Mathematics for engineers:

a case study about assessing knowledge and competencies

Cristina Caridade & Deolinda Rasteiro - Coimbra Institute of Engineering, Portugal

Daniela Richtarikova - Slovak University of Technology, Bratislava

STU Slovak University of Technology in Bratislava · isec Engenharia · Politécnico de Coimbra

Mathematics for engineers: a case study about assessing knowledge and competencies

STU SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA | isec Engenharia | Politécnico de Coimbra

20th SEFI SIG in Mathematics Seminar, June 17-18 2021

Agenda

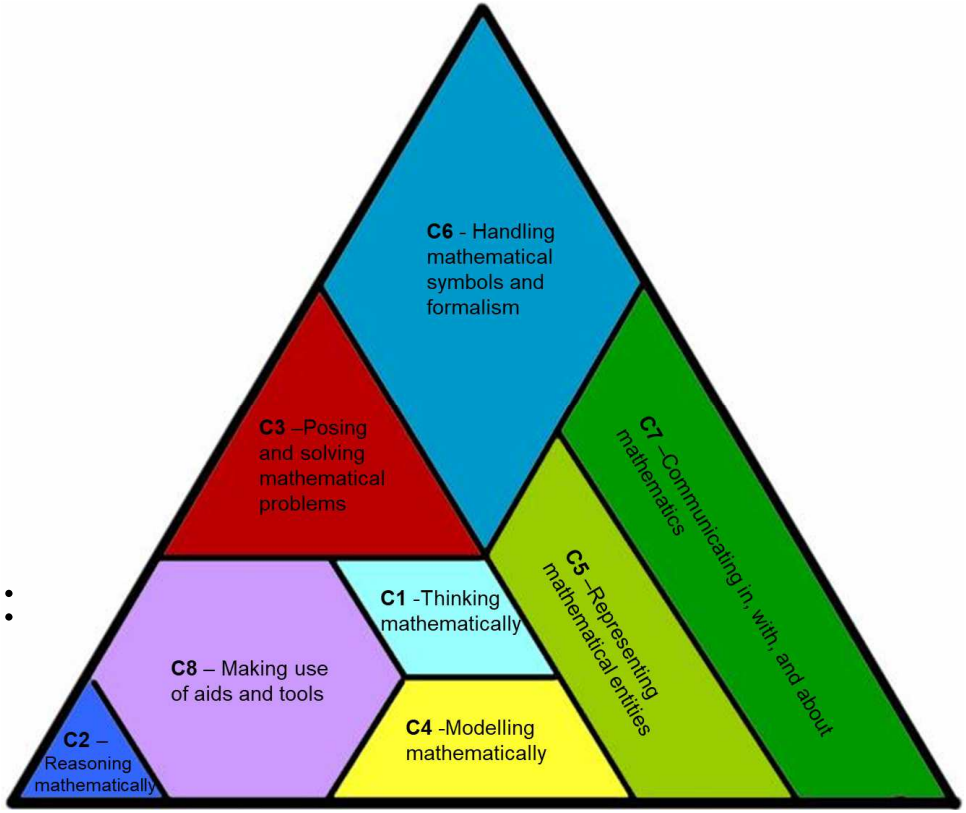
- Introduction
- Methodology
- Case study
- Conclusions

https://www.godfrey.com/insights/thought-leadership/understanding-the-mind-of-the-engineer

INTRODUCTION

Evaluating in education should be understood, not only as a product of education and classification of students, courses, institutions, but mainly as a process with educational, pedagogical, and psychological characteristics.

8 mathematical competencies:

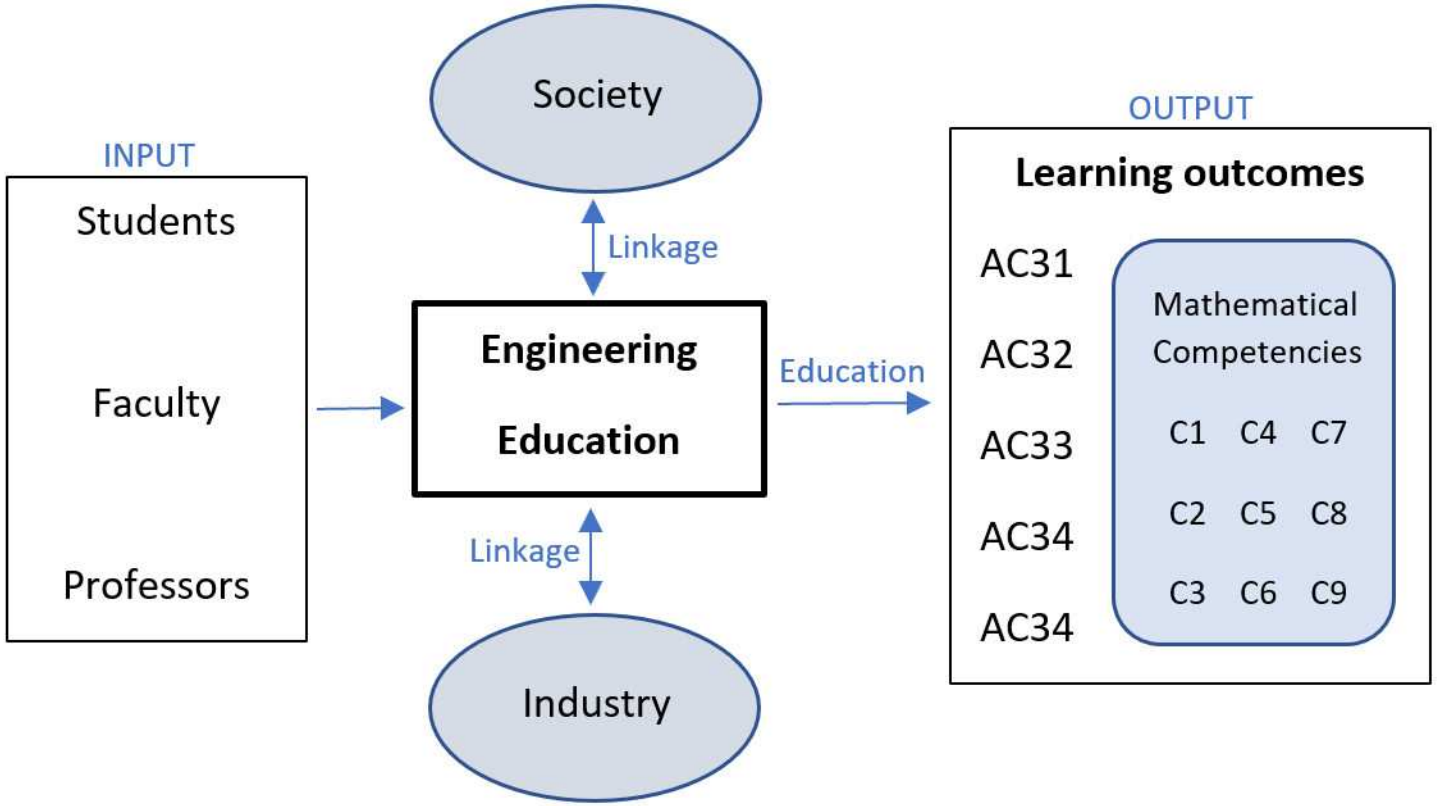


Tangram of 8 pieces

Framework for Mathematical Curricula in Engineering Education

Alpers, B. et al, (2013) “A framework for mathematics curricula in engineering education.” SEFI, 2013. Available online at: http://sefi.htw-aalen.de/

RULES_MATH
NEW RULES FOR ASSESSING MATHEMATICAL COMPETENCIES
https://rules-math.com/



Guide for a Problem

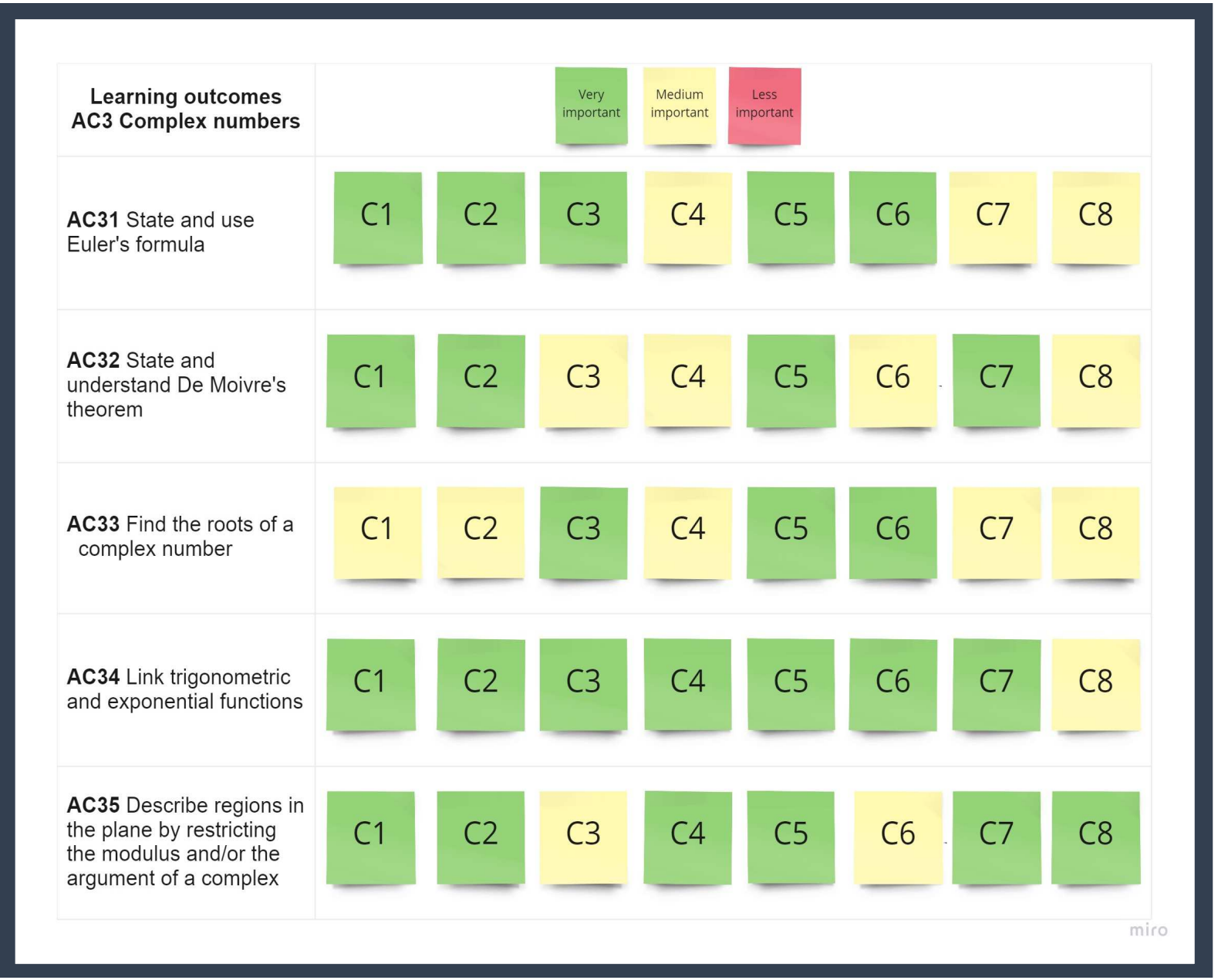
AC3 – Complex numbers

METHODOLOGY

An investigation based on two forms was proposed:

- Analysis of the questions presented in the AC3 guide, their mathematical competencies, and their learning outcomes.

- Analysis of the competencies and learning outcomes acquired by the students through the questions of the AC3 guide.



The 8 competencies

- None is less important.
- Most are very important (62.5%).
- 12.5% are medium important.
- C8 is the least important.
- C5 is the most important.

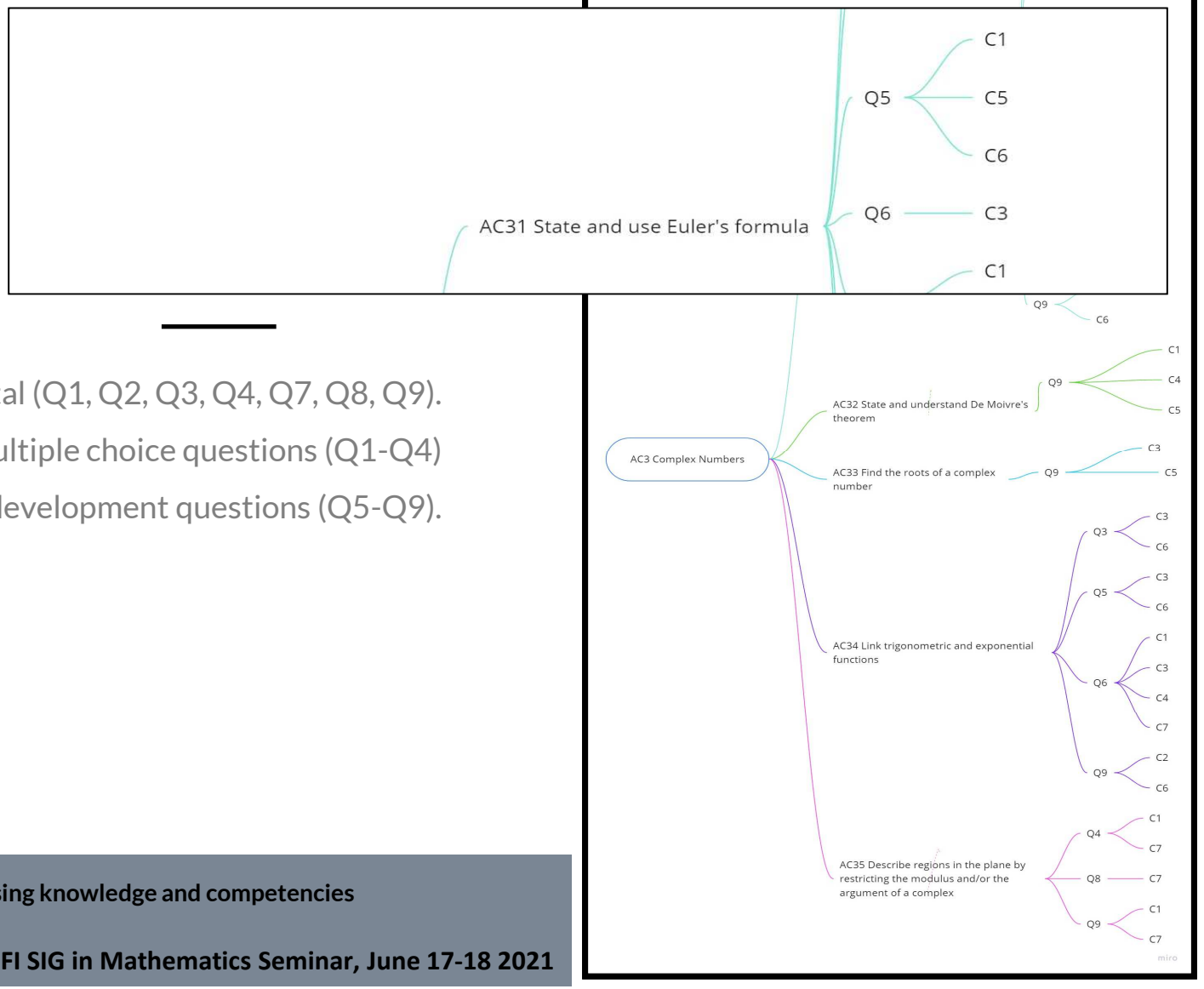
The five learning outcomes

- 62.5% very important – AC31
- 50% - AC32
- 37.5% - AC33
- **87.5% - AC34**
- 75% - AC35.

CASE STUDY

The study was carried out in a group of 126 students of Linear Algebra from Biomedical (20 students), Electromechanical (27 students) and Mechanical (79 students) Engineering in Coimbra Institute of Engineering.

Learning outcomes with degree of competencies involved in this assessment activity



9 questions in total (Q1, Q2, Q3, Q4, Q7, Q8, Q9).

The first 4 were multiple choice questions (Q1-Q4)

and the last 5 development questions (Q5-Q9).

Learning outcomes with degree of competencies involved in this assessment activity coverage

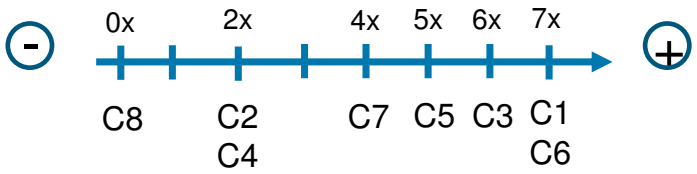
ABOUT TEST

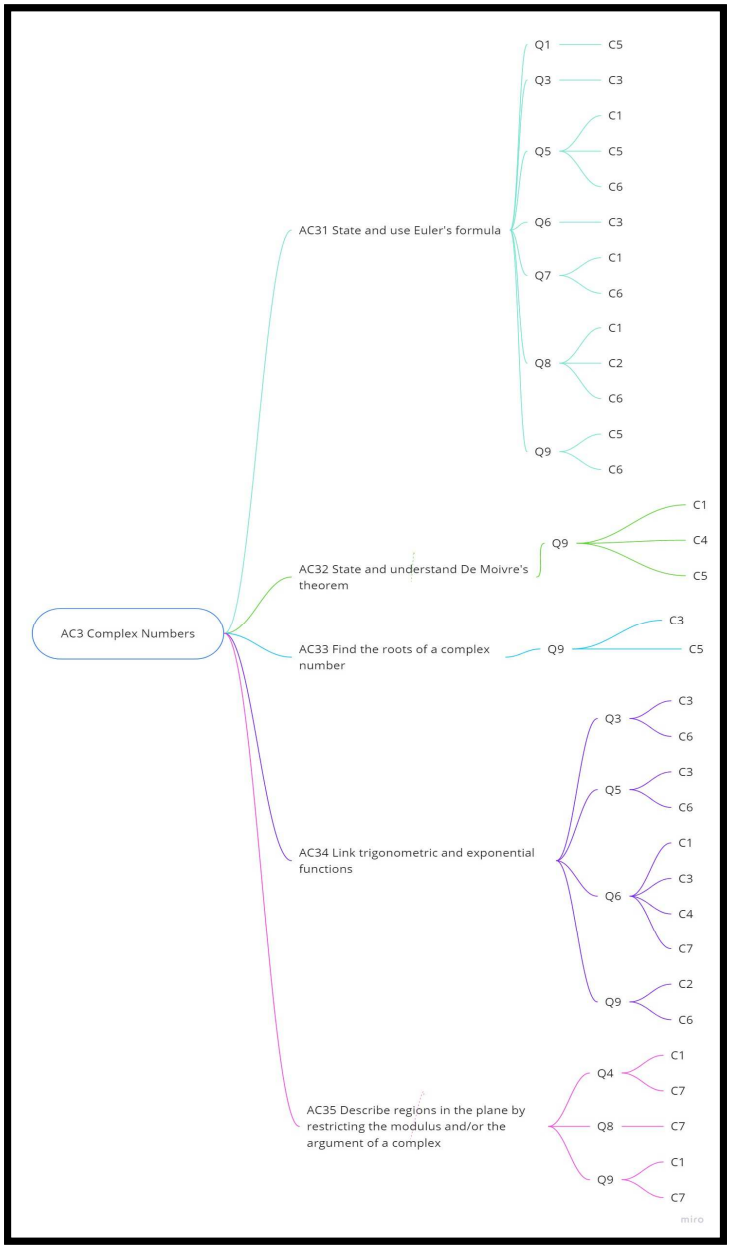
The most frequent learning outcome is the AC31 (7x).

The least frequent is AC32 and AC33 (1x).

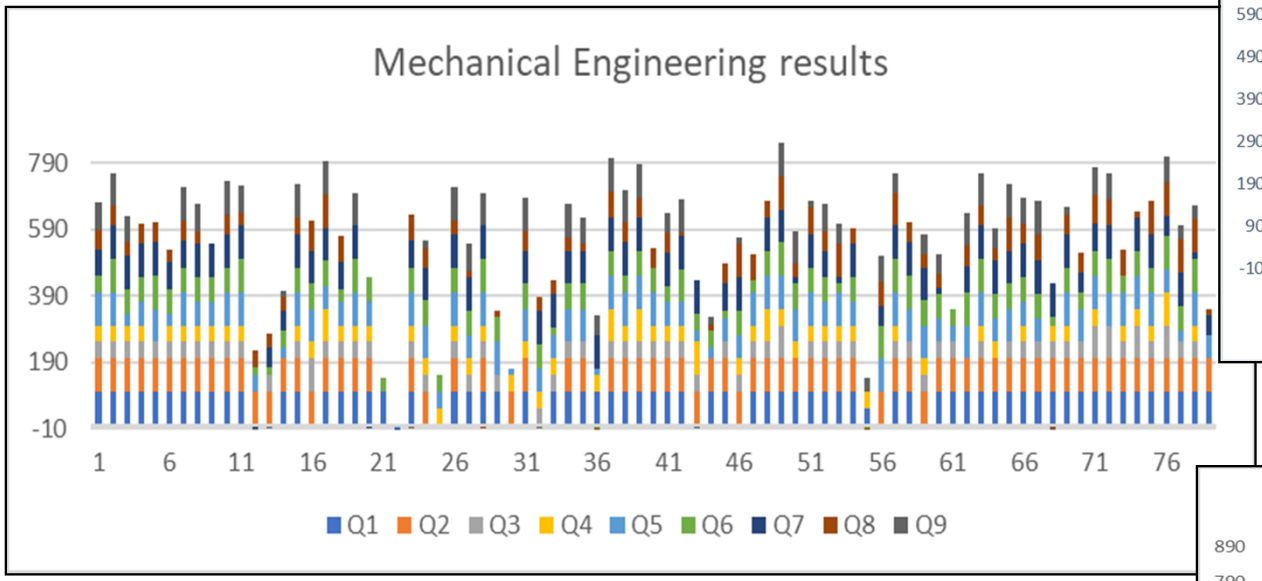
Q9 contains all the learning outcomes.

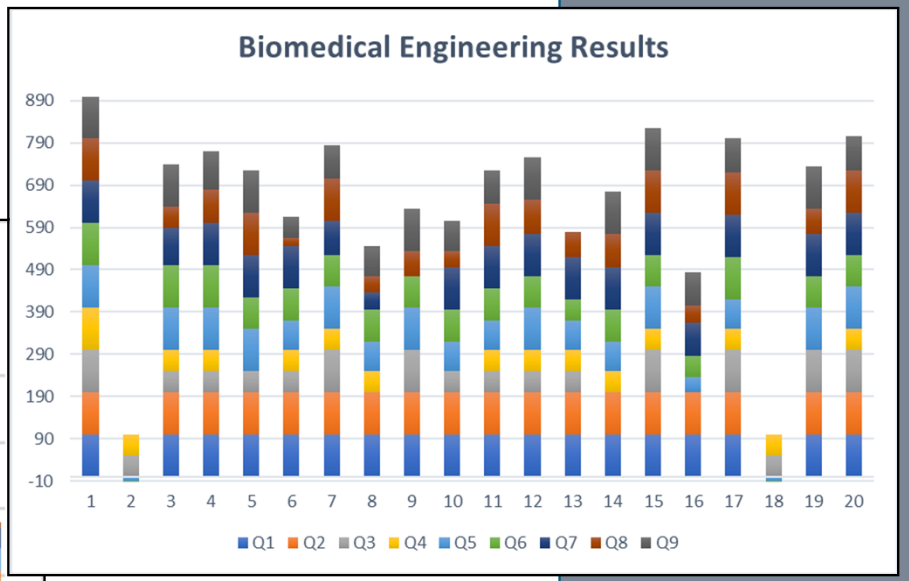
Q4 and Q7 related to one learning outcomes.

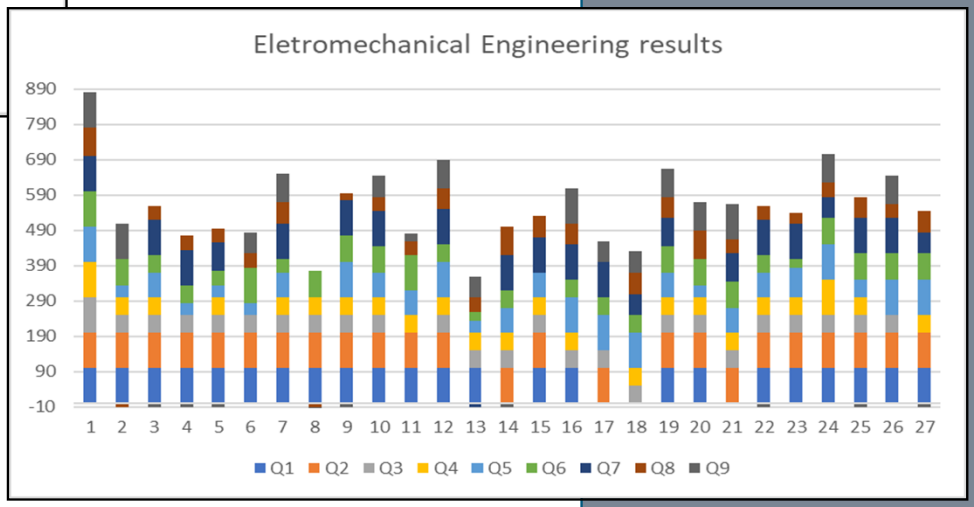




Student's response and interpretation







The results (0%-100%)

Average Biom – Best 90%(Q1, Q2); Worst 40% (Q4).

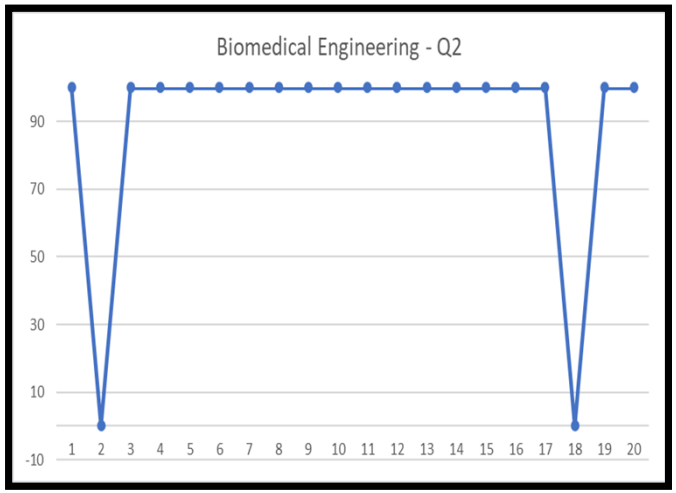
Average ElecMec – Best 89% (Q2); Worst <50% (Q3, Q4, Q8).

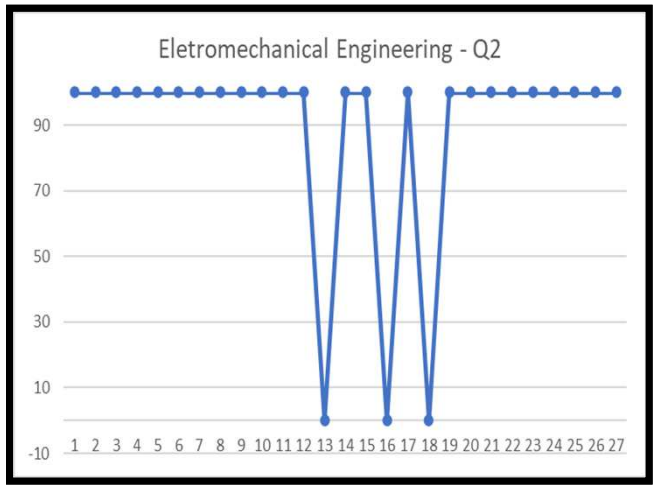
Average Mec – Best 87% (Q2); Worst <50% (Q3, Q4).

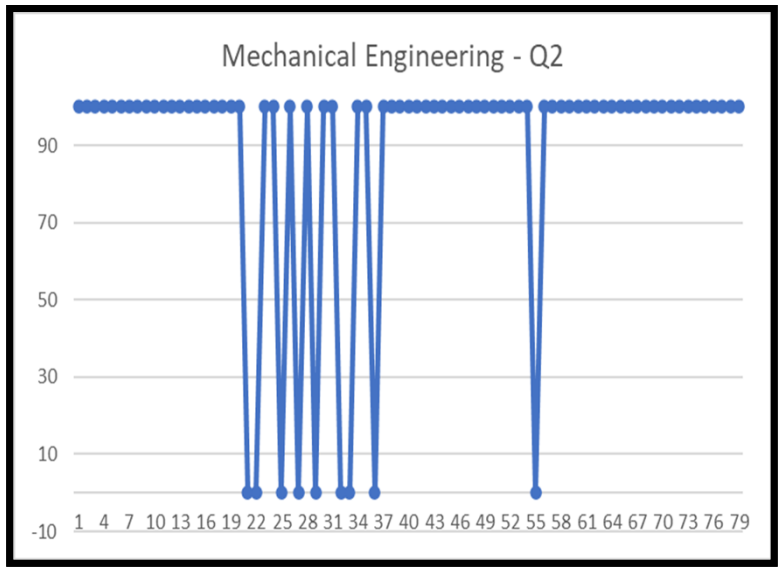
2) Given $z = a + bi$, the result of the sum of complex conjugates z and $\overline{z}$ is:

- ☐ a) 0.
- ☐ b) $2bi$.
- ☐ c) $2a$.
- ☐ d) 1.
- ☐ e) $-2a$.
- ☐ f) $2b$.
- ☐ g) $-2b$.
- ☐ h) $a^2 + b^2$.
- ☐ i) $a^2 - b^2$.
- ☐ j) other: ...

Results obtained in question Q2







112 students with score 100%

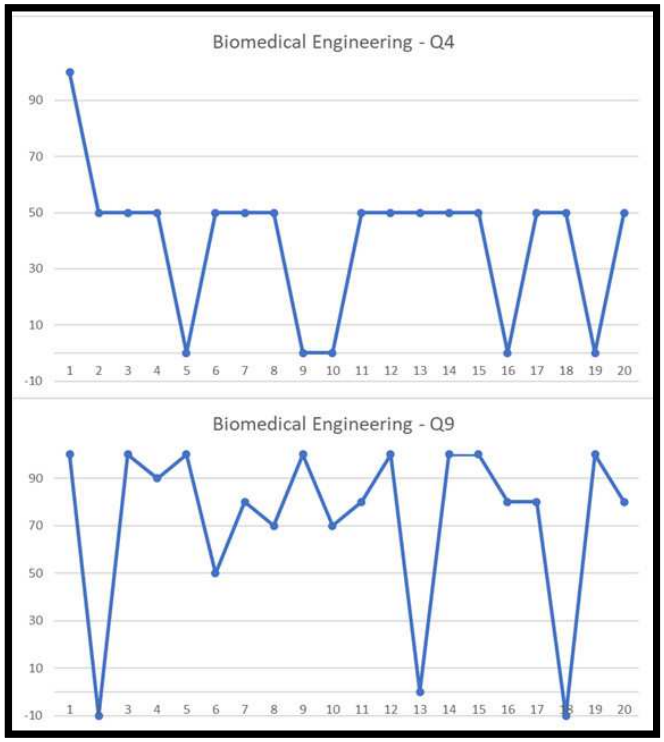
18 students (20) – Biom.

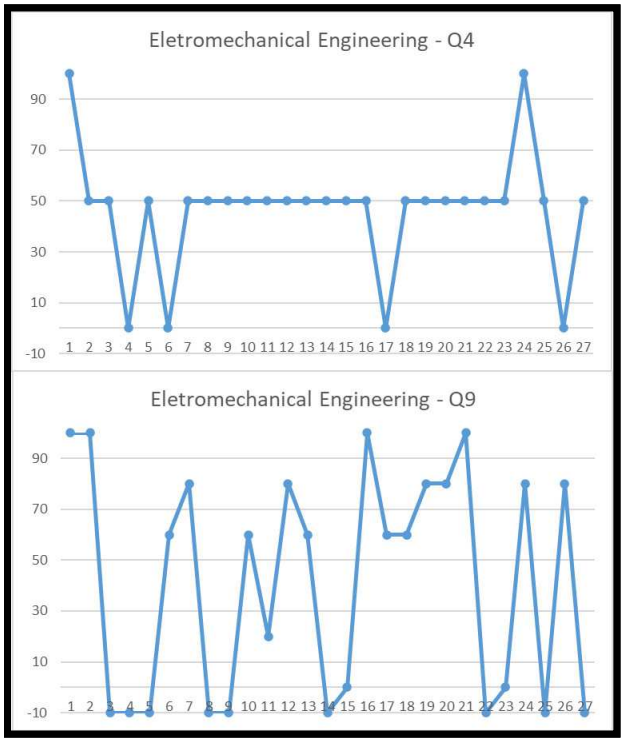
24 students (27) – ElecMec.

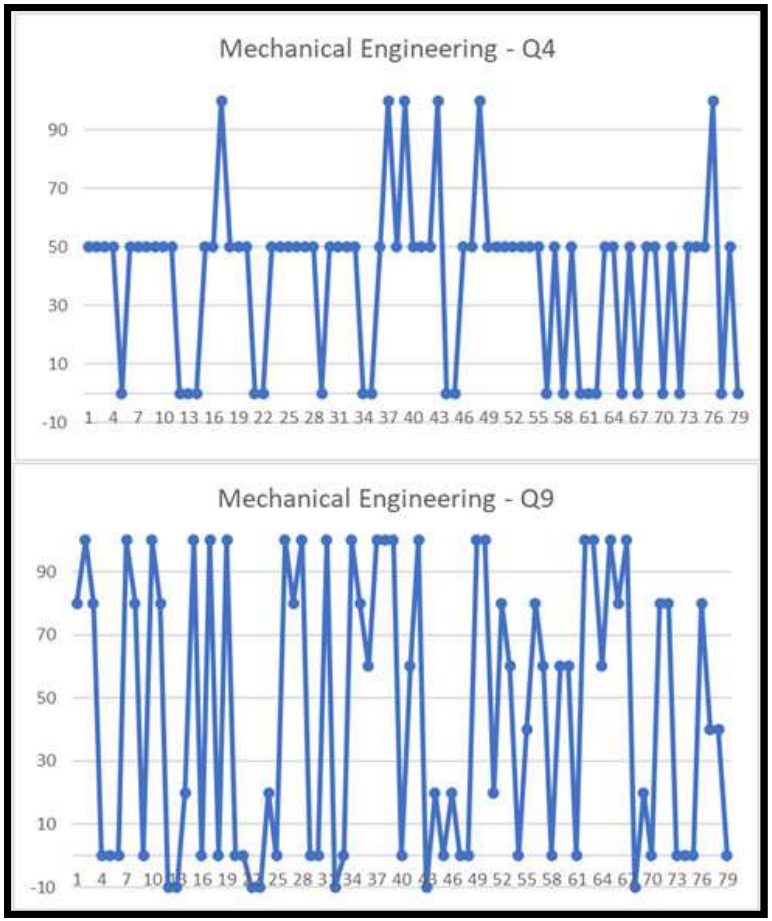
70 students (79) – Mec.

14 students with score 0%

Results obtained in question Q4 and Q9







4) Images of complex conjugates in Gauss plane are:

- ☐ a) Symmetric about horizontal axis.
- ☐ b) Symmetric about real axis.
- ☐ c) Symmetric about origin of axes.
- ☐ d) Not symmetric.

9) Solve the given equation in $\mathbb{C} : x^3 - 8 = 0$. First deduce, how many roots the equation has, then try to sketch the graph of all roots, estimate their characteristics (Re e Im ou ρ e θ), and after all solve.

CONCLUSIONS

From the results obtained, it was found that students acquired the learning outcomes and mathematical competencies.

In general all the students obtained positive marks.

Q3 and Q4, below 50%, (Electromechanical and Mechanical Engineering).

Some students have negative results:

- Need greater support from the teacher,
- It will be possible to identify the students, the mathematical competences and learning objectives that they need more attention.
- Use office hours, support classes or zoom classes to reduce the negative cases that have been identified.

CONCLUSIONS

This methodology can and should be used by teachers in preparing their students' assessment exercises. On the other hand, it allows teacher, to verify if the student has acquired all the learning and competencies involved.

It is essential to develop processes that help understand the difficulty of engineering students in mathematics. In which learning objectives students have more difficulties and what mathematical competencies are more difficult for future engineers to acquire.

CONCLUSIONS

We will continue applying this model in the teaching and evaluation of engineering students and we encourage other teachers to use it too.

SEFI SIG in Mathematics Seminar, June 17-18 2021

THANK YOU FOR YOUR ATTENTION

Cristina Caridade
(caridade@isec.pt)