

1 **Title**

2 ESA/ELGRA Gravity-Related Research Summer School: an introduction to microgravity and hypergravity  
3 research for university students

4

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19 **Acknowledgments**

20 We would like to thank ESA and ELGRA experts who developed and delivered voluntary lectures during the first  
21 four editions of the Summer School and shared their knowledge and enthusiasm with the participating university  
22 students.

23

1 **Abstract**

2 The European Low Gravity Research Association (ELGRA) and the European Space Agency (ESA) co-organise  
3 since 2016 a Summer School on gravity-related research in the frame of ESA Academy’s Training and Learning  
4 Programme. This Summer School is organised every year, in June, at the ESA Education Training Centre located  
5 in ESA’s European Space Security and Education Centre (ESEC), Belgium. The Summer School explains the  
6 fundamentals of performing research at different gravity levels and offers an overview of current research activity  
7 under microgravity and hypergravity conditions in life and physical sciences. Over four and a half intensive days,  
8 up to 30 Bachelor and Master students from ESA Member States, Canada and Slovenia, attend stimulating lectures,  
9 and work within small groups to devise project ideas for prospective experiments. Gravity-related research is  
10 introduced to these future scientists and engineers by experienced professionals from across the European space  
11 and research sector. These trainers are ELGRA members and ESA experts, freely sharing their experience and  
12 know-how with the students, including their day-to-day work and research experience in biology, human  
13 physiology, physics and engineering. Each year the programme incorporates new elements to enhance the  
14 experience for the students based on their feedback. 104 university students and 43 different experts have already  
15 participated in this Summer School.

16

17 **Keywords**

18 Microgravity; hypergravity; research; education

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1 **Declarations**

2 **Funding** The Summer School is a jointly funded initiative from the European Space Agency (ESA) and the  
3 European Low Gravity Research Association (ELGRA).

4 **Conflicts of interest/Competing interests:** Not applicable

5 **Availability of data and material:** Not applicable

6 **Code availability:** Not applicable

7 **Authors' contributions:** All authors were involved in the preparation and delivery of the different editions of the  
8 Summer School.

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## 1 I. INTRODUCTION

2 The European Space Agency (ESA, 2020) and the European Low Gravity Research Association (ELGRA, 2020)  
3 co-organise, since 2016, an annual Summer School on gravity-related research in the frame of ESA Academy's  
4 Training and Learning Programme (Maree et al, 2019). This Summer School takes place at the ESA Education  
5 Training Centre in ESA's European Space Security and Education Centre (ESEC) in Transinne (Belgium) over  
6 four and a half days.

7 The main objective of the Summer School is to promote gravity-related research amongst future scientists and  
8 engineers. These young minds are introduced to the benefits of performing research at different gravity levels and  
9 offered an overview of current research under microgravity and hypergravity conditions in both life and physical  
10 sciences. Other related objectives are:

- 11 • transfer of knowledge and expertise
- 12 • inspire and network with the future generation
- 13 • encourage students to participate in hands-on opportunities
- 14 • attract future scientists and engineers into the space sector.

15 Each year, ELGRA contacts its members to offer them the opportunity to participate in the Summer School by  
16 submitting an abstract to propose a lecture in life or physical science. Three lectures in biology, human physiology  
17 and physics are selected. The selected ELGRA members join the Summer School for a minimum of one day and  
18 along with some additional ESA experts provide a background to their topic area, examples of gravity-related  
19 research and share their experience and expertise as illustrated in Fig. 1. Supporting the Summer School is the  
20 university student arm of the ELGRA association (SELGRA, 2020). SELGRA has created an active association for  
21 student members to communicate and share opportunities in gravity-related research, support conference  
22 attendance and communicate member activities. These experiences are shared at the Summer School and  
23 participating students are offered the opportunity to join the association to provide further points of contact.



24  
25 **Fig. 1** Expert sharing her knowledge and know-how in gravity-related research with University students during  
26 the ESA/ELGRA Gravity-Related Research Summer School 2019

27 After the selection of the 15-20 experts and the finalisation of the programme of the Summer School, a call for  
28 student applications is launched by ESA Education Office. The Summer School was opened to 22 students for the  
29 two first editions and is opened to 30 students since 2018. Applicants should be Bachelor or Master students in  
30 science or engineering disciplines from ESA Member States, Canada or Slovenia not yet involved in the space  
31 sector. Interested students apply via the ESA Education website (ESA Education, 2020) by filling-in an application  
32 form and providing a motivation letter, a CV, a recommendation letter from a university professor or academic  
33 supervisor and a copy of latest academic records. Selected students are informed at least one month before the  
34 Summer School starts.

1 The participating students and experts (Fig. 2) are sponsored by ESA and ELGRA to cover their travel costs,  
2 accommodation and meals.



3 **Fig. 2** Group picture at the ESA/ELGRA Gravity-Related Research Summer School 2016

## 4 **II. CONTENT OF SUMMER SCHOOL**

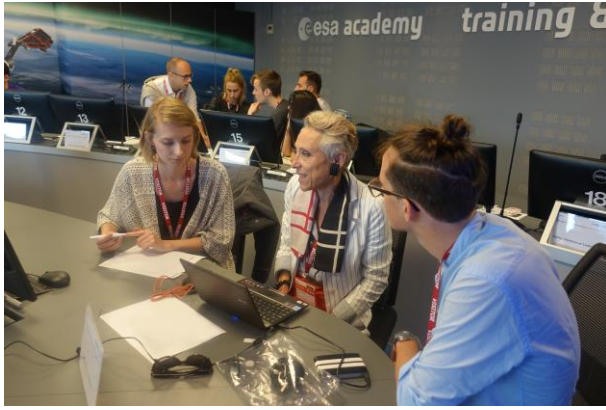
5 The Summer School programme includes lectures in the following topics:

- 6 • Gravity-related research and gravity-related research platforms
- 7 • Hands-on opportunities for university students
- 8 • Introduction to project management
- 9 • Gravity-related experiment development
- 10 • Experiment life cycle
- 11 • Life sciences at different gravity levels - 3 lectures on animal, plant, cell biology etc.
- 12 • Physical sciences at different gravity levels - 3 lectures on fluid & thermal dynamics, material science etc.
- 13 • Human physiology at different gravity levels - 3 lectures on cardiovascular, neurological, musculoskeletal etc.

14 These lectures are complemented by testimonials from university students who have, with their respective student  
15 teams, designed, built, tested and performed a scientific experiment or technology demonstration in microgravity  
16 or hypergravity conditions in the frame of ESA Academy's hands-on projects (Callens et al, 2011). These students  
17 present their projects performed in the ZeroG airplane (Pletser et al, 2015), the Bremen drop tower (Kufner, 2011),  
18 ESA's Large Diameter Centrifuge (Frett et al, 2016) or the Short Arm Human Centrifuge at the :envihab facility  
19 (Frett, 2014). They share their lessons learned and give tips to the participating students for their potential future  
20 projects (Callens et al 2016).

21 Throughout the Summer School, the students are asked, in groups of four or five, to generate an idea for a future  
22 gravity-related experiment or technology demonstration. During the time allocated for this group project, they are  
23 asked to come up with a scientific or engineering objective, to choose a suitable gravity-related platform and  
24 propose a preliminary experimental setup and procedure. Students take advantage of the continuous presence of  
25 experts in the room to discuss their ideas and get advice (Fig.3).

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2 **Fig. 3** Students discussing their group projects with experts during the ESA/ELGRA Gravity-Related Research  
3 Summer School 2017

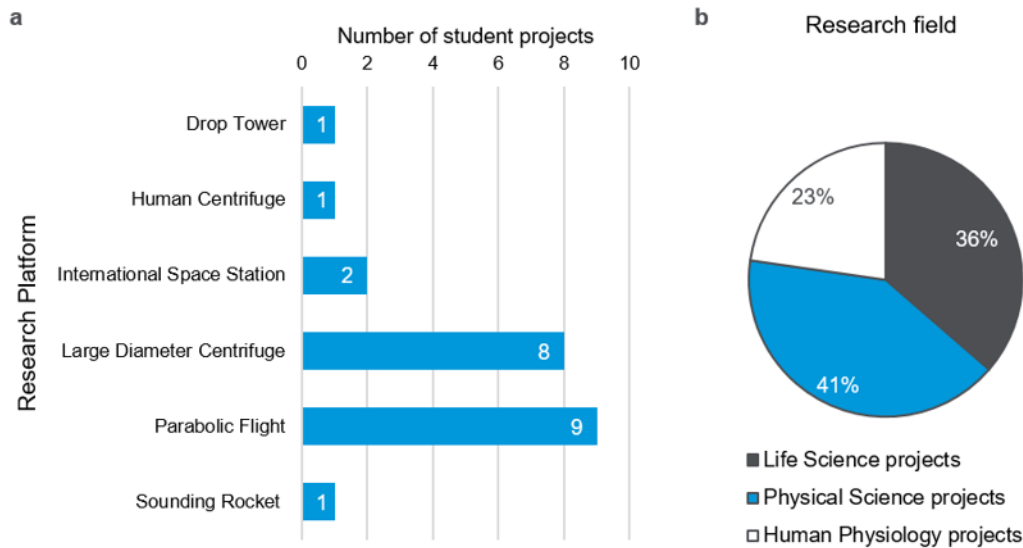
4 On the final day of the Summer School, the student groups get the opportunity to present their project and are  
5 evaluated by experts from ELGRA and ESA (Fig. 4). Upon completion of this process, the students are presented  
6 with a certificate of participation and a transcript including their evaluation. These documents allow them to claim  
7 European Credit Transfer System (ECTS) credit(s) for their participation at their respective universities.



8

9 **Fig. 4** Student group presenting their project to ESA and ELGRA experts during the ESA/ELGRA Gravity-  
10 Related Research Summer School 2018

11 The research projects the students developed during the Summer Schools covered a broad variety of topics,  
12 including investigating the effect of gravity on non-Newtonian fluids, determining the influence of hypergravity on  
13 plant protoplasts and testing the inborn reflex adaptation in altered gravity. Of the 22 student projects proposed so  
14 far, the most popular research platforms were the parabolic flight and the large diameter centrifuge, with  
15 respectively 9 and 8 projects. The other groups selected the International Space Station (ISS), the drop tower, the  
16 human centrifuge and the sounding rocket (Fig. 5a). The proposals consisted of 36% life science projects, 41%  
17 physical science projects and 23% human physiology projects (Fig. 5b).  
18



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2

3 **Fig. 5** Profile of the student projects over the four Summer School editions between 2016-2019: (a) platforms  
4 selected by the students, (b) student project fields

5 Aside from the lectures and team work, students have the opportunity to visit some space-related centres in the  
6 region, including:

- 7
- 8 • Redu site of the ESA's European Space Security and Education Centre (ESEC, 2020) where they learn about  
9 ESA operations activities, as well as the Proba (Proba, 2020) and Galileo (Galileo, 2020) programmes.
  - 10 • The Euro Space Center (ESC, 2020), a science museum and educational tourist attraction devoted to space  
11 science and astronautics where they have amongst other activities the possibility to perform Moon or Mars walk  
12 and test the 3-axis rotating chair.
  - 13 • The Centre Spatial de Liège (CSL, 2020), an applied Research Centre owned by the University of Liège, focused  
14 on design, integration and calibration of space observation instruments. Students can hear about the diverse  
15 activities of the Centre and to see their cleanroom and test facilities (Fig. 6).



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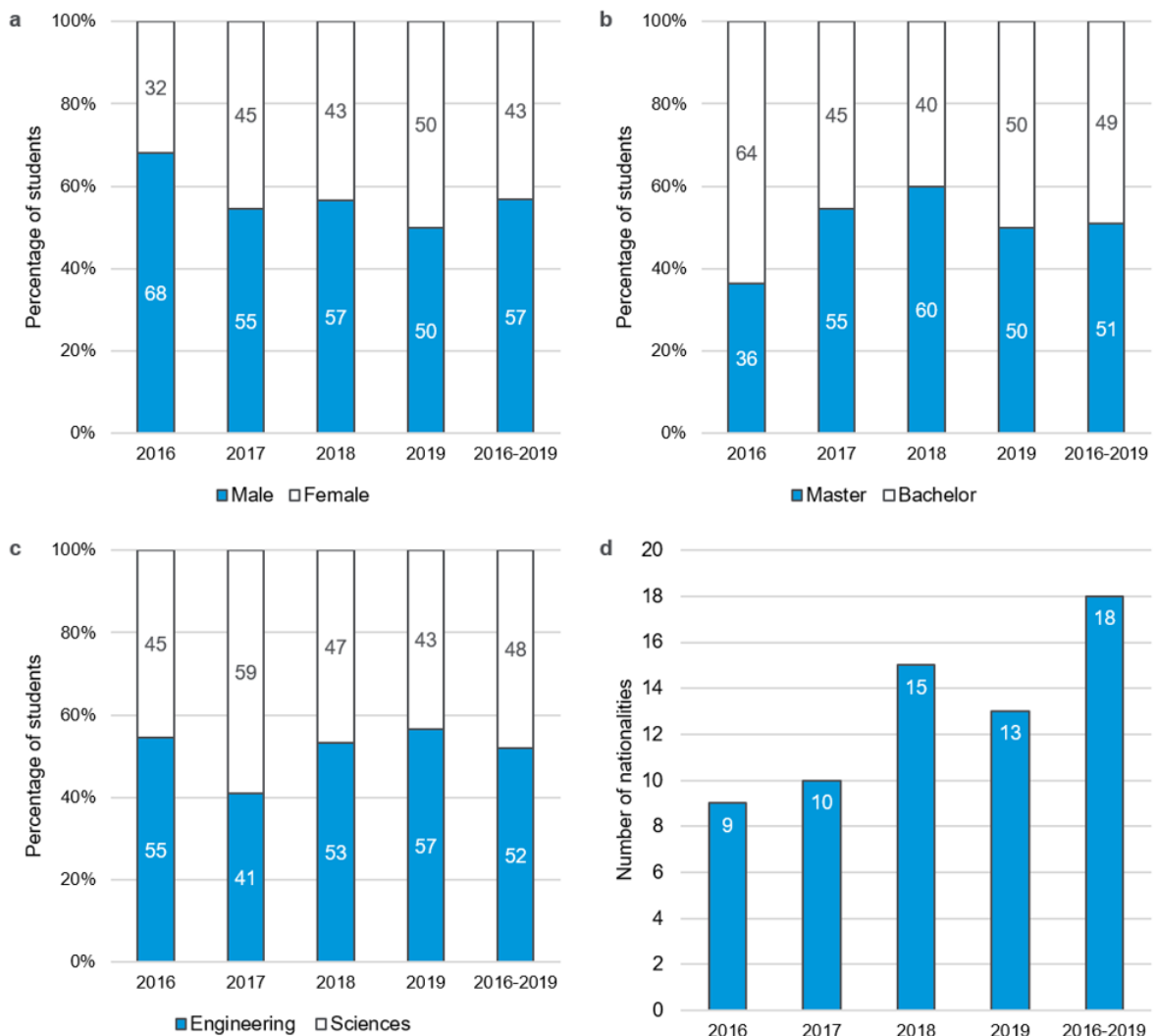
17 **Fig. 6** Student and experts visiting the Centre Spatial de Liège (CSL) during the ESA/ELGRA Gravity-Related  
18 Research Summer School 2016

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### III. PARTICIPANTS

#### IIIa. STUDENTS

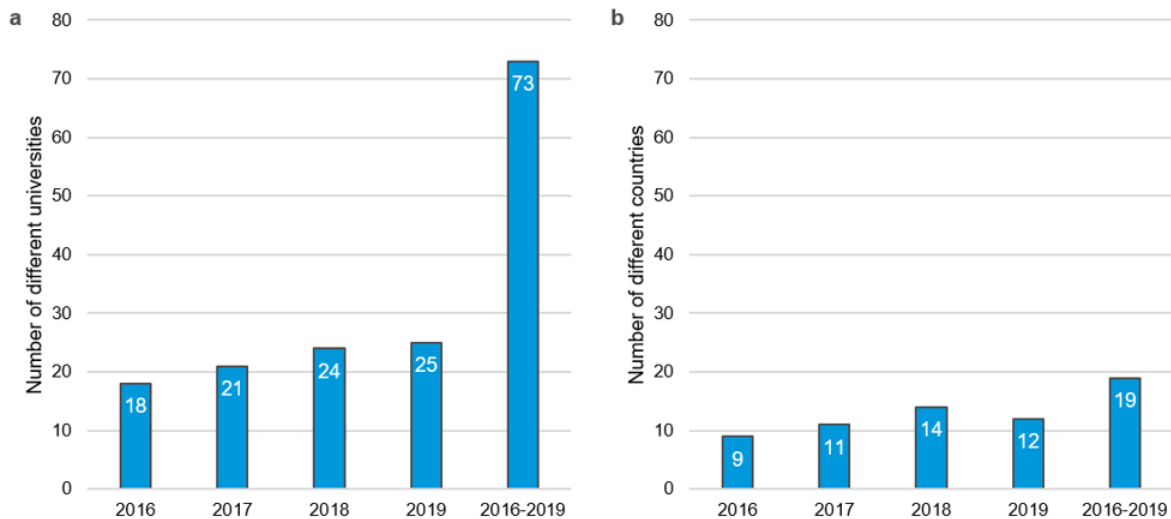
The ESA/ELGRA Gravity-Related Research Summer School has been already organised four times. The first two editions of the Summer School, involved 22 university students. Thanks to the development of the ESA Education Training Centre in 2018, including a larger ESA Academy’s Training and Learning Facility, the Summer School capacity increased allowing 30 students to participate in the 2018 and 2019 editions. The profile of the participating university students is depicted in Fig. 7. From the four editions of the summer school (2016-2019), a total of 104 students have partaken, of which 43% identified as female and 57% as male (Fig. 7A), with an approximate 50/50 distribution between Master and Bachelor level (Fig. 7B) and between scientific and engineering background (Fig. 7C). In each edition there have been between 9 and 15 different nationalities represented (Fig. 7D). Overall, 18 different nationalities have so far participated, coming from almost all eligible countries across Europe and Canada (Fig. 9A):



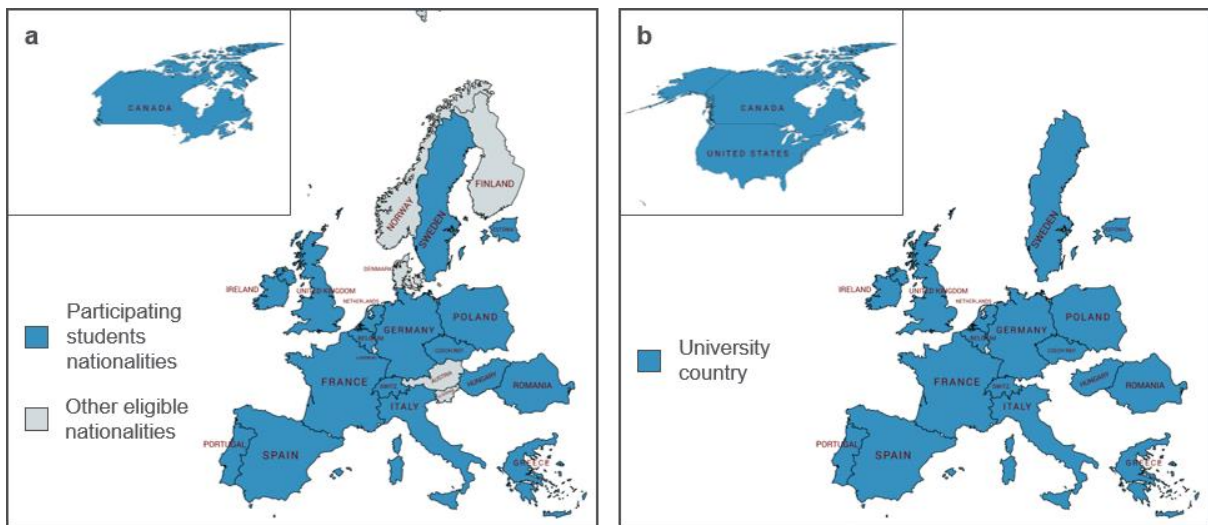
**Fig. 7** Profile of the participating university students over the four Summer School editions between 2016-2019: (a) gender, (b) level of study, (c) background and (d) number of nationalities represented.

For each edition of the Summer School, the students came from between 18 and 25 different universities, representing between 9 and 14 different countries. In total, students from 73 different universities, located in 19 different countries have so far participated in the Summer School (Fig. 8). As many students study abroad, the list of countries of study is even more varied than the countries of origin of the students, e.g it includes the United States (Fig. 9B).





**Fig. 8** Statistics on the universities of the students over the four Summer School editions between 2016-2019: (a) Number of different universities, (b) Number of different countries where the universities are located



**Fig. 9** Geographical distribution of country of origin and university of study of the students over the four Summer School editions between 2016-2019: (a) Participating students nationalities and other eligible nationalities, (b) countries where the students' universities are located

The diversity of the participating students in terms of background, level of study, nationality and university is one of the strengths of the Summer School. It allows the students not only to work, sometimes for the first time, in a group but also in an international environment with peers of different profiles.

### IIIb. EXPERTS

In each Summer School, 17 to 19 experts, some ELGRA members as well as active or retired ESA employees, shared their knowledge and experience with the students. Over the 4 editions, a total number of 43 different experts have supported the Summer School. These experts came from 36 different universities or institutes and represent 10 different nationalities (Table 1). Some of them have participated multiple times.

Expert profile	2016	2017	2018	2019
Supporting experts	17	17	18	19
Total number of different supporting experts	43			

Different nationalities of the experts	10
Different affiliations	36

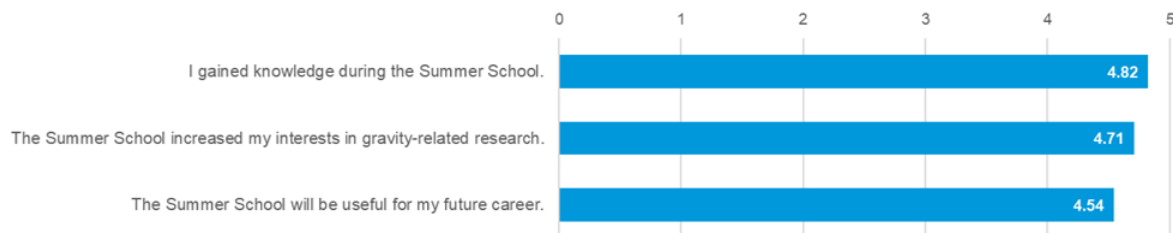
**Table 1** Profile of the experts supporting the four Summer School editions between 2016-2019

**IV. BENEFITS**

After each Summer School, an anonymous online feedback questionnaire is sent to the students to get their feedback in terms of organisation, schedule, content and benefit of the Summer School. These inputs are used to improve for the next edition and enhance the experience of the future participating students. Since 2019, a similar questionnaire has been developed for the experts.

**IVa. STUDENTS**

The feedback from the participating students over the four editions of the Summer School is very positive, as shown on Fig. 10, they gained knowledge and increased their interest in gravity-related research. They also consider that their participation will be useful for their future career.



**Fig. 10** Feedback from the university students who participated in the ESA/ELGRA Gravity-Related Research Summer School between 2016 and 2019. Students scored the statements describing their general impression of the Summer School from 1 (totally disagree) to 5 (totally agree)

After the Summer School 85% of the students envisage to apply for one of the ESA Education gravity-related hands-on opportunities. Several teams have gone on to submit projects to ESA Academy’s hands-on programmes [ESA Academy, 2020]. For example, a group of students from the 2016 edition applied to and were selected to participate in the Drop Your Thesis! (DYT) Programme [Drop your Thesis!, 2020]. The Ferros team participated in the 2017 DYT campaign and investigated the behaviour of Ferrofluids in microgravity [Romero-Calvo et al, 2020].

Other benefits mentioned by the students are a unique opportunity to extend their horizon, to get some knowledge not taught at university, to work in an international environment, to meet so many students with different profiles and to network with a large number of experts.

**IVb. EXPERTS**

The experts who have participated to the Summer School have been very positive about this educational activity and willing to participate again in the future. The experts who participated to the last edition shared with us the following benefits: on the one hand the opportunity to lecture on favourite topics, to share technical expertise and to exchange with a highly motivated and engaged group of university students and on the other hand to network with other experts in gravity-related research. The Summer School provided them with new insights and additional opportunities for career development (for example mentoring opportunities).

**V. CONCLUSIONS**

The ESA/ELGRA Gravity-Related Research Summer School is a unique opportunity for university students to discover and/or get an overview of the research conducted in different fields in microgravity and hypergravity, as well as to acquire new understanding on different topics of space research, work on a group project and network with experts. It is also a unique opportunity for ELGRA members and ESA experts to share with a small group of motivated students from different countries their knowledge and research and to discuss with them innovative

1 ideas. With this Summer School ELGRA and ESA aim at complementing what future scientists and engineers  
2 learn at university, inspire them and attract them into the space sector and its multiple research opportunities.

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