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Using Technology To Teach/Learn Mathematics, How Are We As Teachers Fostering Mathematics Education Mobility?

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Using Technology to Teach/Learn Mathematics, How Are we as Teachers Fostering Mathematics Education Mobility?

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ABSTRACT

Mathematics education plays a critical role in developing analytical thinking, problem-solving skills, and logical reasoning abilities among students. With the rapid advancements in technology, the integration of Information and Communication Technology (ICT) has opened new possibilities for teaching and learning mathematics. In the field of engineering education, the use of ICT tools and methodologies has gained significant attention due to their potential to enhance mathematical understanding and application within an engineering context.

Traditionally, mathematics was taught using traditional pedagogical methods such as lectures, textbooks, and pen-and-paper exercises. However, the integration of ICT tools significantly enhanced the teaching and learning experience. Interactive simulations, computer algebra systems, graphing calculators, educational software, and online resources offer dynamic and engaging platforms for exploring mathematical concepts.

In Engineering Education, the integration of ICT tools in mathematics instruction has become increasingly prevalent. Engineering-specific software packages, computational tools, and programming languages provide students with practical applications of mathematics in engineering contexts. The use of virtual laboratories, simulation software, and data analysis tools helps students connect mathematical concepts to real-world engineering problems.

It seems widely accepted that integration of ICT in mathematics education, particularly in the field of engineering education, has transformed traditional teaching and learning approaches. By leveraging the power of technology, educators can enhance students' understanding, engagement, and application of mathematics. As technology continues to advance, embracing ICT integration in mathematics education becomes imperative to prepare students for the challenges and opportunities of the engineering profession.

In this paper we will present the results of a questionnaire, answered by 29 teachers from 16 countries at the SEFI'2023 conference. This questionnaire delved into teachers' perspectives on utilizing ICT tools and different pedagogical strategies for teaching mathematics.

1 MOTIVATION AND LEARNING OUTCOMES

With this workshop authors intended to do a survey of the software, platforms, ICT approaches that are used by the attendees and the achievements in terms of consolidated knowledge.

Attendees were invited to answer some specific questions regarding ICT platforms and software possible to use while teaching and/or learning Mathematics and perform an evaluation of how their perception of the knowledge is acquired by their students. After collecting the above information, a discussion/reflection period between the attendees was promoted in order to generate conclusions that are fruitful and may be

accomplished by Mathematics teachers when returning to their universities. A not necessarily equal but similar way of teaching and learning Mathematics across Europe is crucial for fostering educational mobility and enhancing students' mathematical competence. By aligning pedagogical methods, curricula, and learning outcomes, students can benefit from a harmonized educational experience that transcends borders. Collaboration, consistent academic standards, and a strengthened European identity are the fruits of such endeavours. Embracing this shared vision of Mathematics education will prepare students to tackle the challenges of a globalized world and contribute to the development of a highly skilled and interconnected workforce.
The following bullet points summarize the content of the workshop and its design:

- A 10-minute activity showing the most common ICT tools used by Mathematics teachers
- A 10-minute activity of individual reflection and questionnaire answers
- A 30-minute discussion/reflection among all attendees
- A 10-minute wrap-up and conclusions document construction to take away.

2 BACKGROUND RATIONALE AND RELEVANCE

Mathematics education plays a critical role in developing analytical thinking, problem-solving skills, and logical reasoning abilities among students. With the rapid advancements in technology, the integration of Information and Communication Technology (ICT) has opened up new possibilities for teaching and learning mathematics. In the field of engineering education, the use of ICT tools and methodologies has gained significant attention due to their potential to enhance mathematical understanding and application within an engineering context. This workshop delves into the state of the art in teaching mathematics, emphasizing the integration of ICT tools and techniques in engineering education and their evaluation by the workshop attendees.
Mathematics serves as a foundation for various disciplines, including engineering. It develops logical thinking, quantitative reasoning, and problem-solving abilities. A solid mathematical background is crucial for students to succeed in their engineering education and future careers.
Traditionally, mathematics was taught using traditional pedagogical methods such as lectures, textbooks, and pen-and-paper exercises. However, the integration of ICT tools significantly enhanced the teaching and learning experience. Interactive simulations, computer algebra systems, graphing calculators, educational software, and online resources offer dynamic and engaging platforms for exploring mathematical concepts. By integrating ICT in Mathematics Education several benefits may be accomplished, such as
1. Visualization and Conceptual Understanding: ICT tools facilitate the visualization of complex mathematical concepts, enabling students to develop a deeper understanding of abstract ideas. Dynamic visual representations and simulations help students grasp mathematical relationships and patterns more effectively.
2. Active Learning and Engagement: ICT tools promote active learning by providing interactive platforms for students to actively engage with mathematical problems. Students can explore mathematical concepts through hands-on activities, simulations, and multimedia resources, fostering a deeper level of engagement and motivation.

3. Personalized Learning and Differentiation: ICT allows for personalized learning experiences tailored to individual student needs. Adaptive software and online platforms can provide targeted instruction, immediate feedback, and adaptive challenges, catering to students' unique learning styles and paces.
4. Collaborative Learning: ICT tools enable collaborative learning experiences, facilitating communication and collaboration among students. Virtual platforms and online forums create opportunities for students to discuss, solve problems, and share mathematical insights, fostering a collaborative and supportive learning environment.
In Engineering Education, the integration of ICT tools in mathematics instruction has become increasingly prevalent. Engineering-specific software packages, computational tools, and programming languages provide students with practical applications of mathematics in engineering contexts. The use of virtual laboratories, simulation software, and data analysis tools helps students connect mathematical concepts to real-world engineering problems.

3 RESULTS AND CONCLUSIONS

Twenty nine individuals from 16 different countries, Fig. 1, were present at the workshop and answered the proposed questionnaire.

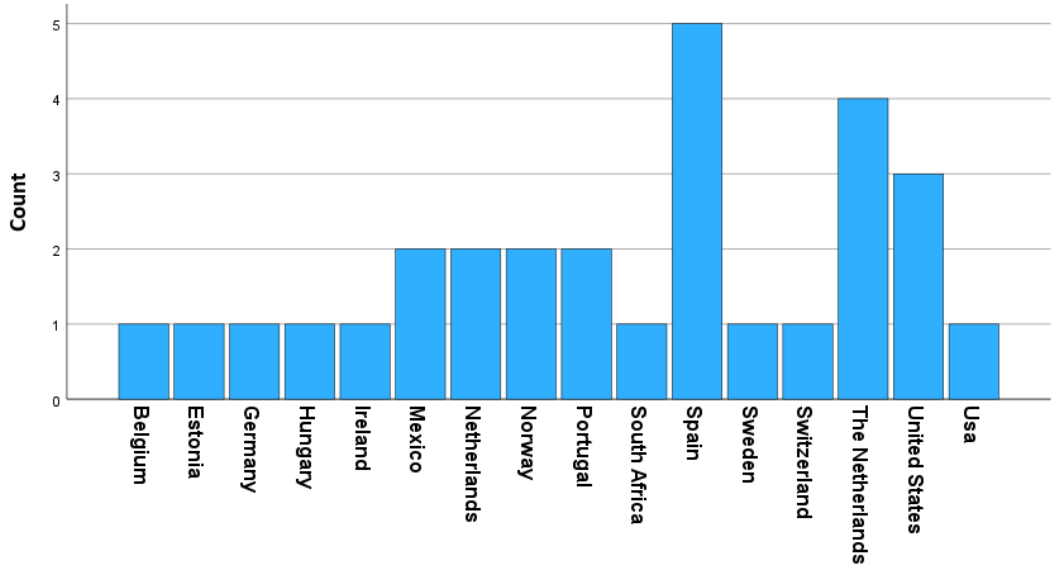

Fig. 1. Attendees origin country

The gender distribution was balanced between male and female individuals, as shown at the pie chart below, which allows to analise possible different perspectives

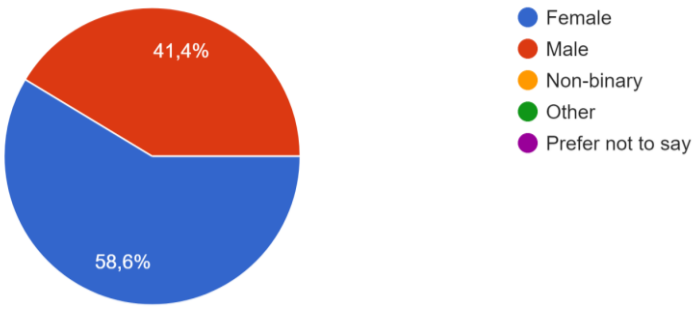

Fig. 2. Attendees gender

The years of teaching experience among workshop attendees were also considered an important variable that could potentially influence the subjects being discussed. As evident from the histogram, Fig. 3, representing attendees' years of teaching experience, the sample includes individuals from all experience levels.

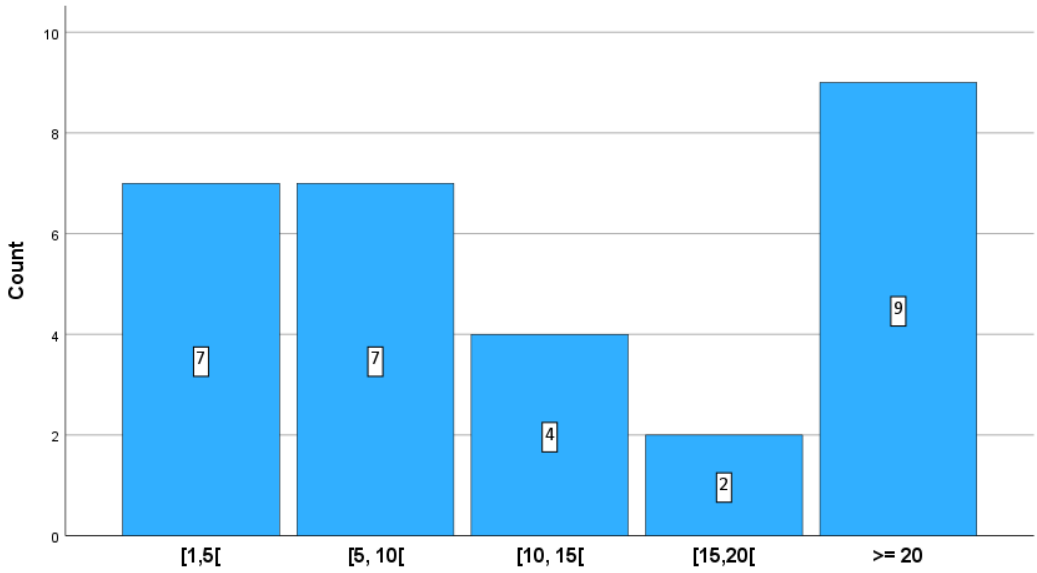

Fig. 3. Attendees teaching experience years

From a list of possible Mathematics curricular units, which may have different strategic pedagogical approaches, attendees were asked to choose which ones did they teach. At Fig. 4 we may observe their answersy

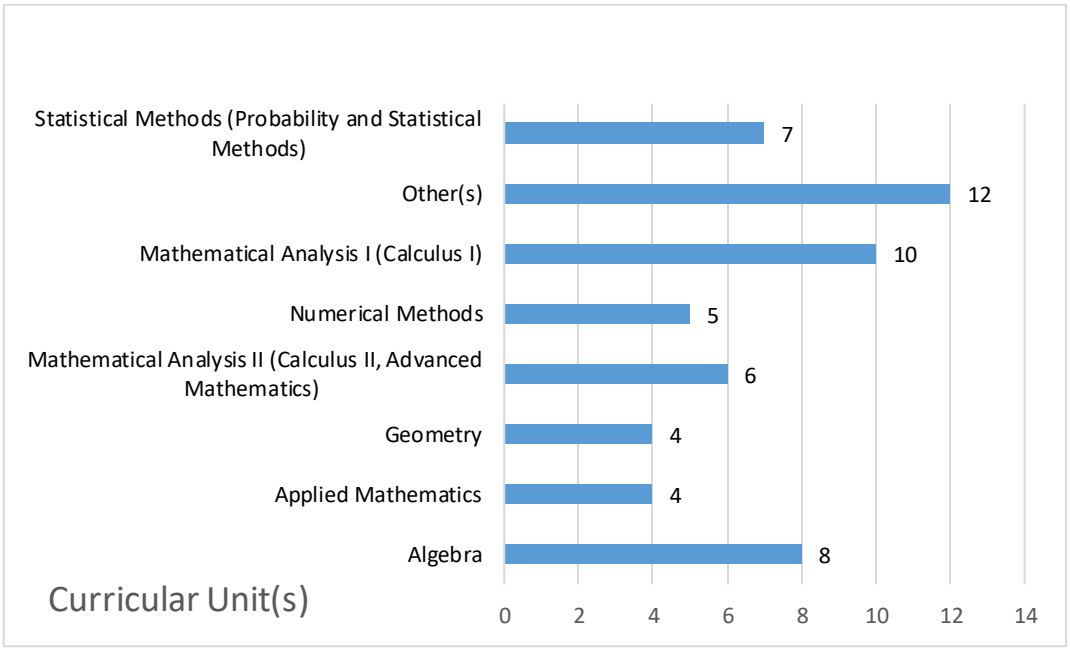

Fig. 4. Attendees curricular units taught

Regarding different pedagogical strategies, Fig. 5, we observed that all attendees use at least one pedagogical strategy besides standard education model (expository using only blackboard).

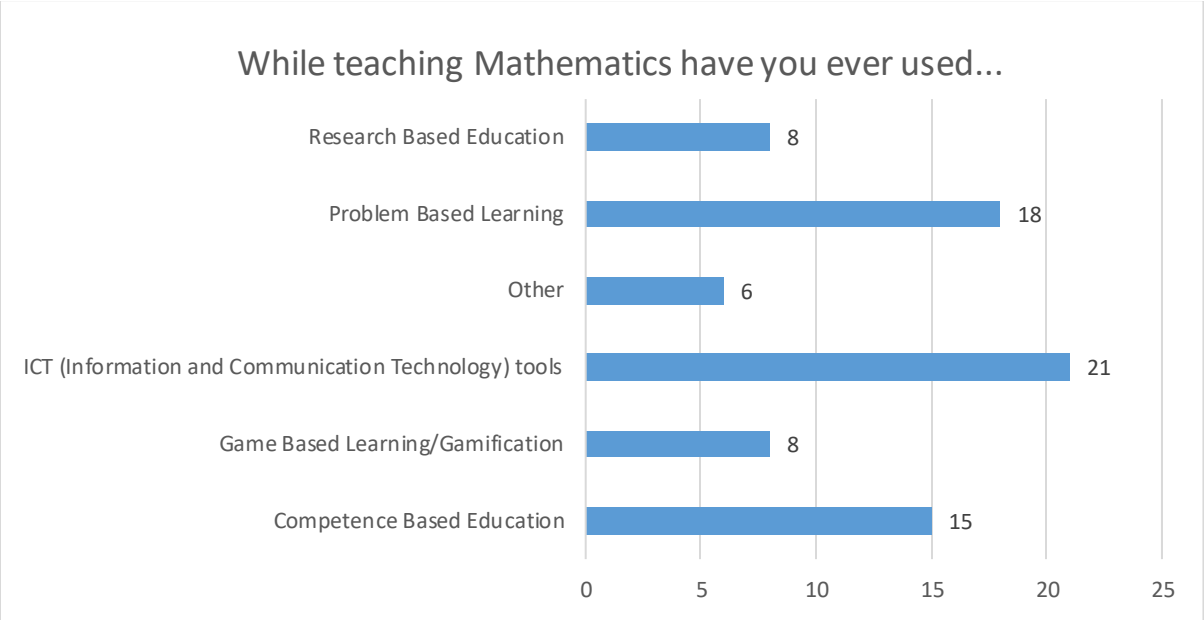

Fig. 5. Attendees pedagogical strategies

When asked about the frequency with which the above mentioned pedagogical methods were applied, we may observe, Fig. 6, that their applicability are at nearly half the amount of classes taught within a semester.

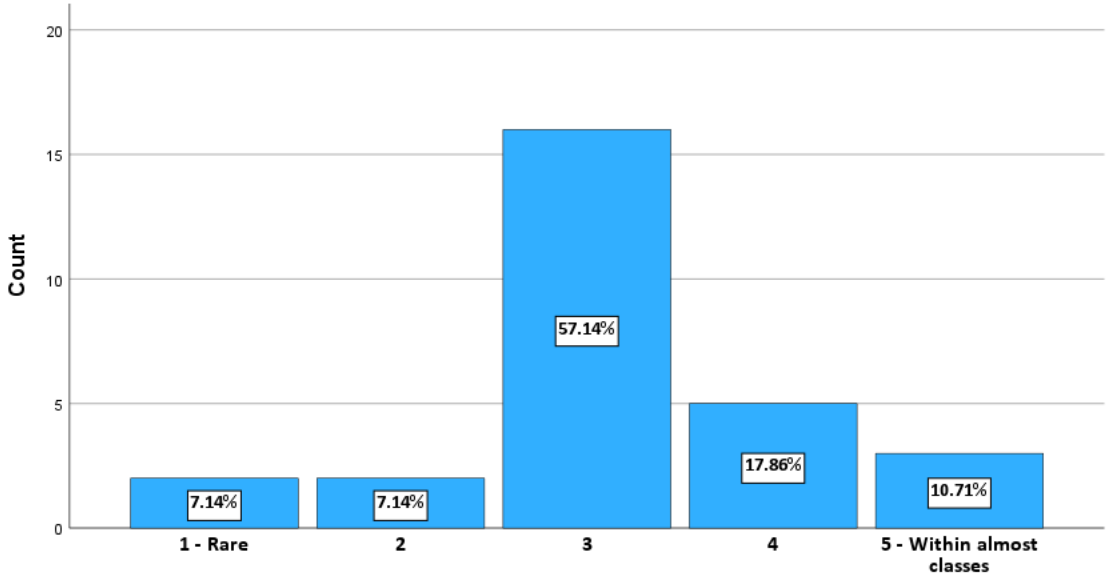

Fig. 6. Attendees different pedagogical strategies usage

When trying to apply these strategies difficulties arise and the pointed main ones that attendees face when overcoming traditional pencil and paper Mathemaics classes were, Fig. 7,

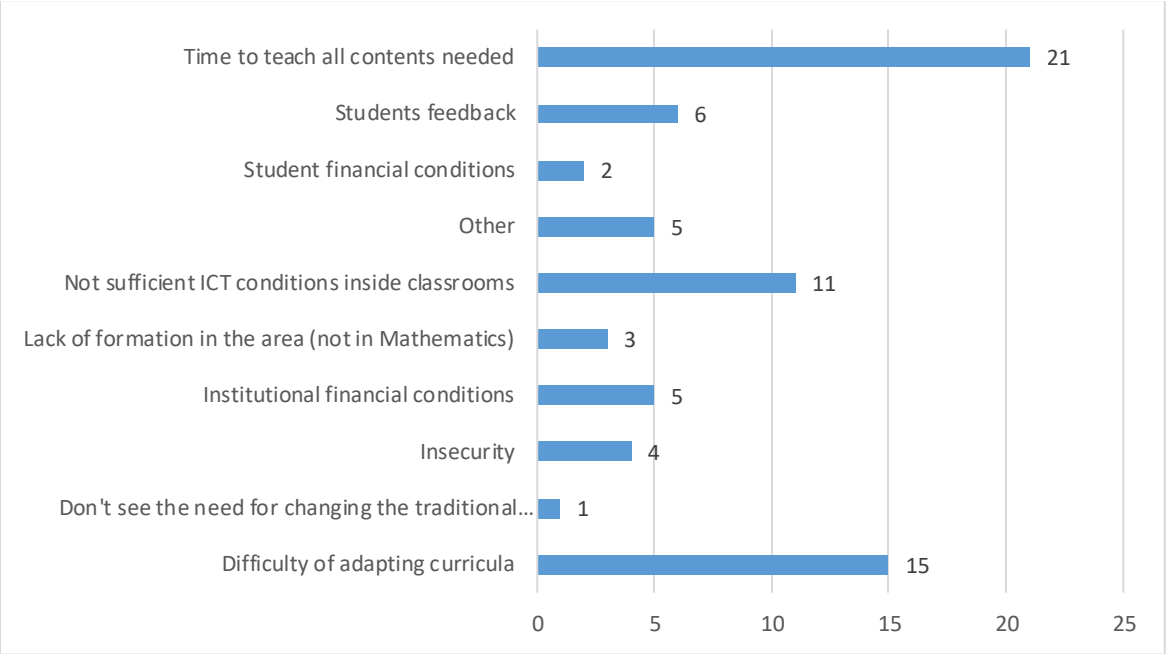

Fig. 7. Attendees main diffilcuties regarding the applicability of different strategies

It's worth noting that the major challenges lie in the time required to teach all necessary content and adapt the curriculum. In future endeavors, fostering synergies between those responsible for engineering curriculum development and mathematics teachers should be regarded as a crucial theme.
The purpose of ICT tools usage inside classes are, for the present attendees, Fig. 8,

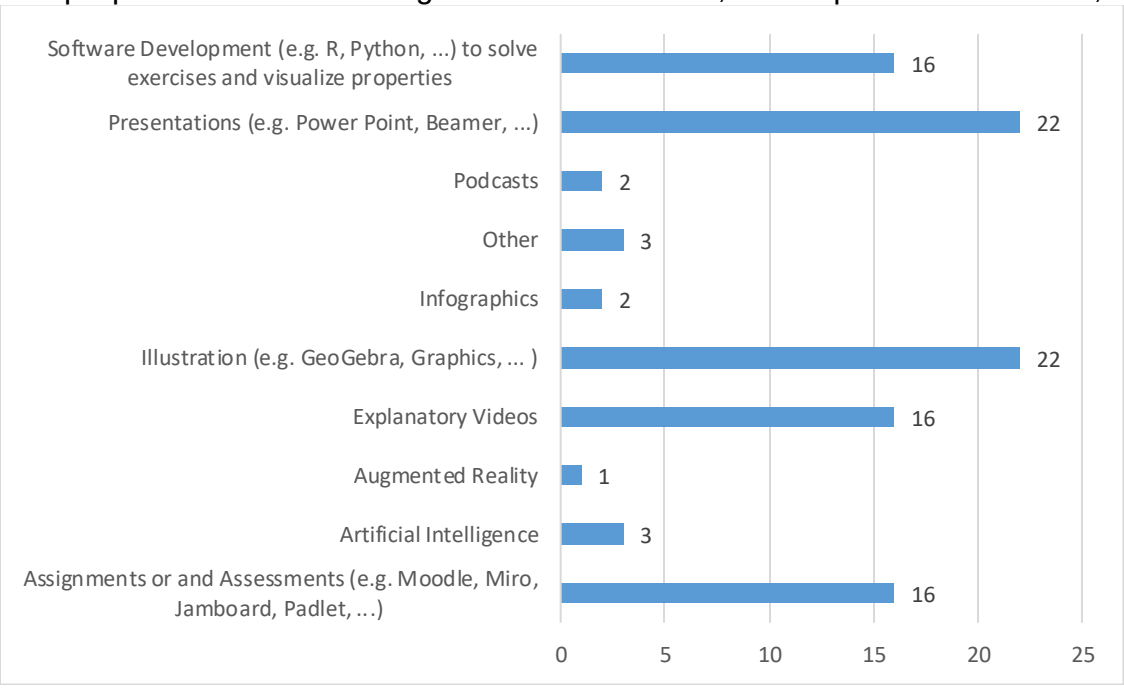

Fig. 8. Attendees ICT tools usage purpose

Students feedback regarding the use of ICT tools is encouraging as expected

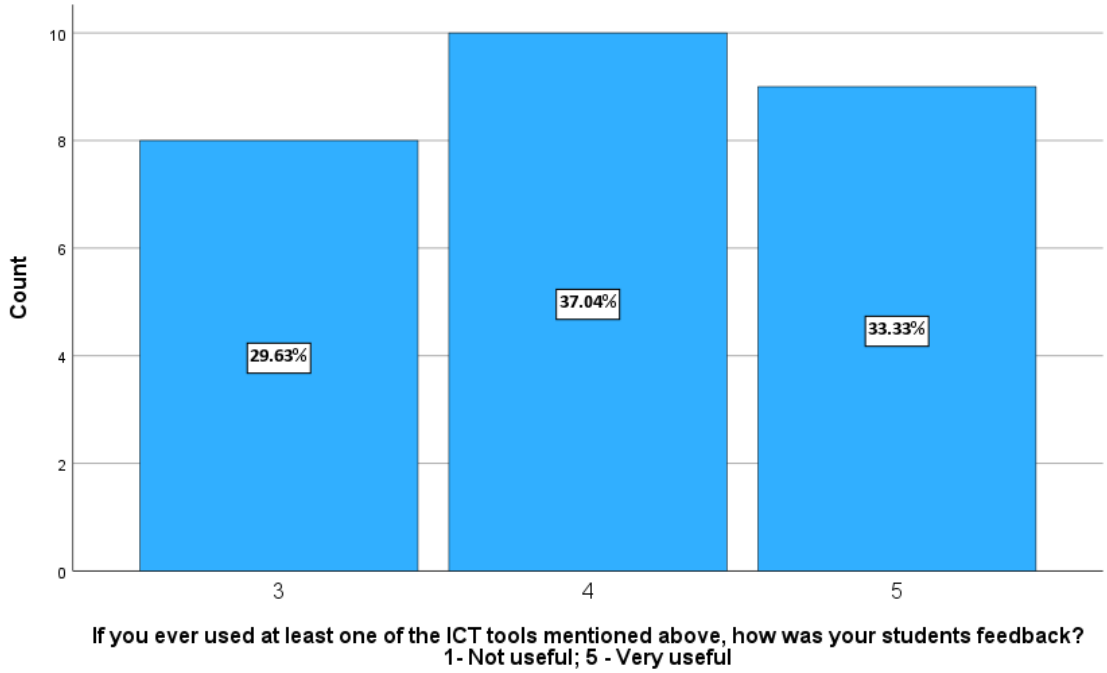

Fig. 9. Attendees students feedback

At the conclusion of the semester, attendees' perception of students' apprehending mathematical concepts is moderate. This suggests that nearly all students grasp the concepts to some extent, although they may not achieve expertise. However, the concepts can be considered as having been apprehended by the students.

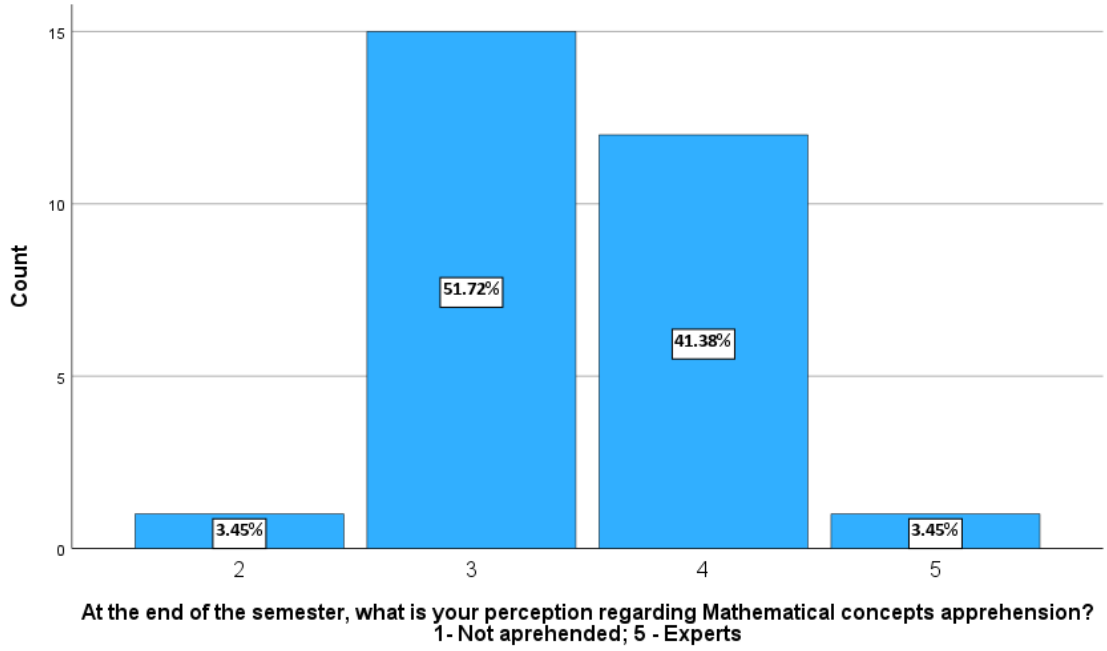

Fig. 10. Attendees' students concepts aprehension

Nevertheless, apprehending the concepts is not a synonym of rigorous application and the attendees' perception regarding the rigour with which the Mathematical concepts were grasped reflects it, Fig. 11,

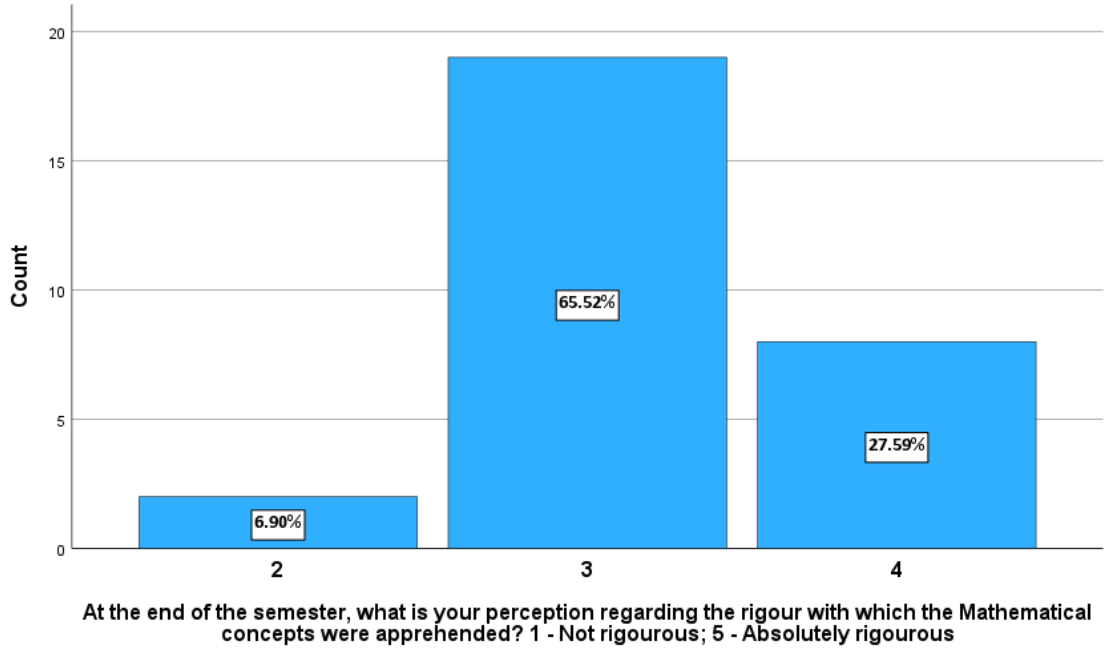

Fig. 11. Attendees' students concepts rigour

Authors were also interested in understanding which Mathematical competences were most valued by the attendees. The answer to that question reveals that to the attendees present at this workshop the most valued competences are the ability to be critical about the solution obtained and also the ability to apply the acquired knowledge to a different situation as we may observe on Fig. 12 a) b)

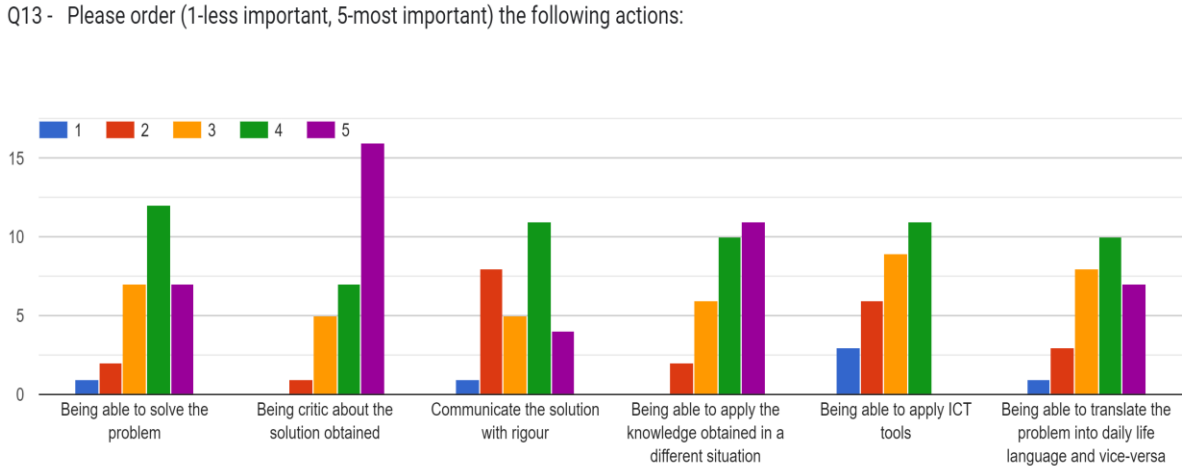

Fig. 12 a). Attendees competences ordering

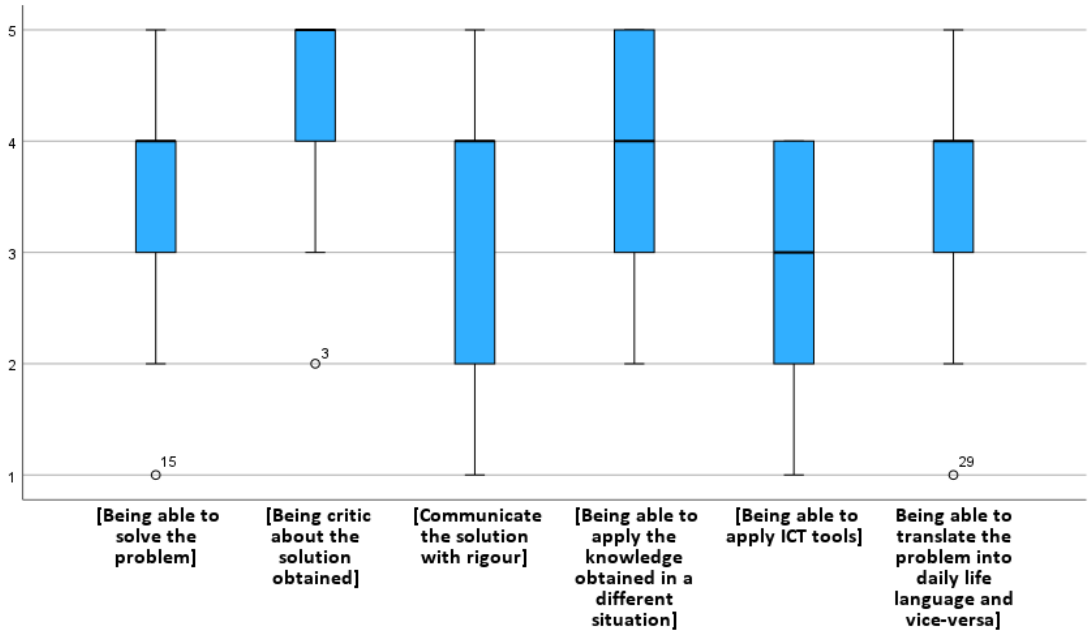

Fig. 12 b). Attendees competences ordering box-plot comparison

At the end of the questionnaire authors asked attendees to share some fruitful educational experience in terms of: pedagogy, ICT tools used, assessment procedures, etc., and the inputs received were the following:

- Challenge-Based learning, Using Möbius to provide feedback and test;
- ICT tools: use Mathematica for numerical methods;
- 3blue1brown makes very good infographics. Fliped classroom works well if the videos are short covering only one subject and can be speed up;
- Using Padlet in laboratory classes;
- Integration Competition;
- Vevox for class engagement, Brightspace for notes and assignment uploads. Regular communication;
- Integration with engineering design, science and mathematics for an authentic problem or product;
- Escape room for review, mind map with the different topics;
- Workshops with students using challenges and experiments as a way to foster thinking and stimulate interest demonstrating that science (stem) can be funny;
- Using Geogebra for dynamic illustration is simple and worthwhile;
- Individually collected data analysis team-project in Statistics course;
- My students have been using Jupyter notebooks for image processing, where concepts of linear algebra are treated;
- Creating/updating activities/tasks that were used for in person teaching to a virtual teaching could be one aspect that we should focus in using Technology in Mathematics education;
- Discussing language models and how they relate to conditional probability, and having students start googling searches and discuss why Google proposes different next words for us;

- Not mine but simple and still beautiful work of some colleagues: "Algorithmic Battle". Students team up against each other developing algorithms for hard combinatorial problems and instance generators to generate tricky instances;
- Peer assessment;
- Students don't mind being prompted with questions as long as grade not affected;
- Service Learning;
- Geogebra can be incredibly useful for students to use themselves to visualise. For example (this is high school level) when learning about the unit circle and sinus and cosines as functions, applets in Geogebra can be a huge addition;
- I teach a combined ordinary differential equations and linear algebra course for engineering students. Through collaboration with the engineering department, we created an integrated lab component to the course involving a mix of numerical methods and experimental data. As an example, we use a beam deflection lab to have students measure the system's Green function;
- The use of Polya's 4 step method to encourage students to be critical of their own answers or those of others proved to work really well for me in a high school context;

4 SIGNIFICANCE FOR EDUCATION

It seems widely accepted that integration of ICT in mathematics education, particularly in the field of engineering education, has transformed traditional teaching and learning approaches. By leveraging the power of technology, educators can enhance students' understanding, engagement, and application of mathematics. As technology continues to advance, embracing ICT integration in mathematics education becomes imperative to prepare students for the challenges and opportunities of the engineering profession.

In an increasingly interconnected world, fostering education mobility has become essential for preparing students to thrive in a globalized society. Within the realm of mathematics education, promoting not necessarily equal but similar teaching and learning approaches across Europe holds great importance. Harmonizing mathematical education methods and fostering mobility among students, emphasizing the advantages of a shared pedagogical framework in promoting educational excellence and enhancing students' mathematical competence is a preoccupation of some teachers. Europe is a diverse continent with a multitude of educational systems and approaches to teaching mathematics. While each country has its unique cultural and educational context, fostering a more similar framework of mathematics education can bridge the divide between different systems. This ensures that students, regardless of their geographic location, have access to high-quality mathematics education and can seamlessly transition between educational systems. Promoting a similar approach to teaching and learning mathematics across Europe facilitates educational mobility for students. When mathematical concepts and pedagogical methods align, students can transfer their knowledge and skills more easily when moving between countries or participating in international exchange programs. This mobility opens doors for students to experience different educational systems, gain diverse perspectives, and develop adaptability skills. A shared understanding and implementation of mathematics education methods can contribute to the establishment of consistent academic standards across Europe. By aligning curricula,

learning outcomes, and assessment practices, educational institutions can ensure that students receive a comparable level of mathematical education, regardless of their location. This consistency fosters transparency and helps students and employers recognize and evaluate mathematical competence uniformly.

Promoting similar teaching and learning approaches in mathematics encourages collaboration and knowledge exchange among educators across Europe. When educators share best practices, pedagogical strategies, and innovative approaches to teaching mathematics, it enriches the professional development of teachers and contributes to the continuous improvement of mathematics education. This collaboration can occur through teacher training programs, conferences, online platforms, and professional networks. By embracing a shared pedagogical framework, Europe can foster a sense of unity and belonging among its diverse nations. This shared educational experience helps create a cohesive community, where students can learn from one another, appreciate cultural diversity, and develop a deeper understanding of their European counterparts.

5 ACKNOWLEDGMENTS

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