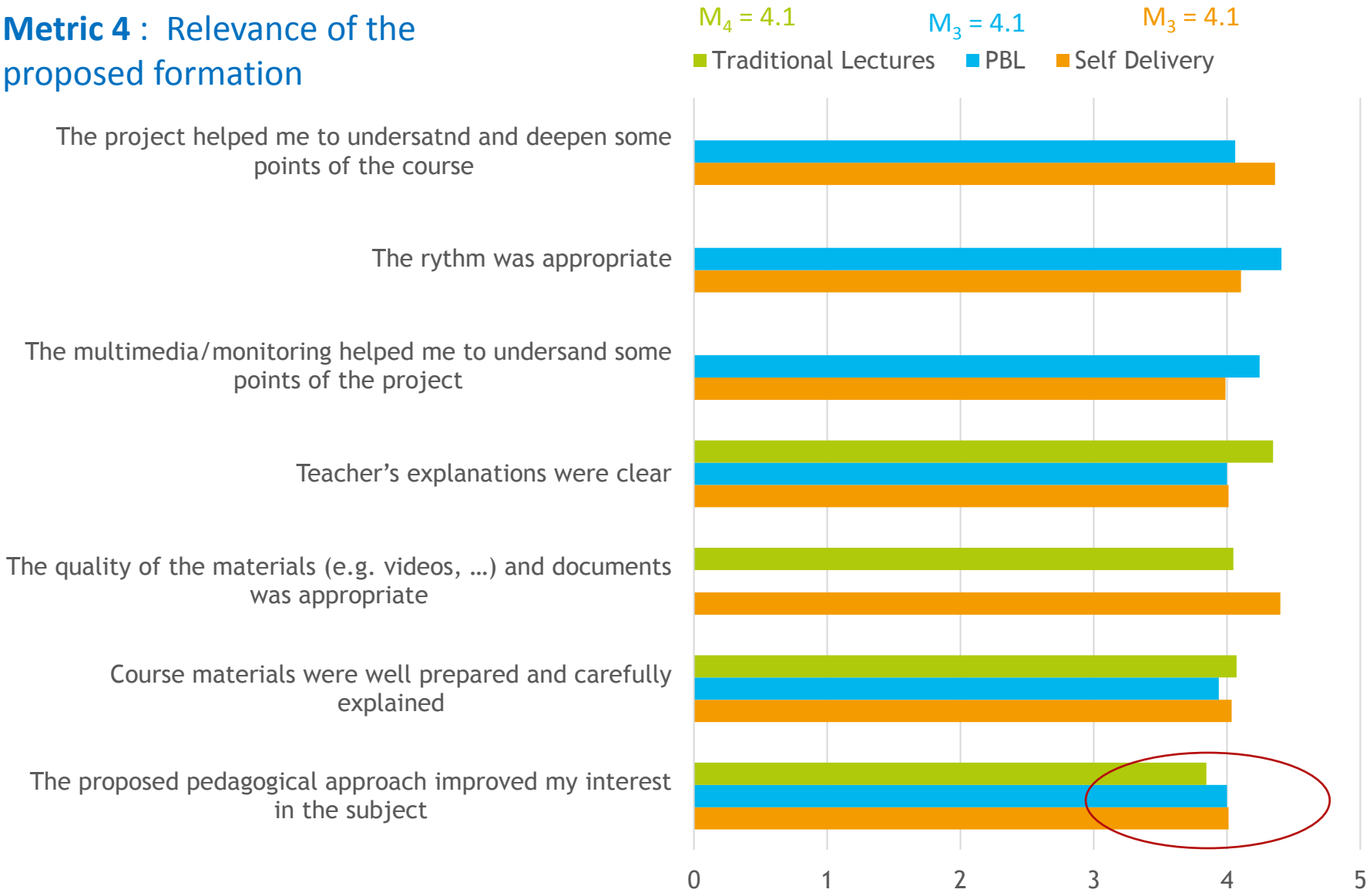
EVALUATION OF DIFFERENT MODULES

Metric 3 : Pedagogical Relevance of the teaching approach



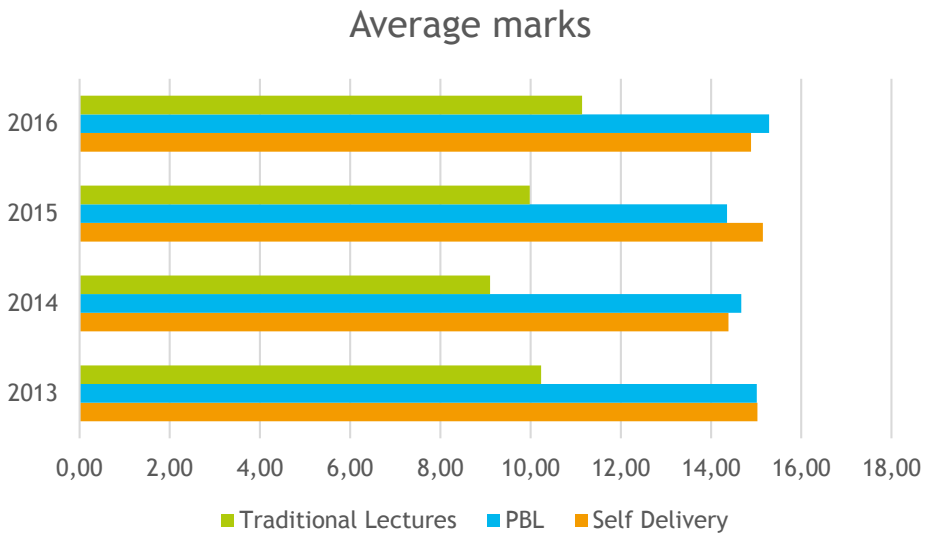
EVALUATION OF DIFFERENT MODULES

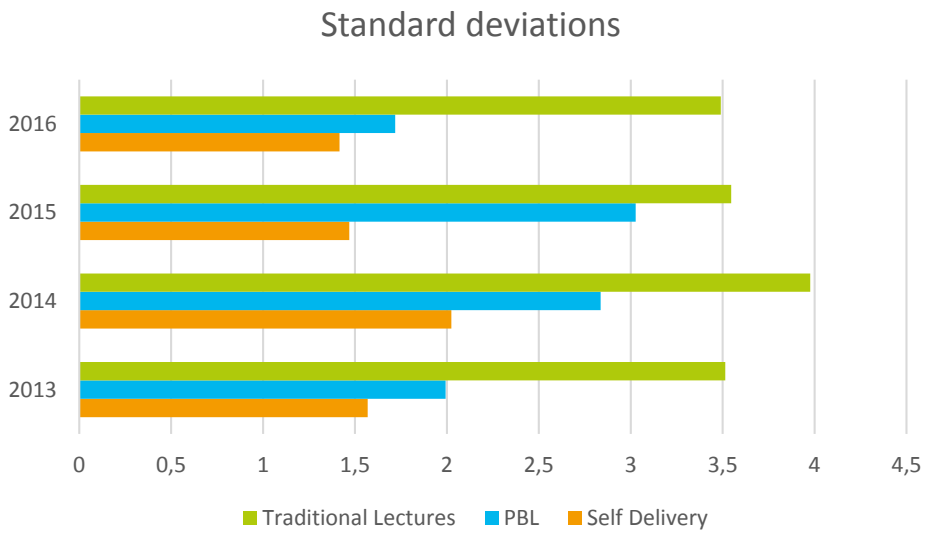
Metric 4 : Relevance of the proposed formation



EVALUATION OF DIFFERENT MODULES

Metric 5 : Evaluation of acquisitions





CONCLUSIONS

- Knowledge and competency learning outcomes reviewed

- Two frameworks have been developed.
  - Effectiveness of a whole formation : strengths and improvement areas
  - Single teaching unit/pedagogical approach

- Although the focus of this project is on chemical engineering formation, the concepts and approaches could be applied to other areas of higher education.

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THANK YOU FOR YOUR ATTENTION

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