ESA Academy Activities during COVID-19

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Abstract
The ESA Academy is the ESA Education Office's overarching programme for university students. The Academy's portfolio consists of both 'hands-on' activities, and a Training and Learning Programme. Conventionally both of these elements involve a significant number of in person events, for example training sessions, workshops and test and launch campaigns. The educational nature and practical aspects of such events has traditionally necessitated in person participation.

Additionally, most of the Academy's 'hands-on' programmes revolve around student teams designing, building, testing and operating an experiment or spacecraft, activities which rely on the availability and delivery of commercial components, and access to manufacturing, testing and launch facilities, and laboratories.

In March 2020, as the COVID-19 pandemic, and associated restrictions, began to take hold in Europe, nearly all the ESA Academy programmes were affected. Despite the challenges, the Academy continued to deliver activities, and the student teams participating in the Academy's programmes continued to achieve major milestones, including launching experiments to the ISS, CubeSat testing and launch and execution of micro- and hyper-gravity experiments.

This paper explores the challenges faced during COVID-19 and how both the programmes and the students participating in the programmes adapted to meet their educational, scientific, and technical goals. Furthermore, the longer-term adaptation of some of these changes into the future execution of the programmes is discussed.

Keywords
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Acronyms/Abbreviations

AIT	*Assembly, Integration and Testing*
CDR	*Critical Design Review*
EARs	*Experiment Acceptance Reviews*
ESA	*European Space Agency*
ESEC	*European Space and Security Centre*
FYS	*Fly Your Satellite!*
ISS	*International Space Station*
REXUS/BEXUS	*Rocket/Balloon Experiments for University Students*
S-, D-, F-, O- YT	*Spin-, Drop-, Fly-, Orbit- Your Thesis!*
TLP	*Training and Learning Programme*

1. Introduction

Like many organisations around the world the ESA Academy faced major challenges during the COVID-19 pandemic. Many of the Academy's activities have traditionally revolved around onsite and in person activities, and throughout the pandemic the Academy rose to challenge of continuing to deliver a high-quality portfolio of activities while prioritising the health and safety of participating students and staff.

2. ESA Education and ESA Academy

The ESA Academy is a part of the ESA Education Office and comprises of a portfolio of activities for university students. Like the Education Office in general, the mandate of the Academy is to enable and inspire students to pursue careers and further education in space related domains. This is achieved through a tailored transfer of knowledge from ESA, industry and academia experts, enhancing students' skills and competences and giving them the tools necessary to achieve their ambitions in the space domain.

The ESA Academy consists of two pillars, a portfolio of hands-on educational activities and a **Training and Learning Programme (TLP)**.

The hands-on programmes are recurring programmes which support students, normally in teams, through the design, test and operation of experiments or satellites. These programmes are:

- **Fly Your Satellite! (FYS)** – supporting student teams to develop, launch and operate their own CubeSats.
- **Spin-, Drop-, Fly- and Orbit- Your Thesis! (S-, D-, F-, O- YT)** – supporting student teams with experiments to be operated on a centrifuge, drop tower, parabolic flight, or on the International Space Station (ISS) respectively.
- **Rocket and Balloon Experiments for University Students (REXUS/BEXUS**) – a collaboration programme with the Swedish National Space Agency and German Aerospace Centre supporting student teams with experiments for sounding rockets and stratospheric balloons.
- **Fly a Rocket!** – a collaboration programme with the Norwegian Space Agency and Andøya Space Education, enabling students to participate in a sounding rocket campaign.

The TLP offers a series of training sessions to students, normally individually, on a large variety of space related topics. Prior to the pandemic these training sessions mainly consisted of 4- or 5-day on-site events taking place in the dedicated Training and Learning Facility at ESA's ESEC-Galaxia site in Belgium, and delivered by topic experts.

Within both pillars a large part of the activities have traditionally required on-site working, and to an extent the success and highlight of the ESA Academy programme has been the excellent interactions between students and experts and among the students themselves, enabled by these on-site, in person elements.

3. Initial effects of the Pandemic

As the numbers of infections and hospitalisations increased in Europe, ESA Education took steps to ensure the health and safety of all students and staff participating in its programmes. Throughout the pandemic the health of students and staff has remained a priority, and ESA Education has continuously, ensured it adheres to best practice with respect to the COVID situation, adhering to the guidelines and regulations of the relevant Member States, and often including additional safety measures.

The initial effects of the pandemic included: the cancellation and postponement of **Training and Learning Programme** training sessions and the rapid transition to online delivery [1]; the postponement of the **REXUS** launch campaign, and transition to virtual Critical Design Reviews (CDRs); the postponement of the **Fly a Rocket!** launch campaign and extension of the existing online training course; and the cancellation of site visits for the **Fly Your Satellite!** teams, and major adaptations to satellite testing.

Across all of the hands-on programmes, project development by the teams was also delayed by the lack of access to laboratories and inability to obtain materials.

4. ESA Academy Programmes: challenges and achievements

4.1. REXUS/BEXUS

Within the **REXUS/BEXUS** programme challenges were faced both by the programme, which traditionally includes many on-site events at ESA and partner facilities, and by the student project teams themselves, however with considerable variation between countries.

Where possible programme activities were switched to a virtual format. This was done for the CDRs (May & Jun. ’20), Integration Progress Reviews (Jun. – Aug. ’21), Cycle 14 selection workshop (Dec. ’21), Student Training Week and Preliminary Design reviews (Feb. ’22).

After some adjustment virtual events could be held with some routine. It was seen that some effort is required by the virtual host, but this is much less than the organisational effort in an in-person event.

Online events were largely able to meet their technical and educational objectives, but they could not be compared in terms of quality to in person events, missing, for example, the important social aspects and informal exchange.

A major advantage of the virtual format was an increased number of participants, no longer limited by venue capacity, and allowing flexibility around exams and work. The Student Training week hosted +/-150 students and +/-50 experts compared to typical on-site numbers of +/-90 and +/-20 respectively.

Conversely this flexibility meant some students were not always giving the training their focused attention, participating only partially or sometimes doing tasks in parallel, something which is difficult to track or monitor.

Many activities could not be performed virtually, such as Experiment Acceptance Reviews (EARs), integration and testing events and launch campaigns. The postponement of these eventually led to a one-year postponement of the entire programme, meaning there was no selection for new teams in 2021.

At the time of the postponement the participating teams were at the AIT (Assembly, integration and Testing) phase of their projects, however with the extra time, design changes were permitted and validated through additional design reviews.

Additional webinars were also organised, with 70-100 attendees at a time.

Once EARs were possible, they were often performed in a hybrid format, with some reviewers attending virtually and with mixed results. During the team’s presentation and project discussion, virtual participation did not constitute a disadvantage, but the main objective of the EARs, hardware inspection and demonstration, could not be performed virtually.

With an improving situation the integration, testing and launch campaigns could resume, with strict COVID measure in place, including proof of vaccination, facemasks, social distancing, daily tests, and strict limits on campaign numbers. The participation limit not only represented a disappointment for the students, but also presented a challenge for the teams to ensure the right expertise was available to support their experiment operation and any anomalies.

With the use of many virtual events the social and informal exchange aspects of the programme were soon lost. This is a particularly important feature in educational programmes which aim to motivate and inspire students and enable knowledge transfer. To mitigate this, events such as virtual coffee meetings and pub quizzes were held, with positive results.

For the teams the problems faced were mainly logistical, such as limited (or no) lab access and inability to obtain materials (compounded by the chip shortage).

Additionally, students’ academic careers did not stop, and teams were faced with members ‘aging out’ and graduating before their experiments were launched, necessitating either older students facing continued participation in the programme into their working lives and/or recruitment of new students and hand-over of responsibilities, a challenge even under normal circumstances.

4.2. Fly a Rocket!

The impact of COVID may be considered less severe than other programmes for **Fly a Rocket!**, although a significant delay was still experienced, with the launch campaign delayed from Mar. to Oct. ‘21. During this time, the existing online pre-course was extended. Students were given more time to work on the two existing assignments and an additional third assignment was created. Additionally, students were invited to join webinars organised in other programmes.

4.3. Fly Your Satellite!

Unlike REXUS/BEXUS the **Fly your Satellite!** programme has always consisted of a blend of

in-person (reviews, test campaigns, launch campaigns) and online (webinars, status meetings) elements. However, the pandemic significantly altered this balance.

During this period two cycles of the programme were running, FYS-2 with teams at the AIT phase, and FYS-3 with the teams around the CDR stage of their projects.

Within FYS-2 the initial challenges were broadly: The access of ESA Education to the teams for inspection and support with their hardware; the access of the teams to ESA test facilities to qualify their hardware for flight; and the ability of the teams to continue with their AIT activities due to complications with lab access and procurement (as with REXUS/BEXUS).

During the pandemic the LEDSAT team were integrating and testing [3], their protoflight model. This process usually includes ESA visits to the University, as well as testing at ESA facilities, neither of which were possible. However, as the launch was identified, these critical preparations could not be delayed and adaptations were found, including testing at university facilities. The inevitable reduced visibility led to some delays and further work, which may have been avoided otherwise.

Other test campaigns were adapted to allow critical testing, such as the EIRSAT-1 antenna test [5] which was conducted without the team physically present, and with other activities at the University taking place with ESA joining remotely.

Throughout the pandemic the teams showed remarkable resilience and adapted to enable project progress even in the virtual world, for example by enabling elements of remote access to their labs [6], to continue development and functional testing with reduced personnel.

Some activities could be performed onsite again in 2021 with extensive safety measures in place. These included the LEDSAT integration into the flight deployer [7], and EIRSAT Engineering Qualification Model testing [8]. The LEDSAT team were also able to attend a part of their launch campaign [9], although with a very limited number of participants, partly due to a clash in timing with the vaccine roll out in Italy.

Save for a small number of subsystem test campaigns [10], [11], the FYS-3 programme cycle has consisted almost entirely of virtual events.

Like in REXUS/BEXUS, programme reviews were moved online [12] [13], utilising lessons learned from the other programmes. Webinars were also offered throughout, with the added value of opening to other hands-on programme participants. New webinars were also offered, and a virtual soldering course was delivered with a live connection to ESTEC labs.

The Phase-D workshop [14], previously ran as a TLP style training event, was held entirely online in Oct. '21.

In addition to the programme adaptations, considerable adaptations were also made by the FYS team including supporting remote internships, online on-boarding of new trainees and virtual participation in conferences.

Despite the challenges and inevitable delays, FYS continued to deliver a high-quality programme for its participants, and throughout the course of the pandemic one satellite was launched, another qualified, and two achieved a Critical Design Review pass.

4.4. Spin-, Drop-, Fly-, Orbit- Your Thesis!

The primary element of the **-Your Thesis!** Programmes affected by the pandemic was the execution of the experiment campaigns, which requires access to specialised facilities (e.g. drop towers and parabolic flights). Other elements of the programmes were shifted online, following the example of the other programmes [15].

However, through adoption of strict COVID mitigation measures and shifting of schedules all campaigns were realised within 6 months of their originally intended date.

In particular the Fly Your Thesis (FYT) campaign was moved from Bordeaux, FR to Paderborn, DE (a lower risk area at the time of the campaign) [16]. An unexpected outcome of the pandemic was that the FYT teams were also able to take advantage of an additional partial-g flight one month after their nominal flight due to the cancellation of other experiments [17].

As seen with other programmes, -YT teams also faced considerable challenges with lab access, with solutions implemented with the help of universities enabling access under strict conditions, and often with limited numbers or the retrieval of hardware to be worked on at home. Procurement also impacted the teams, often reducing the time for testing before the final experiment campaigns.

Despite all the challenges faced, all selected teams and all students eventually participated in their campaign and managed to obtain data from their experiments.

4.5. Training and Learning Programme

The **TLP's** primary challenge during the pandemic was the rapid transition from a portfolio of on-site delivered training courses to an entirely online delivery. However, it may also be said that this evolution was already under investigation, with the emergence/acceptance of relevant technologies and the increased demand for more accessible opportunities.

Initially courses were postponed or cancelled, with already selected students offered participation in the delayed online edition of their training course, or an alternative. However, it was not long before the first fully online training course could be offered in Jun. '20 [1].

Through a culture of continuous improvement, the TLP was able to transition to a successful entirely online portfolio relatively quickly. This also proved excellent support to the hands-on programmes and provided a wealth of lessons learned for online course delivery.

Figure 1 shows the reduced number of training sessions in 2020 and the switch to online delivery.

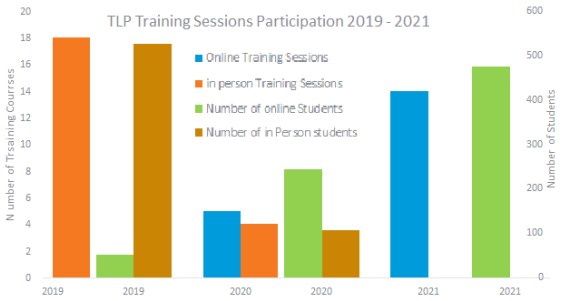

Figure 1: TLP Training Session Participation 2019 - 2021

Some of the main challenges with the transition were around the availability of suitable IT tools allowing quality delivery of the session and meeting relevant legal and regulatory policies (e.g. IT security, data protection). These were mitigated through support from other ESA departments.

As with the other programmes, the 'human' aspect of the sessions was initially lacking, an important aspect for student networking and knowledge exchange, but also for maintaining motivation and attention during the course. To address this several strategies were implemented, with many adopted into other programmes:

- An Ice-breaker a few days before each training session.
- Online informal get-togethers after the day's activities.
- Use of messaging platforms during the sessions.
- Increase of active participation through questions, quizzes, and chats
- A dedicated 15-minute Q&A session for every lecture.
- Re-scheduling from 4-5 full days to 8-10 afternoons, allowing flexibility around schedules and easier participation for Canadian students.
- Increased time allocation for teamwork and the use of breakout sessions with experts.

The transition to online delivery was also challenging for the experts, both in terms of adapting their content to be suitable for this medium and the delivery itself. To mitigate this, guidelines were produced on E-learning and Instructional Design Methodologies and additional test sessions were organised. Students were also requested to have their cameras on during the lectures, allowing for important visual feedback for the experts.

An unexpected outcome of the pandemic was an increase in the average number of applicants per training course. This may be due to a combination of the increased availability of students and the online format offering more flexibility for students to participate who might not have done so otherwise. Interestingly as academic courses began to return, applications numbers decreased, suggesting the TLP may have been filling the gap when curricular activities were reduced.

Despite the challenges the TLP maintained a high standard of delivery, with student and expert feedback continuing to be very positive as illustrated in Figure 2.

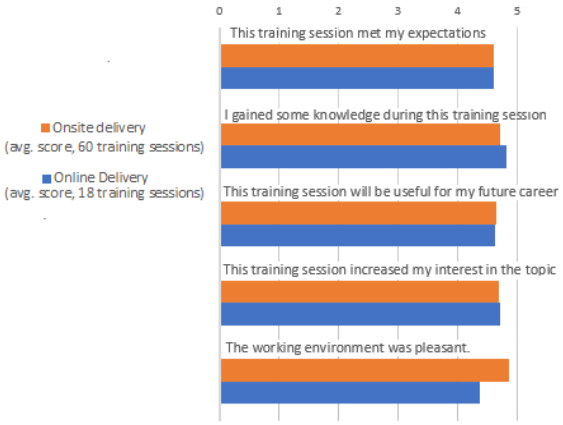

Figure 2: TLP Training Course Survey results

5. Lessons learned and adaptations for the future

The experience of the pandemic has provided a wealth of lessons learned for the Academy in

how programmes may be ran with limited on-site elements and the relative advantages/ disadvantages of such adaptations.

The potential for online training sessions to reach more participants has clearly been demonstrated, though the depth of involvement of online attendees may sometimes be less and certainly harder to monitor. However, the consistent positive feedback and experience has demonstrated that the Academy should continue to complement its existing portfolio with synchronous E-learning. Furthermore it's proposed that asynchronous E-learning should also be developed. The implementation of Small Private Online Courses supported by an e-learning Management System Platform, which was already in the longer term planning, will now also be prioritised.

Instructional System Design techniques have also been demonstrated to enhance the interaction between students and experts, showing good potential for future blended training sessions.

The experience of the REXUS/BEXUS programme has highlighted that hybrid reviews may be implemented for training events or early design reviews (when there is no hardware to review), but their effectiveness is limited later in the programme. Their implementation earlier in the programme may also allow participation of more experts from different organisations than have traditionally participated, potentially identifying issues earlier in the projects' development.

Within the '-Your Thesis!' programmes, a blended training session after selection will now be adopted, with an additional online session following the site-based Training Week. This will help conclude the initial design ideas discussion, giving students time to implement decisions made in the face-to-face meetings and come with additional questions to the experts.

The extension of online webinars, previously delivered to only one programme cycle, to multiple programme cycles and to other programmes has proved effective, and will be implemented more systematically in the future.

The important social elements of the Academy's activities were also demonstrated, and measures were implemented to ensure this is maintained as best as possible.

In general, further work will be done to share the lessons learned in the individual programmes and across both pillars of the programme and beyond, in particular exploiting the wealth of experience gained in the TLP.

6. Conclusion

Throughout the COVID-19 pandemic the ESA Academy has adapted and continued to delivery a high-quality portfolio of education activities, without compromising on student or staff safety.

The transition to a hybrid, blended and E-learning scheme has been considerably expediated by the pandemic, and adaptations made in reaction to the situation have allowed testing and demonstration of new methods of instruction and learning. The results show that these methods of distance learning offer important advantages and, when balanced well with a suitable set of onsite and face-to-face learning activities, deserve a place in all elements of the future ESA Academy portfolio.

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