STUDENTS' INTERNATIONAL COMPETITION – PROMOTING ENGAGEMENT AND SOCIAL SKILLS

F. Soares[1], A.P. Lopes[1], V. Bocanet[2], K. Brown[3], A. Cellmer[4], I. Kierkosz[4], O. Labanova[5], C. Serrat[6], A. Uukkivi[5]

[1]CEOS.PP / ISCAP / P.PORTO (PORTUGAL)
[2]Technical University of Cluj-Napoca / UTC (ROMANIA)
[3]Letterkenny Institute of Technology / LYIT (IRELAND)
[4]Koszalin University of Technology / PK TUK (POLAND)
[5]TTK University of Applied Sciences / TTK UAS (ESTONIA)
[6]Universitat Politècnica de Catalunya-Barcelona TECH / UPC (SPAIN)

Abstract

Six Higher Education Institutions (HEI), from different European countries (Estonia, Ireland, Poland, Portugal, Romania, and Spain) joined forces in 2018 to launch a shared Erasmus+ Project under the Key Action - Cooperation for innovation and the exchange of good practices. The project's "heart and soul" was to provide an online course on fundamental mathematical themes that would serve as a base for the specialized domain of engineering mathematics. Upon its approval and funding, partner institutions have developed a common platform for students and professors interested in Fundamentals of Linear Algebra and engineering applications. A mathematics on-line learning model was developed from the scratch and is now available in seven different languages. As presented in the project proposal, the student competition activity was introduced as a Learning/Teaching/Training activity (LTT) and it was established inside the online course setting and framework to add an international dimension to the studies of the enrolled students. The students' competition in EngiMath project, connected learners from different countries through common tasks. It has settled an open international space, where students could deal with assessment "stresses" in an indirect and ludic manner, promoting, in a gamification way, their self-confidence when dealing with on-line tasks, tight schedules or even "against the clock", motivating them to complete the course and to avoid drop out behaviour. Despite all of the pandemic limitations that all partner members had to cope with, the students' competition can be considered one of the Project's main triumphs.

Keywords: Mathematics, Online learning, Competition, Gamification, Multinational cooperation, Erasmus+, Technology enhanced learning.

1 INTRODUCTION

New techniques and technology are widely employed in today's society at all levels of education, particularly at higher education (HE). Even before the massive "response" to the Covid epidemic, all subject areas within the HE scope are being addressed, specifically those that fall under the broad title of Science, Technology, Engineering, and Mathematics (STEM).

The continuous access to learning resources has quickly changed its role from being a simple convenience to become a natural expectation from learners. Since the proliferation of the internet, uninterrupted access to resources from different parts of the world has been possible allowing students to adapt their learning schedule to their busy lives [1]. Anyone with an internet connection can learn how, where and when desired.

Technology has increased the speed at which information can be accessed and distributed through faster networks and mobility, it allowed teachers to develop more complex courses faster and added a virtual social layer through social networks [1]. Learning efficacy is boosted by producing and delivering a well-designed course that is easily available to learners and allows them to interact with both the material and each other. In distance learning courses, if the three support types identified by Lee et al. [2] are considered: instructional, peer and systemic, a positive impact may flourish since students' satisfaction increases, enrolment attrition decreases and it helps students' bond by approximating a face-to-face situation.

Nonetheless, online courses transfer the responsibility for the learning process from the teacher to the learner. The student must gain and demonstrate self-efficacy, namely “the ability to effectively manage themselves, to perform tasks, and to achieve defined goals” ([1], pp. 226). Students must have intrinsic motivation to go over the material provided and to overcome challenges that they might face during their learning. Shen et al. [3] found that students learning success is dependent on three types of self-efficacy: technological, in learning and in social interaction. Higher technological self-efficacy has been linked to higher academic achievement [4] and increases students satisfaction with their online learning.

A successful online learning system needs to be perceived as useful. Students must feel that by using it they improve either their academic or job performance or it adds value or comfort to their learning process. For the system to be easily accepted by learners, they must perceive its usage as being free of effort. The course must be easy to navigate and use and it should require less mental and physical effort from the part of the learner [1].

These concepts and ideas drove to the development and implementation of the Erasmus+ Project “EngiMath – Mathematics on-line learning model in Engineering education”, a joint venture that gathered seven HEI, namely: TTK University of Applied Sciences (Coordinator -Estonia), Letterkenny Institute of Technology (Ireland), Polytechnika Koszalinska (Poland), Polytechnic Institute of Porto - Porto Accounting and Business School (Portugal), Technical University of Cluj-Napoca (Romania), [6]Universitat Politècnica de Catalunya (Spain – on the 3rd Year of the project) and University of the Basque Country - UPV/EHU (Spain – only on the two first years of the project).

In the EngiMath framework [5], the Students’ Competition proposal was planned and approved as a Learning/Teaching/Training activity (LTT), coordinated and fully organized by the Portuguese partner team. This competition attempted to capitalize on students' inherent proclivity towards "gaming" type activities [6], with a clear objective of a good “reward” at the end – an internationalization opportunity for the three best students per partner institution.

2 METHODOLOGY

2.1 Activity Description

Students’ Competition in the EngiMath Project has connected learners from 6 different countries (Estonia, Ireland, Poland, Portugal, Romania, Spain) through common tasks. It tried to bring an open multinational space, where students could deal with assessment “stresses” in an indirect and ludic manner, promoting in a gamification way, their self-confidence when dealing with on-line tasks, tight schedules or even “against the clock”, motivating them to pursue the complete course and to avoid drop out behaviours. It was a problem-solving competition of a logical-mathematical nature, aimed at all the students enrolled in the on-line course project.

This event tried to raise student motivation, support possible student exchanges, use and fasten the knowledge gained from the on-line course, as well as to recognize that Mathematics plays a key role in the formation of an individual, developing and enhancing logical and deductive reasoning [7]. This type of articulation and correct use of valid arguments plays a decisive role in solving everyday problems and it is fundamental in the construction of knowledge in any specific area.

Students’ Competition was sequentially developed on-line through the presentation of a set of Challenges/Problems, using several features available in the on-line learning course in Moodle, through all on-line courses. ICT, such as collaborative workspaces, live streaming, videoconferencing, social media, among others, were used to prepare, support and follow up physical mobility. Problems could be from the fields of Algebra, Analysis, Logic and Combinatory and all the competition materials were in English language.

In a first Phase, using the pilot stages of Engimath course [8], students should solve a predetermined sequence of tasks, inside the course online platform, and, according to the global task score, three students were selected by each partner as “country representatives” for the final and Multinational Phase. This Final Phase was planned in a face-to-face format and would have taken place at the Porto Accounting and Business School, one of the eight schools from the Polytechnic of Porto. This Project activity (programmed and approved by the European Board) would combine a short period of

physical mobility (7 days) for three students from every partner institution, with virtual mobility predefined moments for all other participants, to complement and/or extend the learning outcomes of physical mobility. Physical mobility would only include students.

However, due to COVID-19 restrictions and concerns about students' safety, the "in person" format had to be shifted to an online one, developed in a fully virtual format. This "compulsory" transformation led to substantial changes in the general program of the competition, in the programmed activities as well as in the type of challenges proposed, among many other logistical and operational issues of the competition.

2.2 Objectives

The Competition main objectives may be considered a reflection / communication / investigation space through math knowledge and understanding, where students are encouraged to share their thinking with peers and to examine different problem-solving strategies. These critical reflection moments help students to gain insight into their strengths and weaknesses as learners.

With this International Competition we sought to provide opportunities that will increase knowledge in mathematics and cooperation skills, enhance cooperation between universities and promote students' mobility, namely to:

- Develop abstract, logical and critical thinking and the ability to reflect critically upon their work and the work of others;
- Expose students to the frontiers of scholarship and creative activity, and the complexities of an interdependent world where mathematics is the common language;
- Confront students with the international dimension of mathematics and its multicultural perspectives;
- Promote opportunities for personal growth and leadership development.

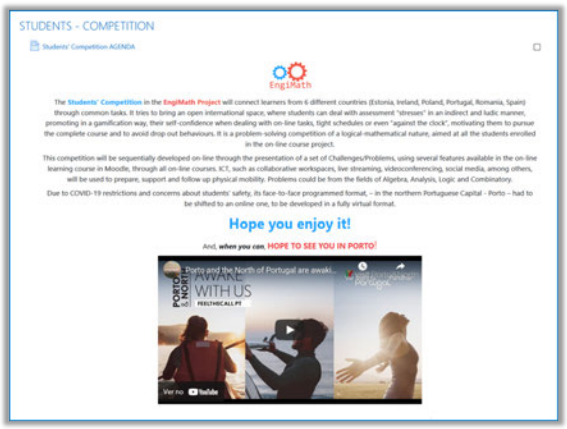
2.3 Participants and Final Competition Phases Organization

Students' Competition embraced 18 contestant students, 3 from each partner institution and from 6 different European countries. Since the competition materials (programme, schedule, challenges, notes, information, zoom meeting links and, even, the answer submission process) had to be delivered "online", is was decided to use the EngiMath Course Moodle Platform, creating a specific section in the course English version (see Fig.1 (a)). As shown in Fig. 1 (b), eighteen "anonymized" accounts in TTK Moodle were specifically created for this purpose, distinguished by the first letter that connected the "account" to the respective partner institution/city/country (for instance, in the Portuguese case: P1, P2 and P3 were the acronyms for the three Porto students). Until the competition was launched, these accounts remained anonymous.

As mentioned, participants' Moodle accounts were randomly distributed among the eighteen competitors in the first competition day, specifically in Competition Opening Session. This Final Competition was developed on three independent phases, each of which with two, or more, stages, in a total of seven challenges to be solved against the clock!

- Phase 1 - Competition in International Groups - Stage 1, 2 and 3
- Phase 2 - Competition between partner countries - Stage 1 and 2
- Phase 3 - Individual competition - Stage 1 and 2

Challenges opened as Essays in TTK Moodle and the answers, with a step by step proposed solution was submitted by one of the team members, in each stage.



				GROUPS		
	Tallin Moodle ID			Ph1 - St1	Ph1 - St2	Ph2
B1 - Spain	Butters	Bumpus	b1@tktk.ee	X2	X	B
B2 - Spain	Blister	Bumpus	b2@tktk.ee	Y2	Y	B
B3 - Spain	Bambi	Bumpus	b3@tktk.ee	Z1	Z	B
C1 - Romania	Crusty	Crumpus	c1@tktk.ee	X2	X	C
C2 - Romania	Craven	Crumpus	c2@tktk.ee	Y1	Y	C
C3 - Romania	Custard	Crumpus	c3@tktk.ee	Z2	Z	C
L1 - Ireland	Larry	Lumpus	l1@tktk.ee	X1	X	L
L2 - Ireland	Louie	Lumpus	l2@tktk.ee	Y2	Y	L
L3 - Ireland	Lucy	Lumpus	l3@tktk.ee	Z2	Z	L
K1 - Poland	Kevlar	Krampus	k1@tktk.ee	X1	X	K
K2 - Poland	Karmen	Krampus	k2@tktk.ee	Y1	Y	K
K3 - Poland	Kelvin	Krampus	k3@tktk.ee	Z2	Z	K
P1 - Portugal	Plimsole	Pimpus	p1@tktk.ee	X2	X	P
P2 - Portugal	Pim	Pimpus	p2@tktk.ee	Y2	Y	P
P3 - Portugal	Plam	Pimpus	p3@tktk.ee	Z1	Z	P
T1 - Estonia	Terrence	Tomps	t1@tktk.ee	X1	X	T
T2 - Estonia	Theodore	Tomps	t2@tktk.ee	Y1	Y	T
T3 - Estonia	Thomas	Tomps	t3@tktk.ee	Z1	Z	T

Figure 1. (a) Students' Competition Section in https://moodle.tktk.ee/course/view.php?id=1619
(b) Students' anonymized accounts and groups distribution

2.3.1 Competition Scoring Rules and Computation

Each challenge was graded on a scale from 0 to 150 points assigned as follows:

- Time Factor – 50 points for the first correct submitted answer (if incorrect these points were lost!) – for the upcoming correct submissions these points were reduced at a rate of 1 point per 5 minutes (continuously measured – 2 decimal places).
- Answer Presentation Factor – 100 points
  - 20 points for the correct answer;
  - 80 points attributed to the Problem-Solving Presentation Quality where 60 were for Reasoning scheme/Formal resolution and 20 for the Clarity of the proposed resolution.

This grading scheme was communicated to all participants, via email (bcc), in the week before the event, along with several other information, remarks and tips, like a "warm up" problem (for training purposes – see Fig. 2), with a step by step proposed solution (Fig. 3), and other additional clarifications like:

> *"Since it is not supposed to typewrite the submitted resolution, be careful with too much "scribbles", that may prevent a correct reading of your resolution.*
>
> *The 80 points attributed to the problem-solving presented quality may be almost fully attributed to an incorrect answer!"*

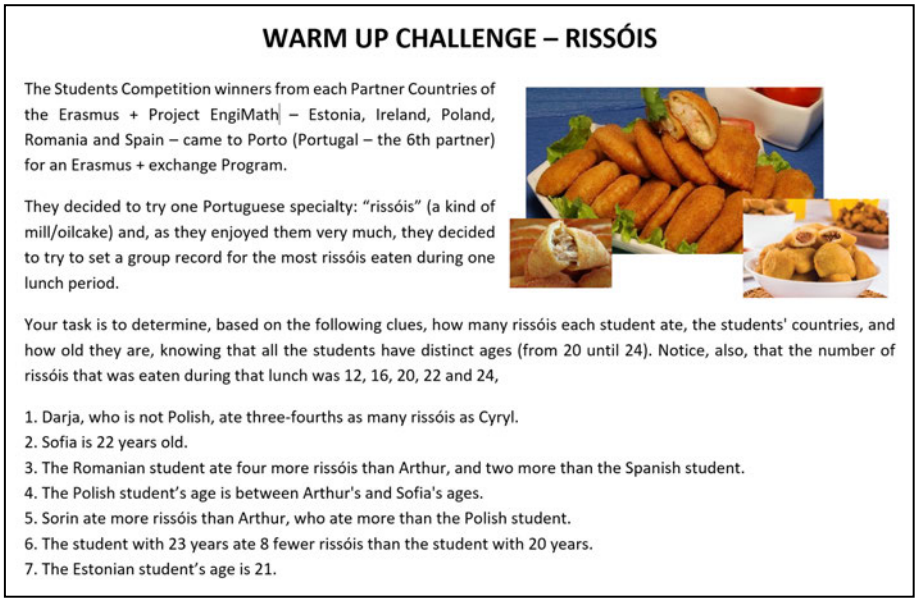


Figure 2. EngiMath SC - Warm up challenge

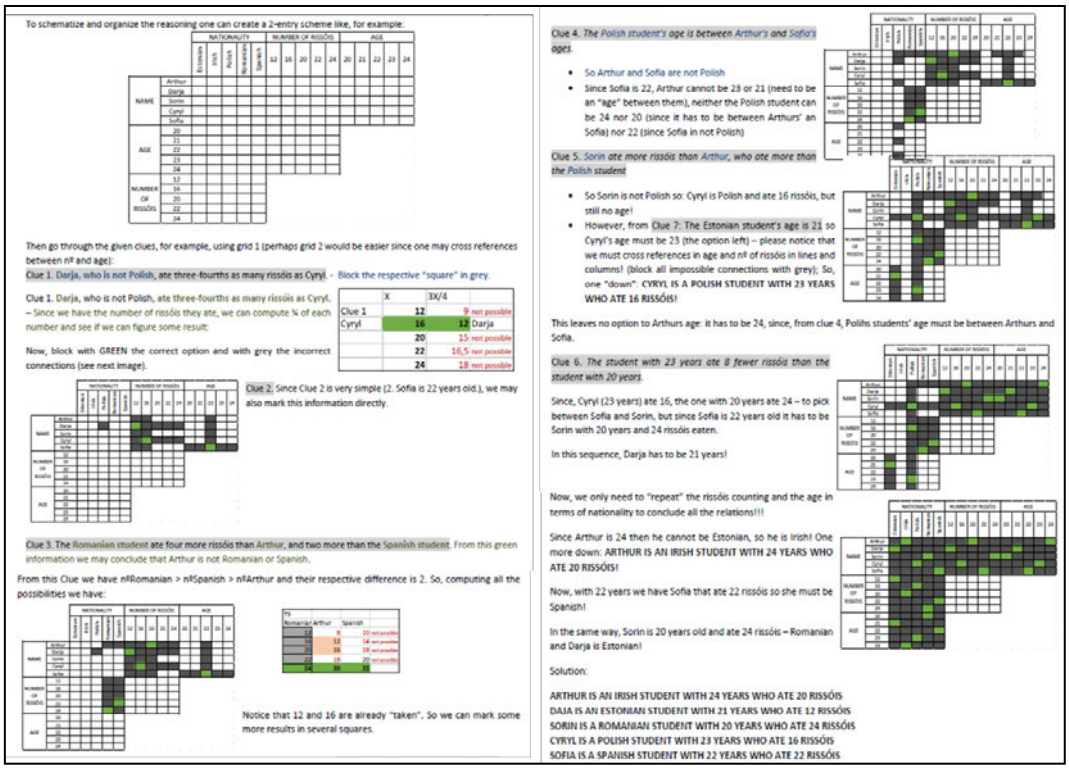


Figure 3. Warm up challenge - proposed solution

The final individual score was obtained by adding the respective group results from the 1st and 2nd Phase (3+2 stages) with the individual score from the last one (2 stages). With a possible score of 150 per stage, the maximum achievable score was 1050 (7x150).

2.3.2 Students' Competition Agenda and Prizes

As already mentioned, all programmed and scheduled in person activities had to be shifted to a complete distinct format – fully implemented online. Dealing with a complete week programme to be fulfilled, was a challenging task, where the major concern was to keep students' motivational level up (see Table 1 for detailed description).

Students' Competition was held from June 28th to July 2nd (Monday to Friday) with all the individual competitors, as well as their respective tutors/supervisors working from home.

It must be noticed that, due to pandemic restrictions, the entire preestablished classification system in each of the phases had to be rethought. Even the prizes planned for this competition (the biggest being the trip to Porto), such as participation prizes, prizes per stage, final individual prize, among many others, had to be reconsidered by the organization and all partners, in view of the various difficulties and restrictions, ranging from logistics (in terms of transporting goods) to financial (transfer of funds).

In this sense, an alternative reward/prize system was settled. The organizing institution (ISCAP) awarded the following (individual) certificates:

- Certificate of participation
- National Classification Certificate - awarded by the institution to its three participants with an indication of their classification
- Global Classification Certificate – awarded to the top three.

These Certificates were individually sent by email to each participant and made available in the Tallinn Moodle for partners' potential use.

The funds available for this STT activity were equally divided among the six partner institutions to afford the Competition Prizes. These were awarded, to all final competitors, accordingly to the Final National results, in the form of a gift voucher from FNAC or equivalent enterprise, at the closing ceremony (Friday, July 2, 2021), held in person at the respective institutions, and broadcasted live from the ISCAP Magnum Auditorium (Fig. 4).

Table 1. Students' Competition Final Schedule

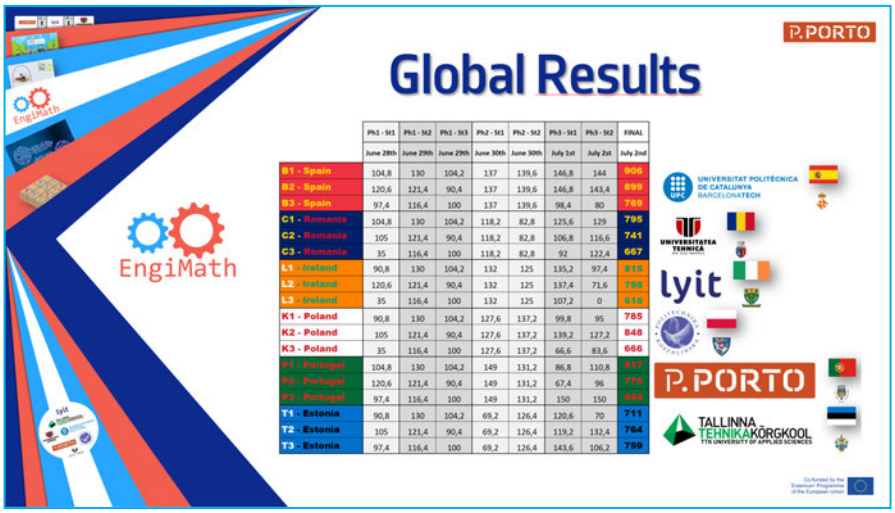
Monday - June 28th		
	09:00 – 09:30	Welcome all - Introduction to Competition Program
	09:30 – 11:15	Partners Presentation – Institution and Students Team
	11:15 – 11:30	Student Competitors Identification • Estonian Team Members - T1/T2/T3 • Ireland Team Members - L1/L2/L3 • Polish Team Members - K1/K2/K3 • Portuguese Team Members - P1/P2/P3 • Romanian Team Members - C1/C2/C3 • Spanish Team Members - B1/B2/B3
	11:30 – 12:00	Brain storming – Students time
	12:00 – 14:00	LUNCH BREAK
	14:00 – 16:00	Phase 1 – STAGE 1 – 6 International Groups • X1 – Members – T1/L1/K1 • X2 – Members – P1/C1/B1 • Y1 – Members – T2/K2/C2 • Y2 – Members – L2/P2/B2 • Z1 – Members – T3/P3/B3 • Z2 – Members – L3/K3/C3
	16:00	Submission deadline for Ph1/St1
Tuesday - June 29th		
	09:00 – 12:00	Phase 1 – STAGE 2 – 3 International Groups • X – Members – T1/L1/K1/P1/C1/B1 • Y – Members – T2/K2/C2/ L2/P2/B2 • Z – Members – T3/P3/B3/L3/K3/C3
	12:00 – 14:00	LUNCH BREAK
	14:00 – 16:00	Phase 1 – STAGE 3 – 3 International Groups
	16:00	Submission deadline for Ph1/St2 and Ph1/St3
Wednesday - June 30th		
	09:00 – 12:00	Phase 2 – STAGE 1 – 6 National Groups • Estonian Team Members - T1/T2/T3 • Ireland Team Members - L1/L2/L3 • Polish Team Members - K1/K2/K3 • Portuguese Team Members - P1/P2/P3 • Romanian Team Members - C1/C2/C3 • Spanish Team Members - B1/B2/B3
	12:00 – 14:00	LUNCH BREAK
	14:00 – 16:00	Phase 2 – STAGE 2 – 6 National Groups
	16:00	Submission deadline for Ph2/St1 and Ph2/St2
Thursday - July 1st		
	09:00 – 12:00	Phase 3 – STAGE 1 – 18 individual competitors
	12:00 – 14:00	LUNCH BREAK
	14:00 – 16:00	Phase 3 – STAGE 2 – 18 individual competitors
	16:00	Submission deadline for Ph3/St1 and Ph3/St2
Friday - July 2nd		
	09:00 – 12:00	Final Meetings • Students Moment – Erasmus exchange opportunities • Results Compilation and Analysis - "place your bets"
	12:00 – 14:00	LUNCH BREAK
	14:00 – 16:00	Closing Session – "bets" results COMPETITION Award Ceremony – Winner / Runner-up / Second runner-up (3 distinct prices) by Project Partner

Figure 4. SC Award Ceremony

3 COMPETITION RESULTS

In the following figures (Fig. 5 and 6) the results from all the seven stages are presented. Despite not having a specific prize, the winner team from each competition phase was publicised in the closing ceremony (see Fig. 7 to 9).

During these 4 competition days, at 16:00 (Lisbon time) the Portuguese team downloaded all student´s submissions from TTK Moodle, a proceed with a "double blind" answer correction, after which an arithmetic mean was taken for the score given to the Problem-Solving Presentation Quality (from a maximum of 80). If the correct answer was given students got more 20 points (or less, if not 100% correct). The score given to the submission time factor was computed, decreasing from the 50 points attributed to the first submission with a correct answer (according to the aforementioned scoring system description). All this scoring procedure of the submitted answers was carried out daily, in order to allow the presentation of all the results on the last day of the competition.



	Ph1 - St1	Ph1 - St2	Ph1 - St3	Ph2 - St1	Ph2 - St2	Ph3 - St1	Ph3 - St2	FINAL
	June 28th	June 29th	June 29th	June 30th	June 30th	July 1st	July 2nd	July 2nd
B1 - Spain	104,8	130	104,2	137	139,6	146,8	144	906
B2 - Spain	120,6	121,4	90,4	137	139,6	146,8	143,4	899
B3 - Spain	97,4	116,4	100	137	139,6	98,4	80	769
C1 - Romania	104,8	130	104,2	118,2	82,8	125,6	129	795
C2 - Romania	105	121,4	90,4	118,2	82,8	106,8	116,6	741
C3 - Romania	35	116,4	100	118,2	82,8	92	122,4	667
L1 - Ireland	90,8	130	104,2	132	125	135,2	97,4	815
L2 - Ireland	120,6	121,4	90,4	132	125	137,4	71,6	798
L3 - Ireland	35	116,4	100	132	125	107,2	0	616
K1 - Poland	90,8	130	104,2	127,6	137,2	99,8	95	785
K2 - Poland	105	121,4	90,4	127,6	137,2	139,2	127,2	848
K3 - Poland	35	116,4	100	127,6	137,2	66,6	83,6	666
P1 - Portugal	104,8	130	104,2	149	131,2	86,8	110,8	817
P2 - Portugal	120,6	121,4	90,4	149	131,2	67,4	96	776
P3 - Portugal	97,4	116,4	100	149	131,2	150	150	894
T1 - Estonia	90,8	130	104,2	69,2	126,4	120,6	70	711
T2 - Estonia	105	121,4	90,4	69,2	126,4	119,2	132,4	764
T3 - Estonia	97,4	116,4	100	69,2	126,4	143,6	106,2	759

Figure 5. Students' Competition Final Results

Figure 6. Students' Competition Podium

Figure 7. Phase 1 Results

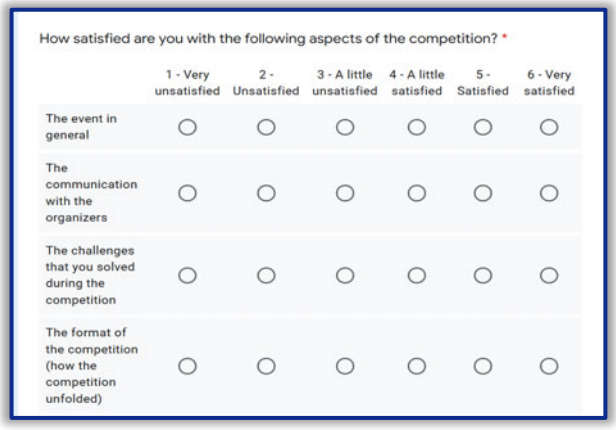
Figure 8. Phase 2 Results

Figure 9. Phase 2 Results

3.1 Participants' Feedback

Twelve competitor students and three lecturers answered a feedback survey that was given to them at the end of the competition. The feedback gathered was mostly descriptive and in the form of answers to open ended questions.

All respondents were either "satisfied" or "very satisfied" with all the features of the competition (see Fig. 10) revealing a Median of 6 and a Mean of 5,60 or greater in all assessed items, on a scale of 1 to 6.



How satisfied are you with the following aspects of the competition? *

	1 - Very unsatisfied	2 - Unsatisfied	3 - A little unsatisfied	4 - A little satisfied	5 - Satisfied	6 - Very satisfied
The event in general	○	○	○	○	○	○
The communication with the organizers	○	○	○	○	○	○
The challenges that you solved during the competition	○	○	○	○	○	○
The format of the competition (how the competition unfolded)	○	○	○	○	○	○

Figure 10. Part of Feedback Form (closed quality questions)

Regarding the opinions expressed in the feedback form opened questions, several may be shared:

Question: "*What did you like about the event*?" (please tell us 3 things you liked about the competition)

- "*The challenge, people from different countries come together, communication with other students*";
- "*I loved the exercises, collaborating with my partners from all around Europe and also I liked so much the possibility of representing my university. All organization was prepared very professionally*.";
- "*It's a great opportunity to learn math and solve problem with group members who from other countries. I realized that have many interesting applications of mathematics in our life.*";

- "*Interacting with students from other countries and institutions; Solving interesting challenges; Learning how to work as a team and working around language differences*";
- "*I like more about the event is being part of a European competition involving multiples countries. The stages were another great point because it enabled us work with people from other countries, but also test our collaborative and communicative skills. Also, I would like to say that the challenges were great fun, and for me, were one of the top parts in the competition.*"

Question: "*How can future events be improved*?" (please tell us 3 things that can be improved)

- "*I don't know what can be improved, everything was well organized*";
- "*If we need to do online, then it could be the same*";
- "*I don't think it could be more perfect, but it's a shame it was online, but the reason is understandable*";
- "*Maybe icebreakers for students to get to know each other*";
- "*I hope in the future it will take place in Porto, for better communication with other students, maybe more introduction (person by person)*";
- "*The event was well managed and well carried, but maybe the weakest part was the fact of being an online competition. I think that online a bit of its essence was lost and also the opportunity to go to another country and meet new people in person. However, I think that with the conditions that we have, the event was well organized and couldn't have been better*".

As can be seen from the open comments presented (the "most different" among the twelve), there seems to be a general and common feeling about the SC, that we can summarize as follows: Students enjoyed working in an international setting and interacting with students from other universities. Some even made new friends during the competition and got information about other universities and countries. The students liked the challenges and the communication during the event. They appreciated the format of the competition and the flexibility of the schedule and tools that they were allowed to use to solve the challenges. The teachers appreciated the format of the competition and the well thought out content and considered it very professionally organized. Although the participants considered the competition to be well organized, some improvements were suggested. The most frequent suggestion was that the competition be held face to face. Some students had small problems with the communication channels that were quickly solved.

4 FINAL COMMENTS

In Mathematics particular area and interrelated subjects, it is important to support and develop activities in a wide variety of ways, contributing to a broad "mathematical coexistence", trying to deconstruct prejudices and misconceptions. The gaming and ludic format of this Competition allowed the development of activities in a relaxed and friendly environment, despite the relative pressure of time and all the constraints arising from its forced implementation, at a distance. It was gratifying for the organizing Portuguese team to have such positive feedback. It will certainly be an activity to be repeated in future European or even national projects.

This sort of students' extracurricular activity can be (and is) "reproduced" in several distinct frames such as:

- "Inter-Classes" – competitors from a same course and degree, but from different classes;
- "Inter-Course" – competitors from a same course, but different degrees;
- "Inter-Degree"– competitors from distinct Degrees in the same School;
- "Inter-Schools"– competitors from distinct schools of the same HEI;
- "Inter-Institutions" – competitors from distinct HEI;

among other possible segmentation and future conceivable regrouping for any Students' Competition in a larger scale.

As it can be easily understood, the competition's scientific common core is completely open, Math is just an interesting starting point due it its international language, but this could also be transformed into an interdisciplinary activity. In this sense, "*the sky is the limit*", as far as one wants to develop a similar student' competition!

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