Improving Teaching Effectiveness in Chemical Engineering Education

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Preliminary analysis of Pilot Implementation results (WP4)

Carlos Miguel & Luis Miguel Madeira

Department of Chemical Engineering,
Faculty of Engineering – University of Porto, Portugal

U.PORTO
FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

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Education and Culture DG
Lifelong Learning Programme

In WP3, a framework to assess an individual unit/course was developed

Metrics considered in the framework:

Metric	Formula
1. Strategic nature of the course/discipline	M1=(2A+G+2E)/5
2. Relevance of the proposed formation	M2=(2A+G+E+S)/5
3. Pedagogical relevance of the teaching approach	M3=(2A+2G+S)/5
4. Perception of relevance of the pedagogical approach	M4=S
5. Evaluation of the acquisitions	----
6. Evaluation of transfer	M6=(A+2G+2E)/5

Stakeholders: A – Academics; G – Graduates; E – employers; S – students

Framework metrics for individual unit/course assessment

	CLASSIFICATION SCALE				
METRIC	5	4	3	2	1
M1	Very important	Important	Average	Modestly helpful	Accessory
M2	Very important	Important	Average	Modestly helpful	Accessory
M3	Very good	Good	Average	Poor	Very Poor
M4	Very good	Good	Average	Poor	Very Poor
M5	Very good	Good	Average	Poor	Very Poor
M6	Very good	Good	Average	Poor	Very Poor

- The proposed framework should result in a radar plot with 6 dimensions (6 metrics) and classifications/levels from 1 to 5 (table above).

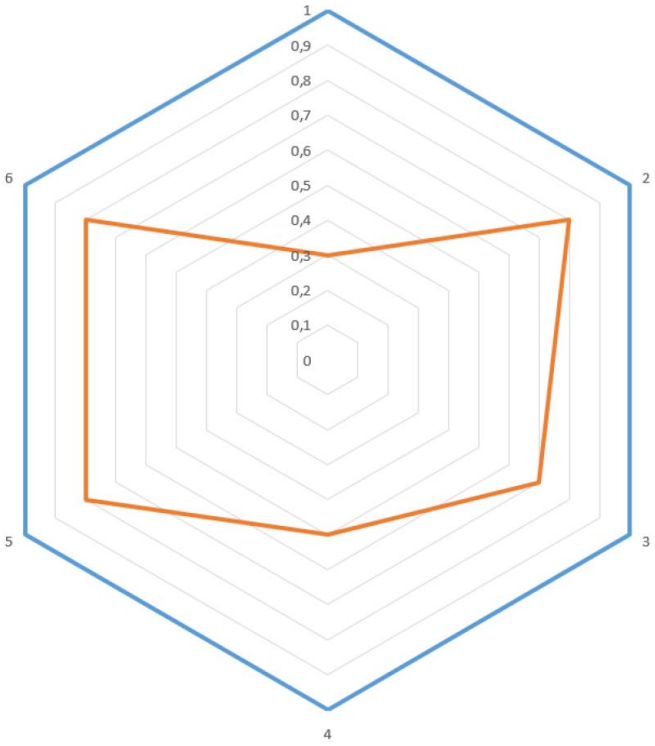


Figure 8: Evaluative image of a formation (in blue: ideal profile; in red / orange the real profile; the axis 1 corresponds to the strategy, the axis 2 to the general relevance, the axis 3 to the educational relevance; the axis 4 to its perception by the students, the axes 5 to the transfer skills, and the axes 6 to the acquisitions).

Framework metrics for individual unit/course assessment

- The proposed framework could be used before and after the different pedagogical approaches listed below. However, it is expectable that only some metrics change.

- **Metrics 1-4 and** 6 were assessed through surveys to the stakeholders (students; graduates; academics; employers);

- **Metric 5 was** assessed considering quantitative results in exams, marks reached by the students (standards tests, such as those of ChemEPass for instance, could be used as well).

WP4 – Pilot Implementation

Pedagogical approaches used

P1(UNEW) – recorded lectures, problem based learning

P2 (UL) – problem based learning, self-instruction delivery

P3 (IBU) – work-based learning, traditional lectures

P4 (FEUP) – recorded lectures, practical instruction via labs

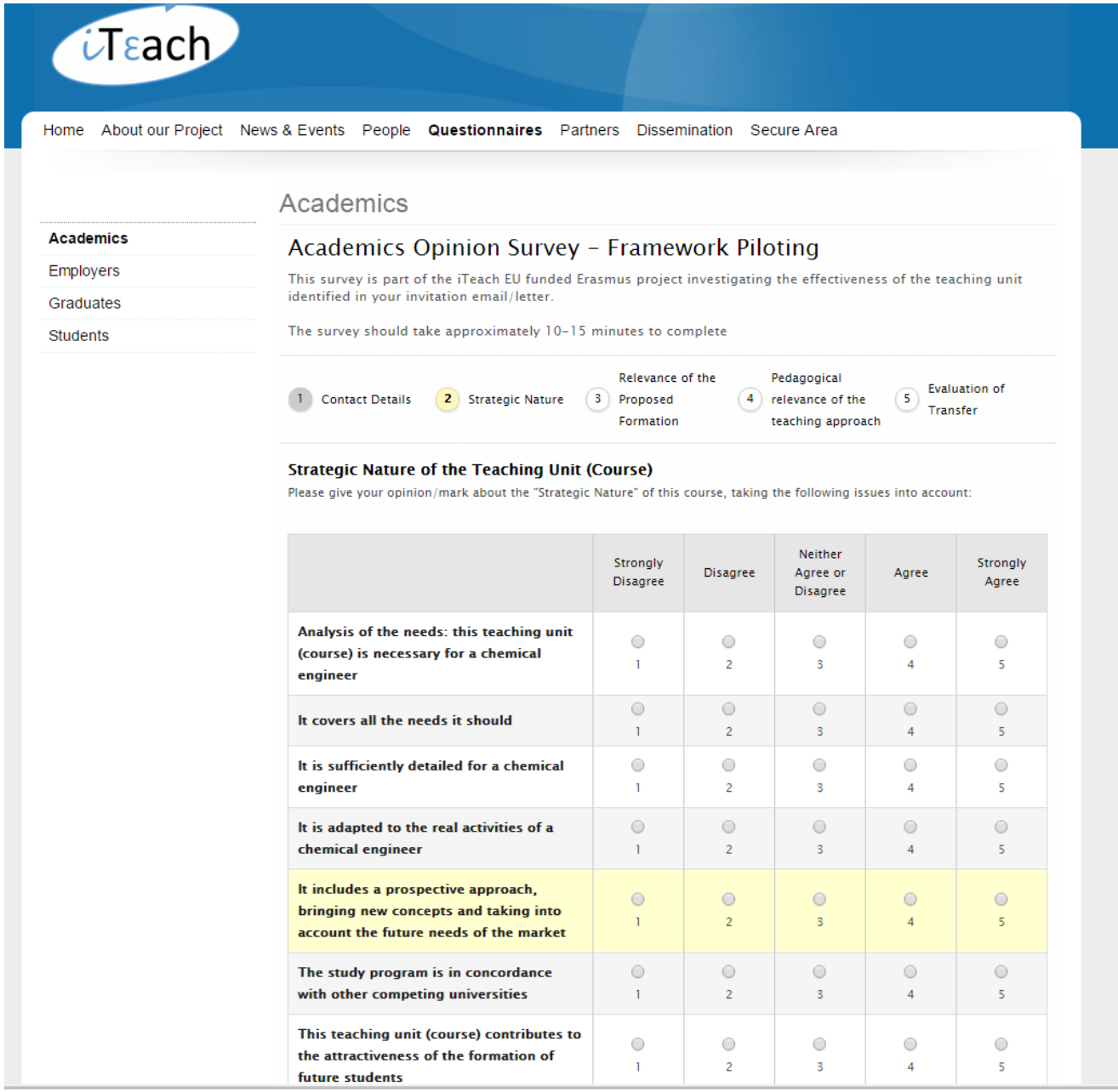
P5 (STU) – traditional lectures, practical instruction via labs

P6 (TUDO) - work-based learning, problem based learning

- If possible, similar topics (courses/subjects) should be assessed by different partners;
- **Reaction Engineering** was agreed as a common one and tested as case-study.

Surveys

- Available online at www.iteach-chemeng.eu
- Each metric is determined through a series of Likert-type scale questions (except metric 5).
- Can be easily adapted to be used by other institutions and to assess any course.



Surveys

Procedure

- Surveys sent out by all partners in February 2016 to academics, industrialists, graduates and students based on their own databases;
- In some institutions reminders were sent, more than once…
- In some institutions associated partners were involved;

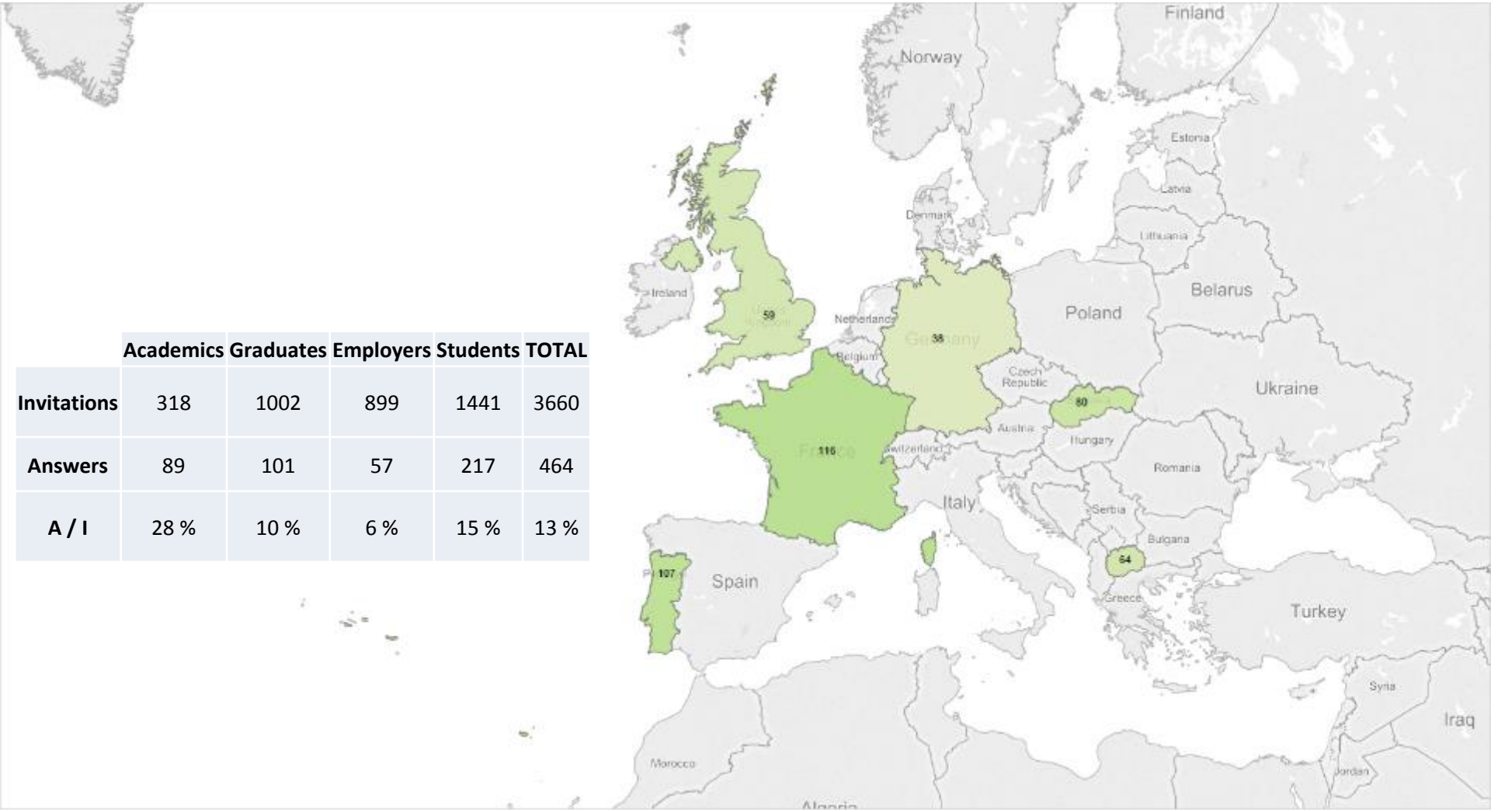
Procedure at FEUP

- Survey sent out by email to 84 academics from other universities (which were specifically asked to disseminate / send to other colleagues), 94 industrialists and 339 graduates (finished the degree between 2010-2015);
- Students that attended Reaction Engineering I course (94) received the survey also by email in Feb.

PILOT IMPLEMENTATION – RESULTS

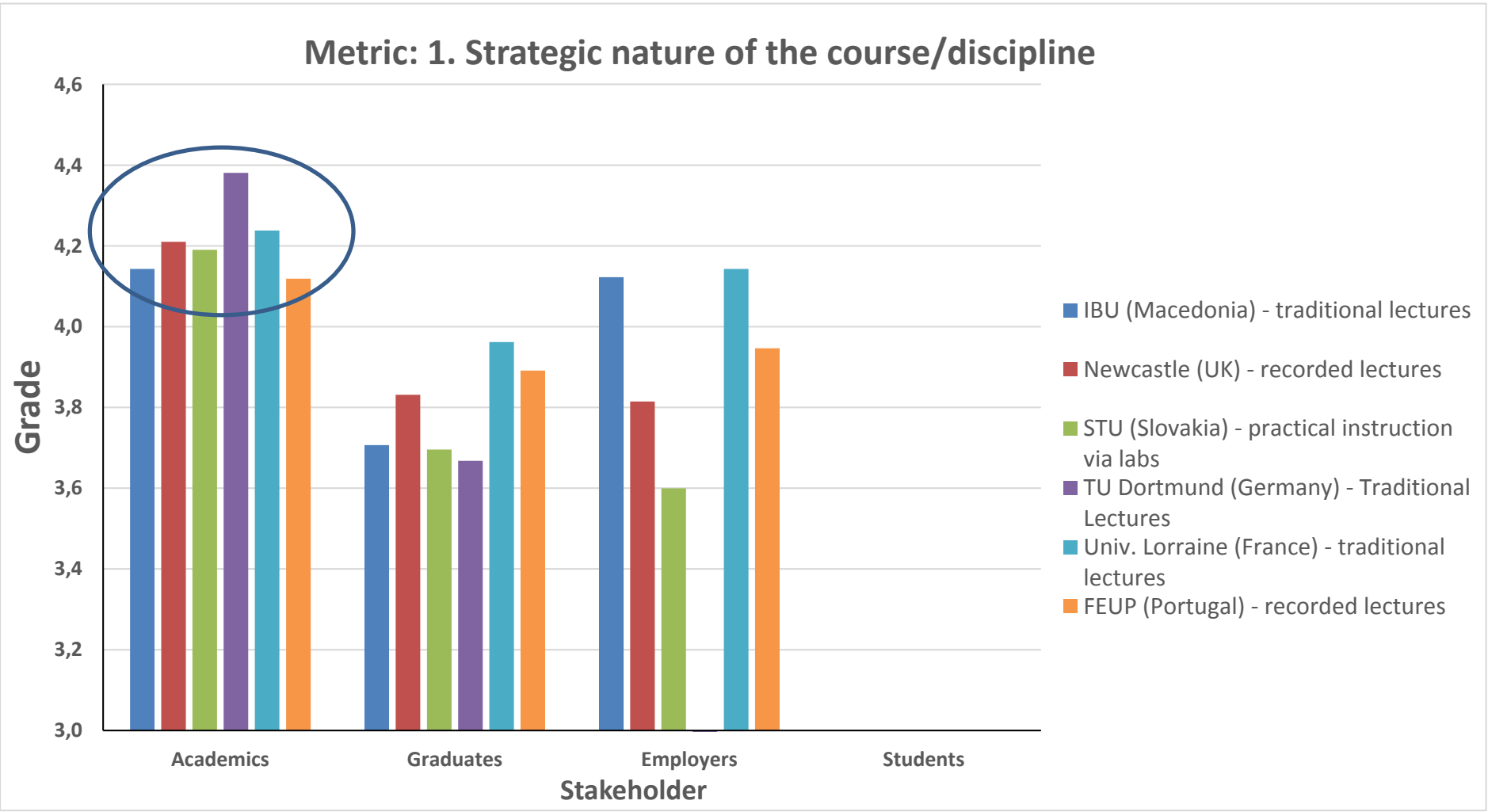
Chemical Reaction Engineering (1st Semester) – Total nr. answers

	Academics	Graduates	Employers	Students	TOTAL
Invitations	318	1002	899	1441	3660
Answers	89	101	57	217	464
A / I	28 %	10 %	6 %	15 %	13 %



PILOT IMPLEMENTATION – RESULTS

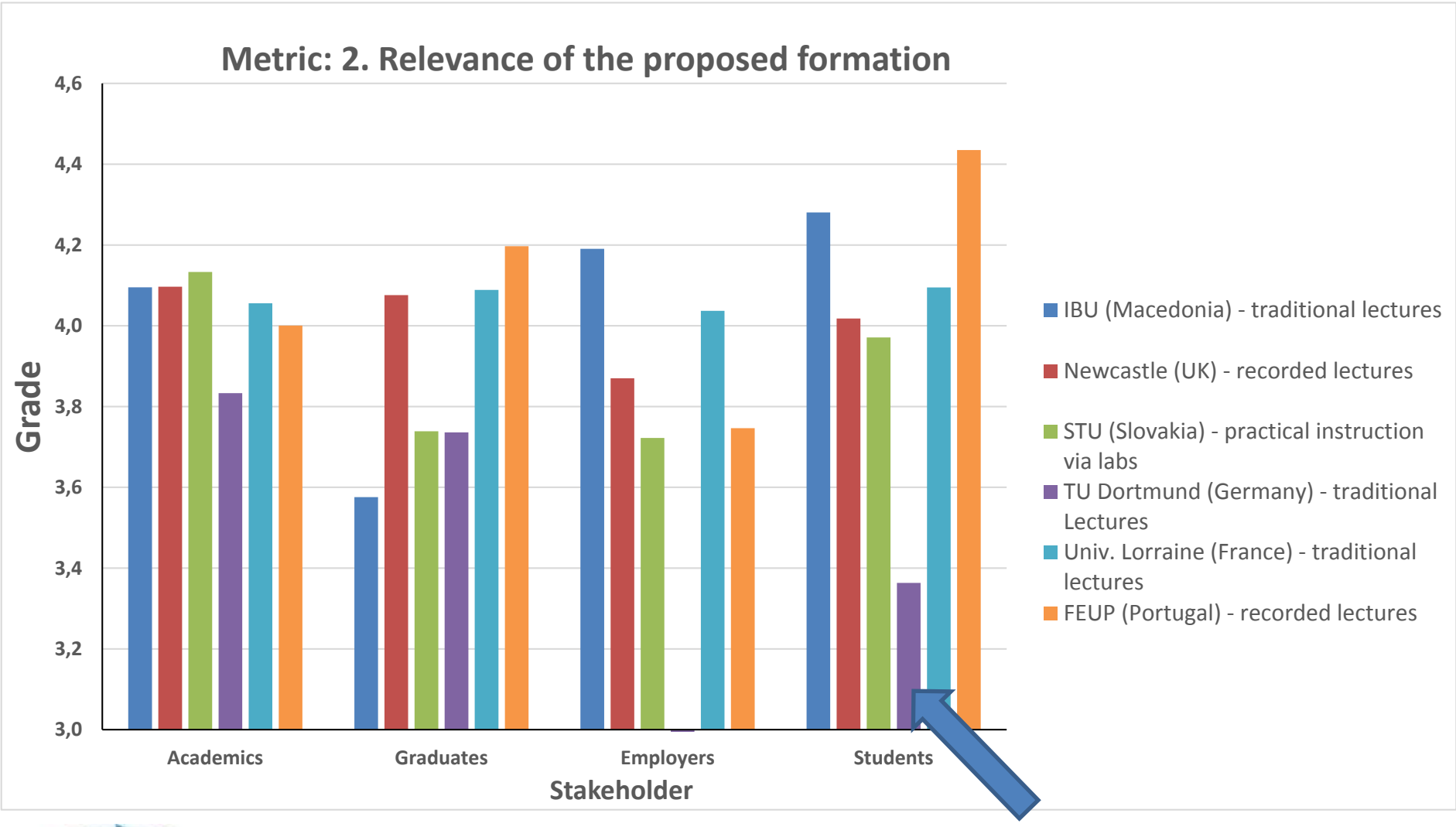
Chemical Reaction Engineering (1st Semester)



TU Dortmund lacks “Employers” feedback

PILOT IMPLEMENTATION – RESULTS

Chemical Reaction Engineering (1st Semester)



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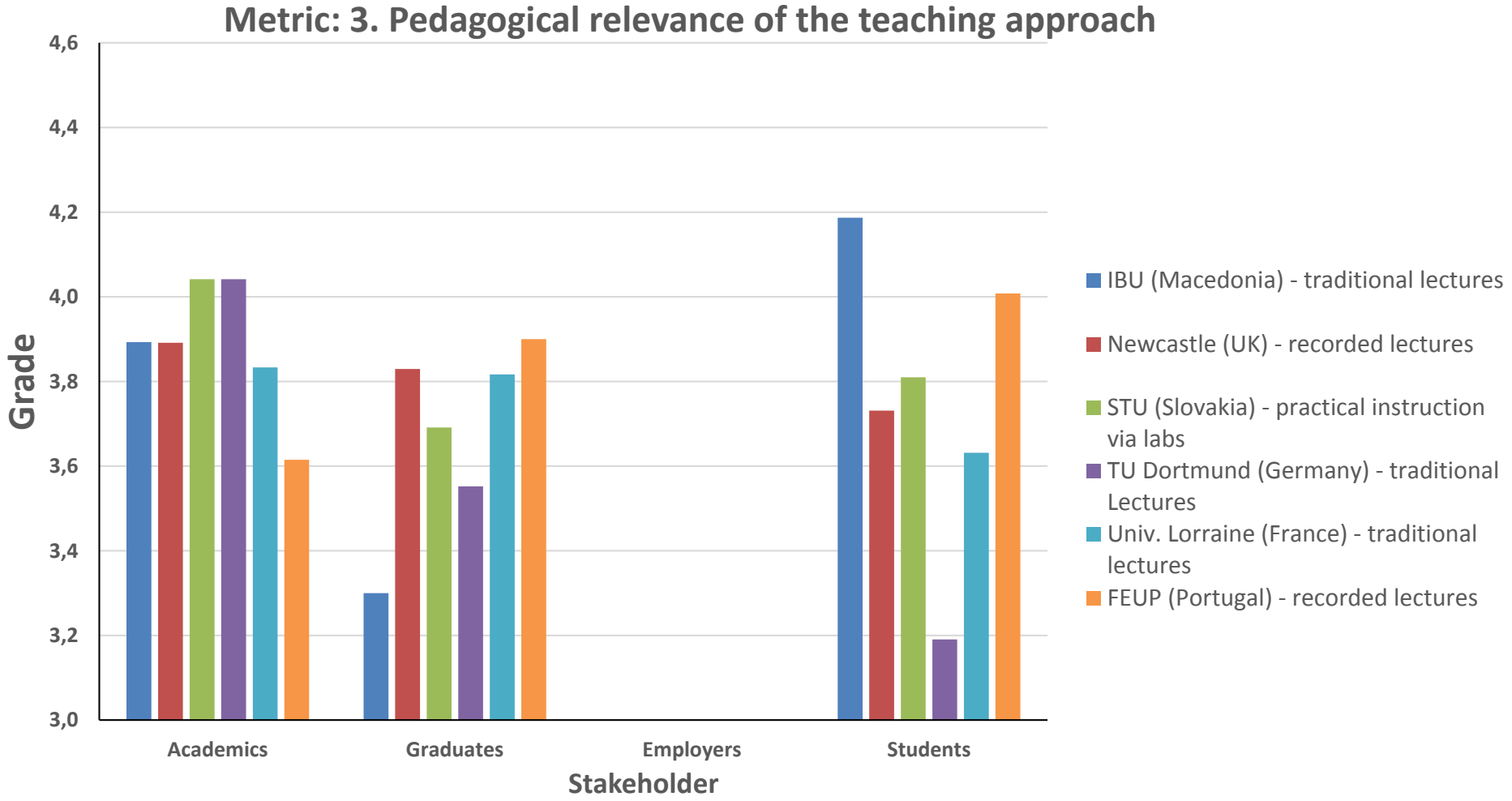

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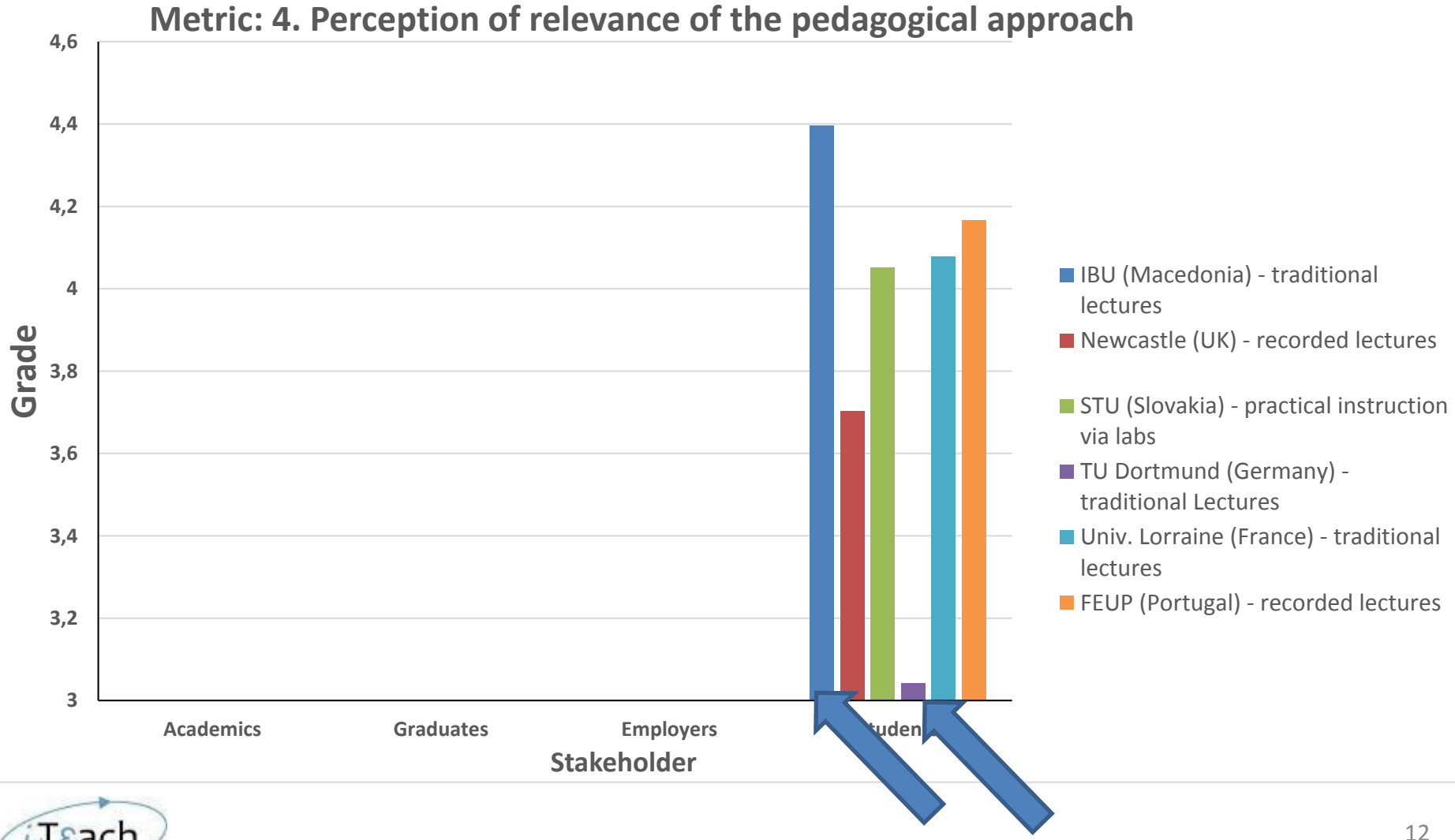
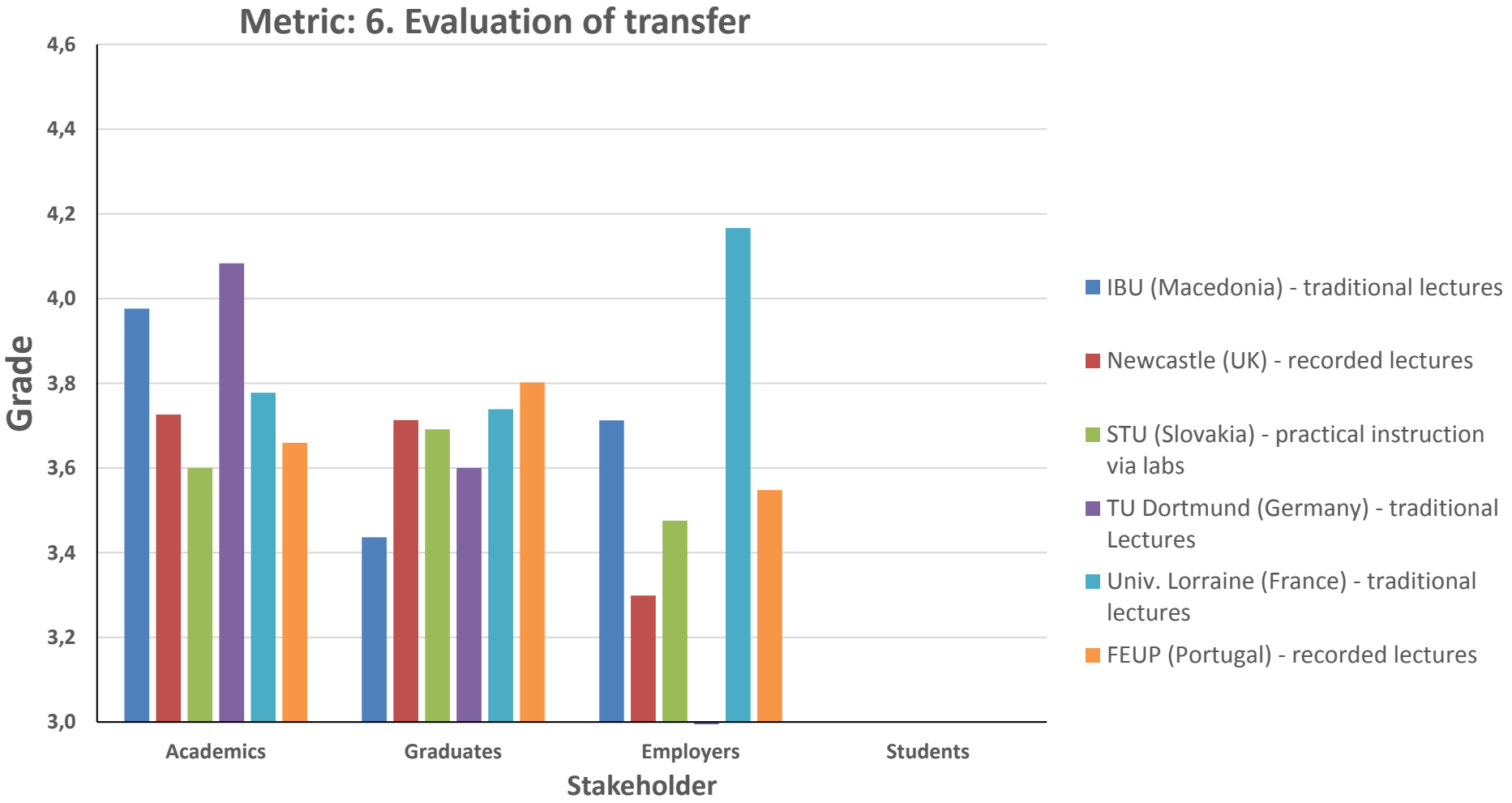
Chemical Reaction Engineering (1st Semester)



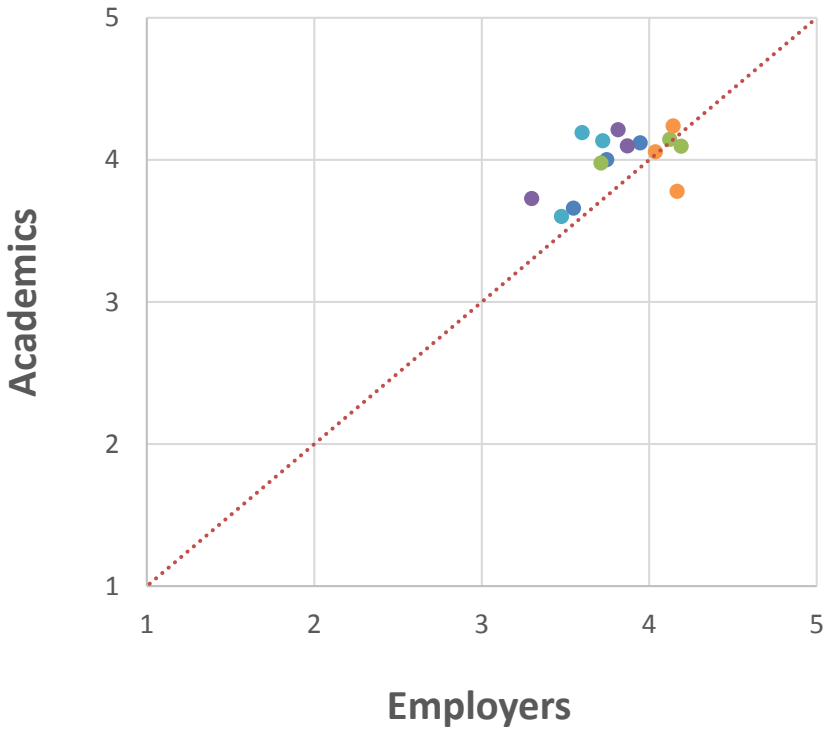
PILOT IMPLEMENTATION – RESULTS

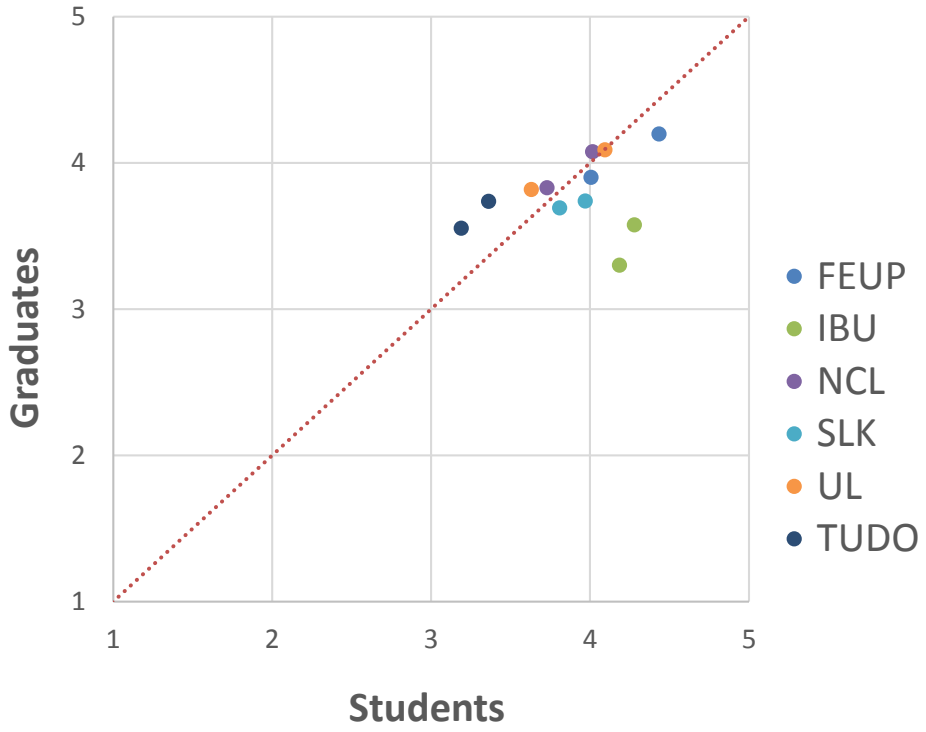
Chemical Reaction Engineering (1st Semester)



Parity plots for stakeholders comparison: marks from all metrics included

Chemical Reaction Engineering (1st Semester)

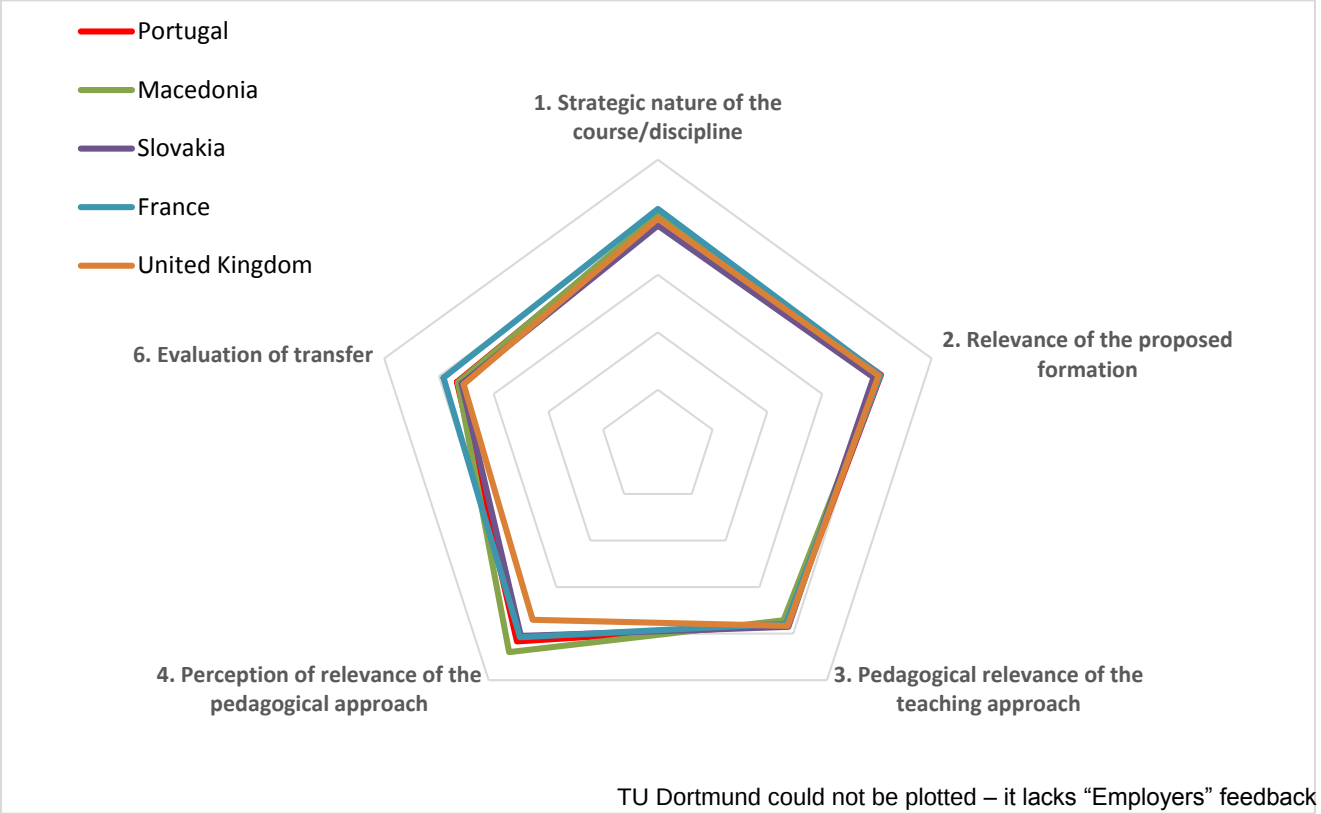




- Academics gave, in general, slightly higher marks than Employers in all countries/partners;
- Graduates and Students gave similar marks, except in TUDO (higher marks by Graduates) and IBU (higher marks by Students).

PILOT IMPLEMENTATION – RESULTS

Chemical Reaction Engineering (1st Semester)



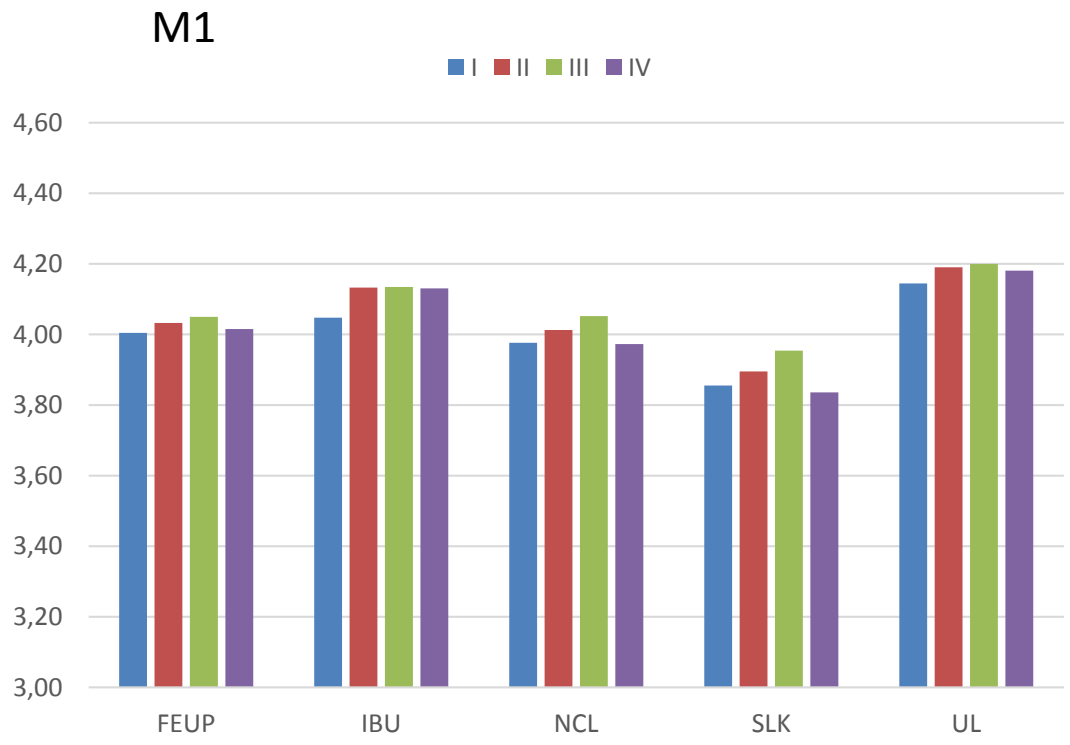
TU Dortmund could not be plotted – it lacks "Employers" feedback

- CRE has been, in general, classified in all Metrics as Good / Important;
- No major differences among the partner institutions found;
- Reason for that related with the course chosen: **Reaction Engineering** (classical in every Chem. Eng. program)?

Sensitivity analysis

Chemical Reaction Engineering (1st Semester)

Metric	Scenarios															
	I (default)				II				III				IV			
	A	G	E	S	A	G	E	S	A	G	E	S	A	G	E	S
1. Strategic nature of the course/discipline	2	1	2	0	2.5	0	**2.5**	0	**3**	0	2	0	2	**0**	**3**	0

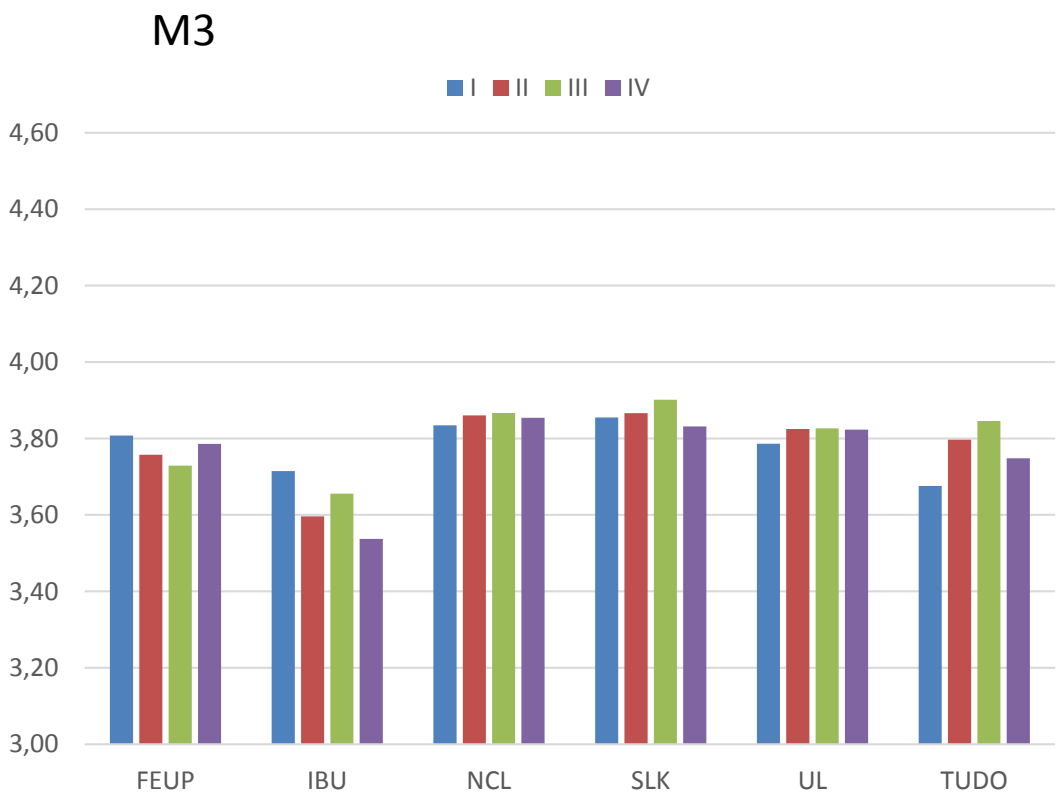


- Changes were made in the weights of each stakeholder, but with a meaning behind – not just playing with numbers (e.g. in metric M1);
- **Changes noticed for metric M1 are smaller than 2.6 % (considering all partners)**;
- A more clear differentiation among partners **was not** observed upon changing the weights in M1 – when M1 increases (or decreases), in general the same trend was noticed for all partners.

Sensitivity analysis

Chemical Reaction Engineering (1st Semester)

Metric	Scenarios															
	I (default)				II				III				IV			
	A	G	E	S	A	G	E	S	A	G	E	S	A	G	E	S
3. Pedagogical relevance of the teaching approach	2	2	0	1	2.5	2.5	0	0	3	2	0	0	2	3	0	0



- **Changes noticed for metric M3 are smaller than 4.8 % (considering all partners);**
- A more clear differentiation among partners **was not** observed upon changing the weights in M3 (except for IBU, where Students gave exceptionally high marks and Graduates lower marks – thus lower M3 values were reached when decreasing the weight of Students – scenarios II-IV and/or increasing the weigh of the Graduates – scenarios II/IV) – cf. also slide 19.

Proposal for Metric 5 - Evaluation of the acquisitions

- M5 deals with the acquisitions of students during and after the course, including regular evaluations.

Major concerns:

- Take into account marks change in a given course / module, where a different pedagogical approach has been implemented – it should hopefully reflect a better (or worse) efficiency of the teaching methodology;
- One should consider differences in cohorts of students (year *y* versus previous year(s));
- Metric definition and calculation should be straightforward and independent of local grading scale.
- … / …

Metric 5 - Evaluation of the acquisitions

Proposals for M5 in a given course, in academic year *y* as compared to the previous one:

$$M5 = \frac{\left(\frac{AM_y^{course}}{AM_{y-1}^{course}}\right)}{\left(\frac{AM_y^{cohort}}{AM_{y-1}^{cohort}}\right)} \times 3$$

$$M5' = \frac{\left(\frac{AM_y^{course}}{AM_{y-1}^{course}}\right)}{\left(\frac{AM_y^{cohort}}{AM_{y-1}^{cohort}}\right)} \times 1.5 + \frac{\left(\frac{STD_y^{cohort}}{STD_{y-1}^{cohort}}\right)}{\left(\frac{STD_y^{course}}{STD_{y-1}^{course}}\right)} \times 1.5$$

AM – average mark
STD – standard deviation of the marks

- Marks increase should be as high as possible, but above the cohort performance change (if any);
- A decrease in the standard deviation is aimed, indicating a more uniform understanding of the cohort (or the absence of students who were lost in some parts of the course)

Proposal for Metric 5 - Evaluation of the acquisitions

Example of application in Chemical Reaction Engineering

Partner	Metric	2013/14	2014/15	2015/16
NCL	M5	2.4	3.2	2.6
	M5´	2.7	3.1	2.8
UL	M5	2.3	2.4	4.1
	M5´	2.7	2.7	3.5

- Variations along time not so clear!...

Refinement of Metric 5

Proposals for the metric in a given course, taking info from academic year *y* as compared to previous 3 academic years:

$$M5 = \frac{\left(\frac{AM_y^{course}}{AM_{y-1;y-3}^{course}}\right)}{\left(\frac{AM_y^{cohort}}{AM_{y-1;y-3}^{cohort}}\right)} \Big/ \frac{\left(\frac{STD_y^{course}}{STD_{y-1;y-3}^{course}}\right)}{\left(\frac{STD_y^{cohort}}{STD_{y-1;y-3}^{cohort}}\right)} \times 3$$

$$M5' = \frac{\left(\frac{AM_y^{course}}{AM_{y-1;y-3}^{course}}\right)}{\left(\frac{AM_y^{cohort}}{AM_{y-1;y-3}^{cohort}}\right)} \times 1.5 + \frac{\left(\frac{STD_y^{cohort}}{STD_{y-1;y-3}^{cohort}}\right)}{\left(\frac{STD_y^{course}}{STD_{y-1;y-3}^{course}}\right)} \times 1.5$$

AM – average mark
STD – standard deviation of the marks

- Fluctuations due to unintended factors are accounted for;
- Metric definition is independent of local grading scale!

Proposal for Metric 5 - Evaluation of the acquisitions

Example of application

Using info from previous 3 academic years

Partner	Metric	2015/16
NCL	M5	**2.5**
	M5´	**2.8**
UL	M5	**3.1**
	M5´	**3.1**

- For NCL, the recorded lectures were always used in Reactor Eng. 1 – change of lecturing staff probably would have influenced the results!
- For UL no major changes have been observed – traditional lectures were used now and in the past.

Proposal for Metric 5 - Evaluation of the acquisitions

Example of application – Reaction Eng. 1 vs Reaction Eng. 2 at NCL

Course	Metric	2013/14	2014/15	2015/16
React Eng 1	M5	2.4	3.2	2.6
	M5´	2.7	3.1	2.8
React Eng 2	M5	2.6	2.7	**4.0**
	M5´	2.8	2.9	**3.5**

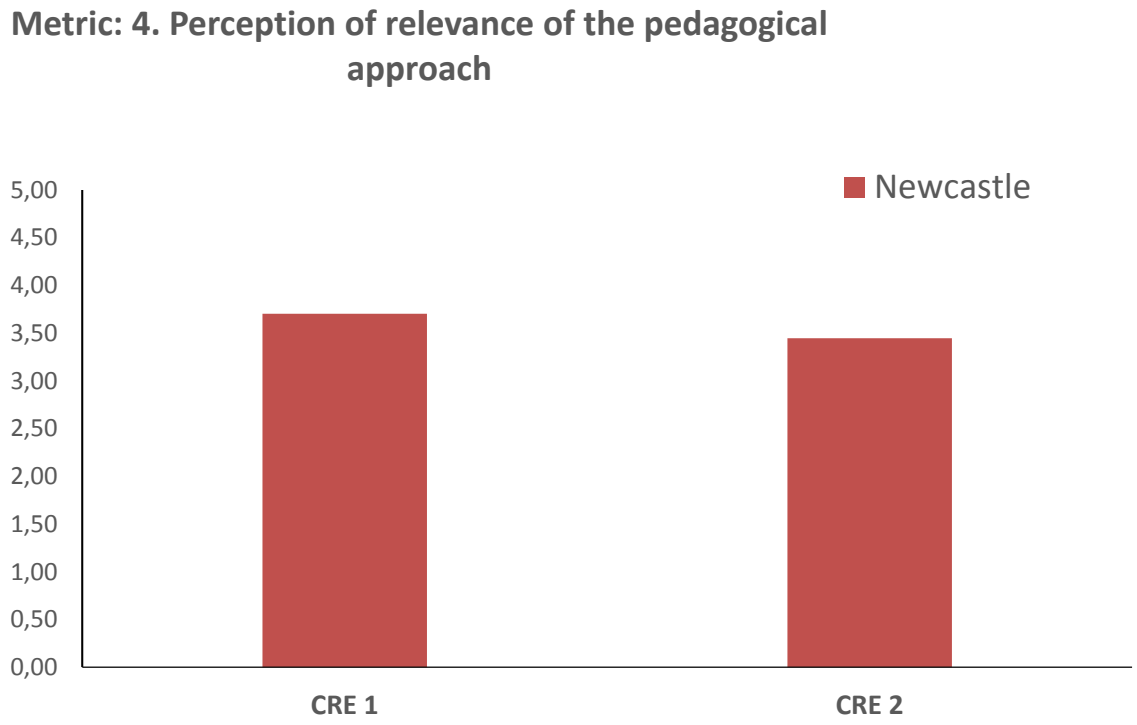
Using info from previous 3 academic years

Course	Metric	2015/16
React Eng 1	M5	**2.5**
React Eng 2	M5	**3.5**

- Apparent positive result in 2015/16 for React. Eng. 2 (CME3035) possibly due to additional recording of the lab instructions! ☺

Metric: 4. Perception of relevance of the pedagogical approach

Stakeholders: only students from NWC (M4=S)



- Students consider pedagogical approaches used **Important** and their opinion remained nearly the same in both semesters (M4);
- But, there is an apparent positive result in M5 for CRE2 (2.5 → 3.5) possibly due to additional recording of the lab instructions. **More effective teaching / learning!** ☺

Conclusions

- The Assessment framework developed in WP3 was piloted (WP4 – Pilot Implementation) at each (6) partner institutions;

- A range of methods of teaching were assessed, including use of recorded sessions, classical teaching methods, etc.;

- Chemical Reaction Engineering course was selected as case-study – it has been classified in all Metrics as Good / Important, for all partners;

Conclusions

- Deviations in metric 5 from the base line (3) were not significant, possibly due to the core subject selected (CRE) and minor changes implemented. More differences are expected (!) when we compare the framework on different subjects with completely new pedagogical approaches.

- The methodology is ready to be tested at these (and other) HEIs for other courses.

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Thank you for your attention

(mmadeira@fe.up.pt)