Report of the FY2021 External Evaluation Committee for OISTER
15 June 2022

Executive Summary

This is the report of the External Evaluation Committee (EEC) appointed by NAOJ to evaluate the activities of the *Optical and Infrared Synergetic Telescopes for Education and Research* (OISTER) project between FY2019 and FY2021. It was carried out during the first four months of 2022 and is based on documents provided by OISTER, on interviews with a range of participants in OISTER, and on a survey of students and early career researchers. The report is divided into eight sections covering the various aspects of OISTER that the EEC was asked to examine, followed by a conclusion. Each section is followed by recommendations for consideration by the OISTER Joint Council and/or NAOJ. These recommendations are brought together in Appendix 4, and organized, **very roughly**, according to their priority.

OISTER is doing an extremely good job on the educational side, both in terms of training young astronomers and in preparing people for hi-tech jobs. It is running a network of university telescopes situated around Japan very effectively, although there have been challenges with some instrumentation. Its scientific output is adequate in terms of quality and quantity, although rather little has been possible in terms of its priority targets.

The EEC offers suggestions for improving the response time for transient follow-up, automating data reduction and data archiving. The follow-up of transients has become an international focus area and is one in which OISTER could play an important role. To do so will require increased funding to cover the costs of new instrumentation, improved software and the essential archiving resources. However, such funding can only be expected if OISTER develops a far-sighted and innovative strategic plan that integrates its diverse activities, and partners it with other Japanese role players.

Contents:

1. Background to OISTER and to this review

OISTER started in 2011 as the "Inter-University Collaboration", and the name OISTER came to be used gradually. Officially OISTER is still called the "Inter-University Collaboration" and is funded under that title. The External Evaluation Committee (EEC) understands that OISTER and "Inter-university Collaboration" are the same thing and have been used interchangeably in various documentation, including in publications.

In terms of management, and the organisation of this review, the National Astronomical Observatory of Japan (NAOJ) treated OISTER in the same way as it would an internal instrumentation project, with research objectives. However, OISTER started life as an inter-institutional collaboration, with research **and education** objectives. It remains an inter-university project, coordinated from NAOJ. It should therefore be managed and evaluated somewhat differently from a normal NAOJ Project, as its broader focus must be acknowledged. OISTER's mission ([DD00] section 2.2) is:

> 1. to compile and deliver time-domain astronomy data to the scientific community by systematically combining small/medium/large aperture optical-infrared telescopes that have been operated and maintained by the respective university or institute in Japan; and
> 2. to nurture highly-skilled youths by offering opportunities for undergraduate/master/PhD students to engage in not only extensive science activities but also productive education programs including on-site observation experience.

This mission guided the EEC's review, rather than the more focused milestones specified in [DD01]. All of the people interviewed were exceedingly positive about their personal experience of OISTER and about its importance to students.

OISTER is in its second term (funding cycle), which ran from 2017 to 2021; it is funded by the National Institute of Natural Sciences (NINS) through NAOJ. Note, however, that this review covers only the last three years of that term, as requested by NAOJ.

The day to day operations of OISTER are governed by the "*Optical and Infrared Astronomy Inter-University Cooperation Agreement*" [S12], which describes the rules for individual scientists joining and leaving OISTER. It also covers the constitution of the Observation Planning and Operations Committee (OPOC). This committee is responsible for all the day-to-day processes of OISTER, but must seek approval from the Joint Council for budgetary and other major decisions. The agreement also describes: - who can apply for telescope time, the rules for authorship, the rules for acknowledgment in publications, how to apply for observing time and how to trigger a Target of Opportunity (ToO). The agreement includes information on web pages where the status of the telescopes can be found, and the contact details of key members of the collaboration.

OISTER currently involves 9 universities (Hokkaido Univ., Tokyo Univ., Saitama Univ., Tokyo Institute of Technology, Nagoya Univ., Kyoto Univ., Hyogo Univ., Hiroshima Univ. Kagoshima Univ.) and NAOJ/NINS. They can make use of 16 telescopes, including those of two cooperating organisations, with apertures ranging from 0.36m to 3.8m (Seimei) ([S01 Table 1][S06]). They can also involve the 8.2m Subaru telescope in Hawaii, should the observations require it. Outside of Japan, in addition to Subaru, the IRSF is in South Africa and MiniTAO is in Chile. Not all of these telescopes were used for OISTER-related science during the review period ([S01 Table 4][S04]).

The organisational structure Is led by the Joint Council, who meet regularly once or twice a year and who decide on budgetary and high level policy. They also oversee OPOC and monitor the research programs. This has representatives from each of the Universities and from the Okayama office of the Subaru telescope, NAOJ, which handles the open use of the Seimei telescope, although not from the operations office of the Subaru telescope itself. Most of the organisational work is performed by OPOC, the membership of which includes most of the specially-appointed staff and postdocs for OISTER, who meet monthly. Note that [S10], prepared by the Chair of OPOC and presumably up to date, includes the names of two more OPOC members (plus that of a new representative for Tokyo Univ.) than does the formal Management Plan, [DD01] which dates from 2020-04-01.

Although everyone interviewed thought that both the Joint Council and OPOC functioned well in terms of day to day operations, there was some concern expressed that the Joint Council needed to provide more strategic guidance if OISTER were to operate as a state-of-the-art network, and that a number of software/hardware upgrades were necessary.

The EEC were told that the uniqueness of OISTER derived from its multifunctional flexibility and specifically from (1) access to polarimeters, photometers and spectrographs, and (2) to the availability of a near-infrared capacity alongside the more common optical wavelength coverage.

The PI for an OISTER observation must be a member of OISTER. Observations can be Target of Opportunity (ToO), or time critical observations. A *Call for Proposals* is issued twice a year. Each member institute contributes 10-20% of their observing time, at their discretion. OPOC sorts out any conflicts, but these are rare. ToOs cannot be triggered during open-use time (currently 63.5 nights per semester, 6 months) on Seimei, which limits what can be done. Targets over the last 3 years include a very large range of astrophysical objects, from Solar System objects, through flare stars to FRBs and IceCube neutrino sources.

OISTER supports observers from proposal to publication. Specifically, OPOC keeps track of data analysis and publication through their monthly meetings, with regular reports from observers. OPOC also holds data-analysis and instrumentation workshops for students as part of the education initiative. They organise science seminars with speakers from inside and outside of OISTER. At the time of this review OPOC were in the process of organising a second special feature on OISTER for Publication of Astronomical Society of Japan (PASJ) journal.

Recommendation

R1.1 Partners' Agreement: The EEC encourages the Joint Council to draft a Partners Agreement that includes a process for dealing with changes in OISTER's circumstances, including, but not limited to: (1) a new partner joining OISTER, (2) a partner leaving OISTER. This Agreement should include financial considerations and the processes to be followed when deciding on new members. The additions and changes should be made with the objective of encouraging new members who would add value to OISTER. The Agreement should include some details of how conflicts will be resolved, should these arise.

R1.2 Code of Conduct: To be aligned with current international best practice the Joint Council should draft a Code of Conduct for OISTER and display it prominently on the OISTER website in both Japanese and English. It is important that all participants in OISTER, including students, are not only aware of this, but actively agree to it. The IAU Code of Conduct may be helpful in drafting something suitable for OISTER.

2. Procedure followed for the review

All meetings were held via Zoom. A preliminary meeting of the EEC, together with the Office of the Project Review Committee of NAOJ, was held on 21 December 2021, at which time a Chair and Vice-Chair were selected. The EEC comprised:
Whitelock, Patricia: Chair of the EEC
South African Astronomical Observatory & Honorary Professor, University of Cape Town
Akiyama, Masayuki: Vice-Chair of the EEC
Professor, Astronomical Institute, Tohoku University
Im, Myungshin: Director, SNU Astronomy Research Center
Professor, Astronomy Program, Dept. of Physics & Astronomy, Seoul National University
Kato, Mariko: Professor Emeritus, Faculty of Science and Technology, Keio University
Yonekura, Yoshinori: Professor, Center for Astronomy, Graduate School of Science and Engineering (Science), Ibaraki University

The EEC met on 4 February 2022 to discuss the documents they had read, the overall plan for the review, and to decide whom they should interview. At this time, they agreed that they needed more information than had been supplied and requested further details and documents from NAOJ and OISTER. They also formulated an online questionnaire that would ask students, including undergraduates and postdocs, about their own experience and perceptions of OISTER. This was a way of getting input from a larger number of people than could be interviewed. The interviews proceeded during March 2022 according to the schedule outlined in the Review Plan (see Appendix 1).

In summary OISTER provided the EEC with 30 documents and answered numerous questions. We conducted 18 interviews over four days: From the staff, we spoke to the Project manager and three members of the joint council; also to the Chair and three members of OPOC. These eight staff members represented seven of the institutions involved in OISTER. We also spoke, rather more briefly, to two MSc and eight PhD students from nine different universities. All of the interviews were interesting and everyone was helpful and constructive.

The review that follows draws on the information provided by OISTER, the questionnaire and the detailed discussions. All of the people interviewed were exceedingly positive about their personal experience of OISTER and about its importance to students. Several individuals also made suggestions for improvements, and many of these have been incorporated into the recommendations that follow each section of this review. All of the material requested in the review plan is included in this document, although the structure of this report, in particular sections 3 to 8, differs slightly from that outlined in Appendix1. This modified structure seemed more logical when we reviewed the material we had collected.

The references given in square brackets [] refer to a specific document as listed in Appendix 3. All of the material listed in Appendix 3, was used to help inform the review, even when no specific reference was made.

Recommendations

R2.1 Future Reviews: Future reviews will depend on various factors and are outside the terms of this EEC. However, given the challenge this EEC had to get the detailed information we required for our review, we strongly recommend that the starting point for any future review be a *Self-Assessment Report* from the OISTER management team, covering the relevant time period. This should provide detailed statistics of how OISTER had fulfilled their mandate, their successes, failures, challenges, and plans for the future.

R2.2 Translation of this Review: The EEC recommends that the final version of this review, together with the OISTER/NAOJ response, be translated into Japanese and access to it provided to all of the OISTER participants, including students.

3. Status of the telescope network

The observation network seems to functionally integrate 11 small and medium-sized optical infrared telescopes (Table 4 in [S01]). The environment to operate the telescopes effectively as a united system to conduct transient or campaign monitoring observations has been organised well and maintained. The proposal review and acceptance, observation operations, data delivery and storage, follow-up of the data handling after the observations, are all well organised by the OPOC members.

No detailed information was provided for the usage of the smallest (<0.45m) telescopes, the two telescopes of the cooperating organisations, or for miniTAO, so we assume they are not generally operating as part of the network.

The numbers of participating universities and faculty/students are adequate. The project contributes to sharing the access to small and medium-sized telescopes for students in the participating institutes. The combination of optical and IR research labs of various sizes provides effective educational opportunities regarding observations, data analysis, and instrumentation.

Some of the telescopes are fully robotic, including MITSuME-Okayama and MITSuME-Akeno. They can start an observation within 20s of getting a notification, e.g., from the gamma-ray coordinate network (GCN). So they can follow-up very fast events. Other telescopes are manual, but remotely operable, while others require an observer in the dome. The manual telescopes are an important teaching tool and the students benefit from the hands-on experience. Views on the need to automate telescopes varied among those staff members who were interviewed on the subject, depending on their own scientific and educational priorities.

OPOC oversees everything, from the applications, through triggering the observations, analysing the data and drafting the papers. The tasks have become sufficiently routine that few, if any, interventions from the Joint Council are necessary. The young people, mostly postdocs, are playing a leading role in the organisation of OISTER and in the modernization of its various processes.

OPOC receives observing proposals twice a year although it is possible to perform ToO observations at short notice, making it attractive to follow-up unexpected interesting events. The observations are carried out by the observatory staff (OISTER postdocs and research staff) and students on duty. Based on our interviews with users, we heard no complaints about the execution status. The number of successfully executed observation runs is appropriate (11 in 2019, 15 in 2020, and 2 in 2021 [S10 page 11, S06 page 17] in response to the following triggers, 11 in 2019, 15 in 2020, and 4 in 2021 [S10 page 11]), more than doubling over the years from 2017 to 2020, although very low in 2021 (possibly because the count provided to the EEC was incomplete for 2021). The total number of nights from all eleven sites that were used for OISTER-related observations is 707 from 2019 to 2021 [S01 Table 4], again showing good usage of the facilities. These numbers suggest that the telescope network was functioning well. However, the total number of observing nights used by OISTER was significantly larger in 2019 than in subsequent years, as shown in the OISTER statistics [S01 Table 4] (except for Seimei which was only commissioned during 2019). This may be partly due to the COVID-19 prohibiting staff movements and necessary repairs in 2020 and 2021, but we suggest that the cause of the reduced number of observing nights be identified internally.

We see good evidence of collaborative research activities taking place through OISTER using OISTER telescopes at different locations, examples include:

- Shidatsu et al. (2019) performed a multiwavelength analysis of the black-hole candidate MAXI J1820+070 (although the associated OISTER data from Adachi (2019 in preparation) does not appear to have been published).
- Kawabata et al. (2020) studied SN 2019ein utilising the OISTER telescopes at multiple locations to build up a dense light curve of the event (see also 4.2).
- Morokuma et al. (2021) used various optical/NIR facilities to understand the nature of the neutrino-emitting blazar, TXS 0506+056, as a part of their multi-messenger investigation of IceCube-170922A.

This kind of collective use of the facilities would have been difficult, if no framework such as OISTER existed.

Notifications of observations are done electronically (through a social network service (SNS) such as Slack or email), and the users are satisfied with the current sharing mechanism. The adaptation of the SNS tool is good for rapid communication between OISTER members, but not always fast enough for triggering ToOs.

The observations carried out by OISTER have proved to be useful in a variety of ways, and users of the OISTER telescopes appreciate the opportunities to interact with others in different institutes and research fields through coordinated OISTER observations.

Involvement in the OISTER project has served as a strong motivation to keep the participating observatories in good operational status, and OISTER funding has been used to assist with maintenance and repairs. In general, the staff hired by OISTER are participating in the daily operation of the observatory, such as scheduling and executing observations, communication with the OISTER team, managing their observing team, arranging data transfer and, in some cases, actual hardware maintenance of their observatory and managing and writing their observing and data reduction software, in addition to serving on OPOC. As testified by various OISTER interviewees, such duties appear critical for the smooth operation of their observatories, which are also used for other research and education activities throughout the year.

Most of the OISTER telescopes are operational and in good condition, as seen by the number of observations. However, instruments in some telescopes suffered breakdowns, for which the repair was delayed, partly by travel restrictions due to COVID-19 and partly because of expense.

Although we heard from the Project Manager that resources were shared, we interviewed at least one person who indicated that it would be helpful if there was more sharing than was currently taking place. In particular, it would be very useful to share expertise on automating telescopes and that this would allow for a more effective and responsive network [S09].

It was clear from our interviews that involvement in OISTER was ***vital*** for the continued maintenance of the university telescopes and instruments. Other considerations: education, collaboration, use of other telescopes, etc were important but secondary [S11].

There were different perceptions, amongst the people we spoke to about the need to automate telescopes, but there was an acknowledged requirement to respond rapidly to alerts, as well as to analyse the data and share the result speedily [S09][S11].

Recommendations

R3.1 Instrumentation development: The strategic development of the instruments across the participating telescopes should be considered to strengthen the effective response to critical transient events in the future. For example, the number of telescopes where NIR observations can be achieved is only four (Nagoya-IRSF, Hyogo-Nayuta, Hiroshima-Kanata, and Kagoshima) and in FY2019-21 two of the four could not be used for some long while due to COVID-19 and/or problems with the instruments and limited funding. Thus it is recommended that OISTER make repairs as soon as possible, and considers increasing the NIR observational capability to reliably offer this to the collaboration (we understand that the NIR imager at Kagoshima is now operating again, although the IRSF in South Africa is not). The EEC understands that this is limited by finance, but we agree with the Project Manager that access to infrared instrumentation makes OISTER much more competitive.

R3.2 Automating Telescopes: It is worth considering the automation of more of the OISTER telescopes and providing for remote operations of others. There are various reasons for *not* wanting to automate everything, including educational usage and cost. These considerations should be strategically balanced with the various advantages offered by automation and remote operation, particularly if the priority science targets require a rapid response. If OISTER is seriously aiming to be internationally competitive it is vital they recognize how much effort other groups are putting into rapid response and automation, and develop a plan that will allow OISTER to, at least, keep up. The EEC appreciates that significant automation will require a considerable increase in funding and that this must be motivated as part of a high level strategy.

R3.3 Response Time for ToO: The flexibility of the procedure OISTER uses for ToO observations was appreciated by the users, but some recognized the need to respond very rapidly to certain transients. The current response is limited by the need to trigger a ToO through Slack, e.g. [15]. The EEC encourages OISTER to examine what is being done internationally in this area and to find a way to trigger certain limited ToOs on certain telescopes automatically.

4. Data reduction, archiving and dissemination from the OISTER network

4.1 Data Reduction and Archiving

Over the lifetime of OISTER a good deal of time and effort has gone into standardising the data reduction process so that the different universities and telescopes are compatible and can share data easily. Some effort will be needed to complete this and keep it this way as new instruments are commissioned, and to ensure that observations can be reduced as rapidly as possible. For the fastest and most interesting transients, making observations rapidly is only the start. They must also be rapidly reduced and announced to the world. From there decisions must be made on what sort of observations to do next.

Some of the people we spoke with were very happy about the data they received, others less so. This really depended on what they were trying to achieve and how important it was for them to combine data from different telescopes and to respond rapidly. We were told during the interviews that there was still a need to standardise the observing data format and its meta-data. This is essential for rapid reduction and rapid dissemination.

Some data are stored at Kyoto University, which seems appropriate for the small scale collaboration over a limited period. Other data are stored at SMOKA within NAOJ and made public after one year (Tokyo Tech [S15]) or after 18 months (Hiroshima [S09]). We heard concerns from several OISTER members that the current system of storing data at SMOKA may be discontinued. There should be a stable, centralised data archiving system for OISTER to operate properly.

4.2 Publications

The EEC were provided with two publications lists covering FY2019 to FY2021 (as of March 7 2022). [S03a] lists a total of 13 refereed and two non-refereed papers based on data from OISTER observing proposals. [S03b] lists a further 89 refereed and 94 non-refereed publications that were based on data from OISTER-funded telescopes or were by researchers employed by the OISTER project.

We assume that [S03a] is a complete list. 13 refereed papers and two non-refereed papers from the OISTER programs can be considered adequate, if not excellent, given the number of years and participants. The publication list covers diverse topics, including a neutrino event, supernovae, X-ray transients, flare stars, cataclysmic variables and the Moon. It certainly illustrates the great potential of OISTER for doing a very wide variety of research.

The paper by Kawabata et al. (2020) nicely illustrates OISTER's time-domain capability for a high priority target. They followed the evolution of a type Ia supernova, from before maximum light, over about 60 days, getting photometry with various OISTER telescopes and spectroscopy with Seimei. This enabled them to follow the velocity evolution in some detail and demonstrate good agreement with theory. The paper has been cited 18 times in two years, so the work is being noticed.

In the period targeted in this review, one NS+NS event, two NS+BH events, and many BH+BH events were reported from the GW detectors. OISTER worked with J-GEM to perform galaxy-targeted follow-up on many of them (Sasada et al. 2021), although no optical/IR counterparts were identified for any of these events. It is difficult to observe such events with small and medium-sized telescopes due to their faintness and large positional uncertainties. The collaboration with J-GEM can improve the GW event research outcome, and it will be a good idea to continue having close association with J-GEM. In future, the uncertainty area should be much reduced, and the follow-up strategy could be changed. The participation of Subaru & Seimei will certainly allow for observations of quite distant GW events in future.

There were three publications (one refereed and two reports to GCN) related to IceCube high energy neutrino events, which are also challenging for small telescopes, but we would hope that more can be done in future and the follow-up observational study of high energy neutrino events can be improved.

The large number of papers in [S03b] is even more diverse, although many are on similar topics to those in [S03a], including several matched with the Primary Scientific Goals of OISTER listed in [AD03], and they should probably not be regarded as much less important. We have concerns about the completeness of the list provided[1], but can only analyse what we were given for this review.

Given the range of publication topics, the OISTER team may also emphasise the importance of performing research outside multi-messenger astronomy. In order to increase the scientific output, OISTER could consider opening the unique opportunities it has, for transient and campaign monitoring observations, to non-OISTER members.

Recommendations

R4.1 Data Reduction Pipeline: For the high priority transients it is essential to provide rapid data reduction. The OISTER collaboration should be able to combine the data from its various telescopes and announce their findings, very rapidly. This process should be as automated as possible for transient observations. This will have the added advantage of reducing the data-reduction workload for the staff.

R4.2 Data Storage and Archiving: The reliable storage, and backup, of data is a vital part of OISTER's activity. It is also expensive, so realistic storage requirements should be built into any future strategy. It is important that data can be retrieved to confirm past discoveries, but it is also important that data can be mined for discoveries not envisaged when the observations were made. Thus data should be archived, and not simply stored, so that it is findable, accessible, interoperable and reusable (FAIR). Virtual Observatory tools are designed to help with the process of making data FAIR and we encourage OISTER to make use of them. Making all, or most, of the data public after a priority period would improve the international profile of OISTER, but it would also be costly; this should be considered.

4.3 GW and Neutrino source follow-up: OISTER should continue to work with J-GEM, and develop a long-term (10 year) strategy for the follow-up of GW and neutrino sources. OISTER needs to develop its own expertise and to work closely with others, including theorists, to optimise their response to these rapidly evolving fields.

[1] A spot search for one random member of the OISTER collaboration, Masaaki Otsuka (Kyoto), in ADS found 11 refereed papers, compared with 5 papers listed in [S03a]+[S03b].

5. Achievements and status of undergraduate, masters, and doctoral student education using the OISTER network

5.1 Source of information

In order to establish the experiences of those participating in the OISTER project, we conducted a survey among students and early career postdocs (see Appendix 2). We received 52 answers in total, distributed as shown in Fig. 1; this includes some respondents who left astronomy after completing masters or bachelor's qualifications. Although the numbers are limited in the statistical sense, they can be taken to represent a significant fraction of the students and postdocs participating in OISTER. Under the OISTER budget framework 9-10 postdocs are employed, and we received an equivalent number of answers from postdocs, but it should be noted that the number includes answers from those who are not hired via OISTER funding. Considering the number of degree holders from the project as shown in [S06], we assume roughly 20

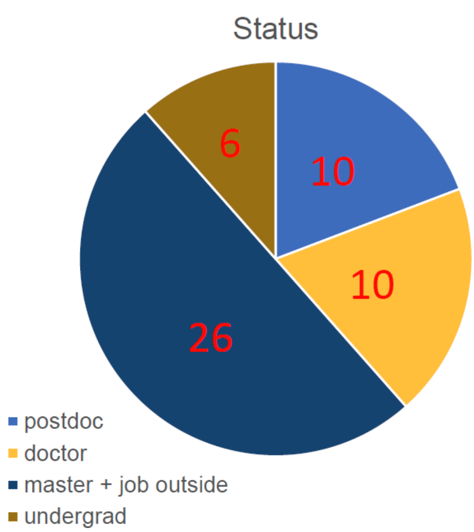

Fig.1 : Answers to "Your current status" (52 answers in total)

undergraduate students, 30 masters students, and 10 doctoral students belong to the project on average each year. On this assumption we received answers from 90% of masters and doctoral students, and 30% of undergraduates. We illustrate the statistics by dividing the answers into four categories based on the respondents' current status. The gender distribution in each category is shown in Fig 2. The distributions are assumed to reflect roughly the gender distributions of the entire membership of each category.

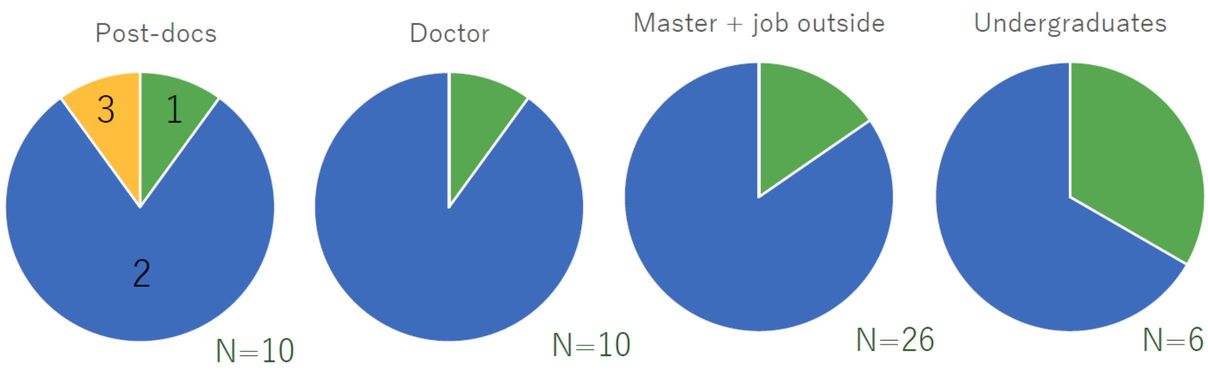

Fig. 2: Answers to “Your gender”. 1(green): Female, 2(blue): Male, 3(yellow): No answer.

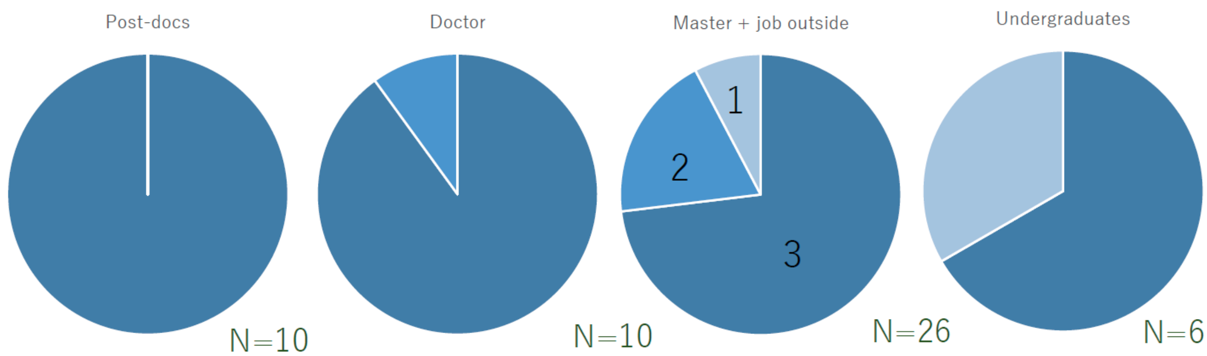

Fig. 3: Answers to “Are you conducting observations at your home institute ?”. 3: More than twice per year, 2: Roughly one time per year, 1: Never.

Fig. 3 describes the frequency that respondents made observations with telescopes in their own institute. Can be seen from the figure, the answers are biased toward observational, rather than theoretical, researchers; the fraction of students involved in observational study with frequent (more than twice per year) or less-frequent observing experience, is 75%. This is higher than the fraction of observing researchers shown in the list of OISTER stakeholders [S01].

5.2 Overall evaluation

We asked about the overall satisfaction with the project. The response is illustrated in Fig. 4. The overall satisfaction level is high. The answers indicate that more than 75% are “Fully satisfied” or “Satisfied”.

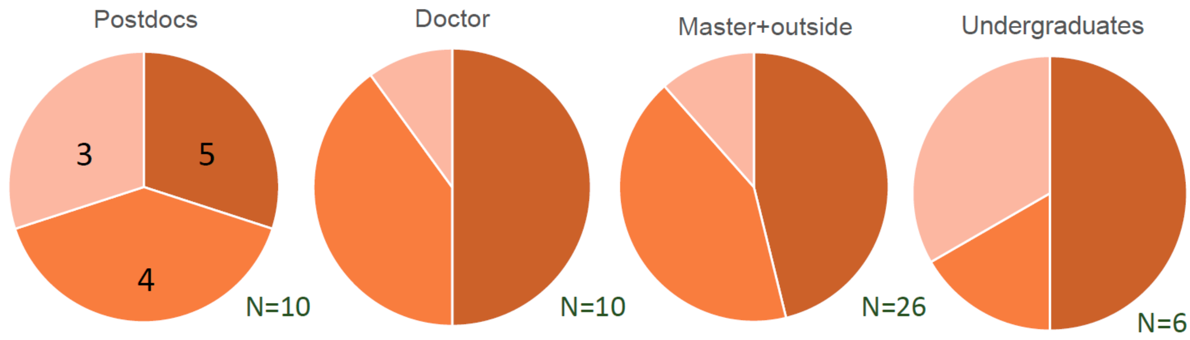

Fig. 4: Answers to "Your overall satisfaction with your own participation in OISTER". 5:Fully satisfied, 4:Satisfied, 3:Neither satisfied nor unsatisfied, 2:unsatisfied, 1:strongly unsatisfied

We also asked about the necessity of the project to the current and/or future research of the individual participants. The response to this is illustrated in Figs. 5 and 6 for the current research and for future research and career path, respectively.

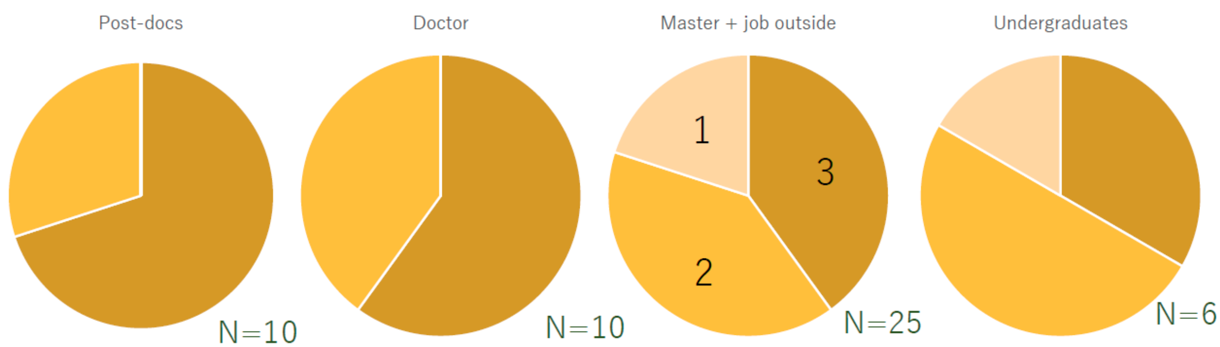

Fig. 5: Answers to "Importance of OISTER in your current research". 3: Necessary to conduct my research, 2: Important as an educational opportunity, but not essential, 1: Not important.

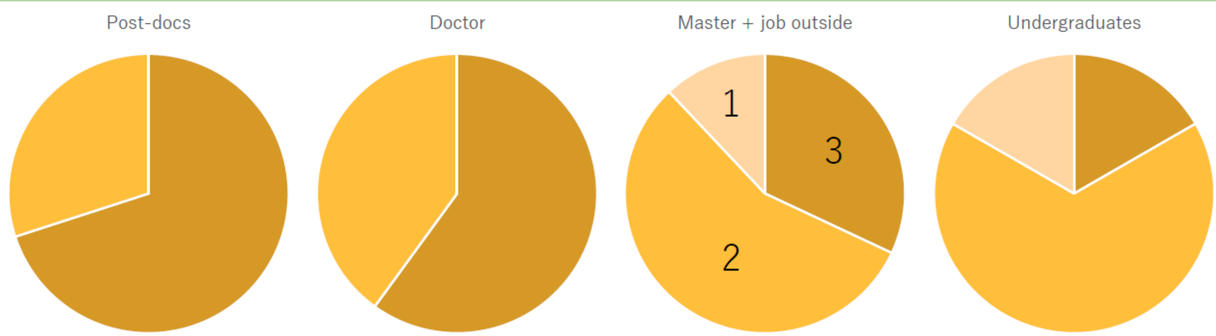

Fig. 6: Answers to "Importance of your experience with OISTER in your future research and profession". 3: Necessary to conduct my research, 2: Important as an educational opportunity,

but not necessary, 1: Not important.

All of the postdocs and doctoral students answered that OISTER is necessary or important to their current research and future projects. The fraction is still high among masters students; more than two thirds recognize the necessity and importance of participating in OISTER. The collaboration framework is recognized as an important foundation for collaborative research and educational opportunities beyond the affiliation of each participant. It should be noted that the answers could be biased toward observational researchers who rely on the project. Nevertheless, the number of students and postdocs who answered the questionnaire is large compared to the number of participants in typical projects of the Japanese competitive research funding, Kakenhi, with similar amounts of funding (Kiban-S, ~0.4M US$ per year for 5 years).

Although the information on observational opportunities, like a list of observing modes, and rules for participating in the collaboration, such as a format of acknowledgement in publication, are organised well by the OPOC, such information is not always recognized by the members, especially students.

5.3 Observing opportunities

The OISTER framework enables students to access telescopes other than those owned by their affiliated universities, and provides good opportunities to obtain necessary data to complete their own research. In addition to the frequency of observation at their own institute, we asked about the frequency of observations with a telescope in other institutes utilising the OISTER framework. The results are shown in Fig. 7.

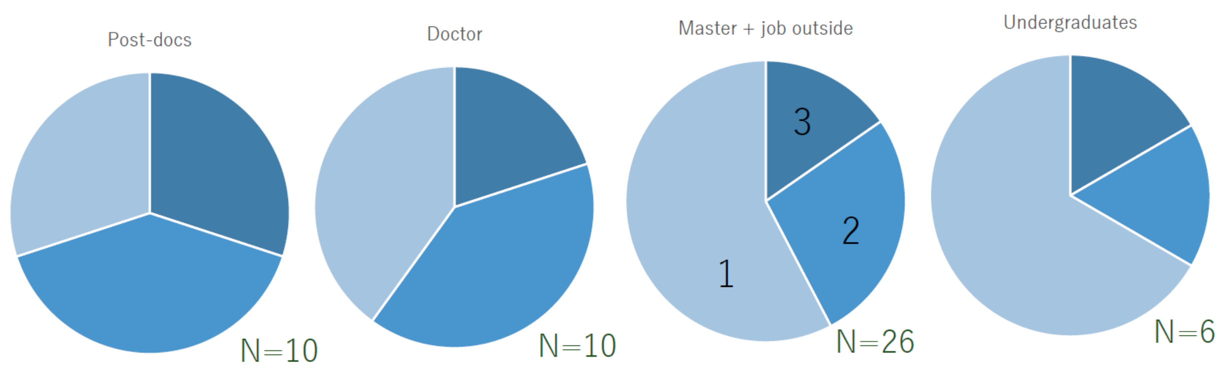

Fig. 7: Answers to “Are you conducting observations at OISTER institutes other than your affiliation ?”. 3: Frequently (more than 2 times per year), 2: Sometimes (roughly 1 time per year), 1: Never.

They indicate that one quarter of the postdocs and doctoral students are frequent observers at telescopes belonging to other institutes, and one third of masters students have experience observing at such telescopes. The usage of data from OISTER telescopes was asked about and the results are summarised in Fig. 8.

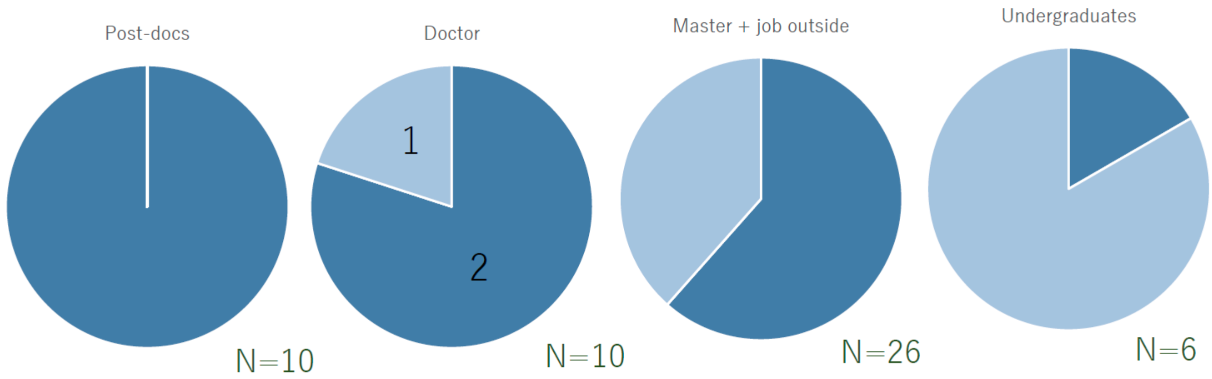

Fig. 8: Answers to "Are you using data obtained with OISTER telescopes in your research ?" 2: Conducting research using data from OISTER telescopes, 1: Never.

More than half the doctoral and masters students are conducting research using data from OISTER telescopes. Furthermore, some examples go beyond access to observing time. Certain students and postdocs interviewed explained that they brought instruments they had developed to telescopes at other institutes to conduct engineering tests and science observations. The close collaboration of the OISTER framework clearly offers special opportunities.

Several masters students mentioned during the interviews that they were reluctant to submit observing proposals to OISTER. Sometimes observing opportunities for such students are provided under institutional collaboration without proposals. They were also concerned that the OISTER proposal was too strongly focused on transient or campaign monitoring. Encouraging students to submit proposals to the OISTER framework will help them think about their scientific works proactively. For example, this could be done by assigning some portion of the available time to students. Such opportunities need not focus on science cases related to transient or campaign monitoring observations.

5.4 Scientific collaboration

Scientific collaboration across the participating institutes is promoted by the project. OISTER workshops provide such opportunities, and the participation to the workshops is indicated in Fig. 9.

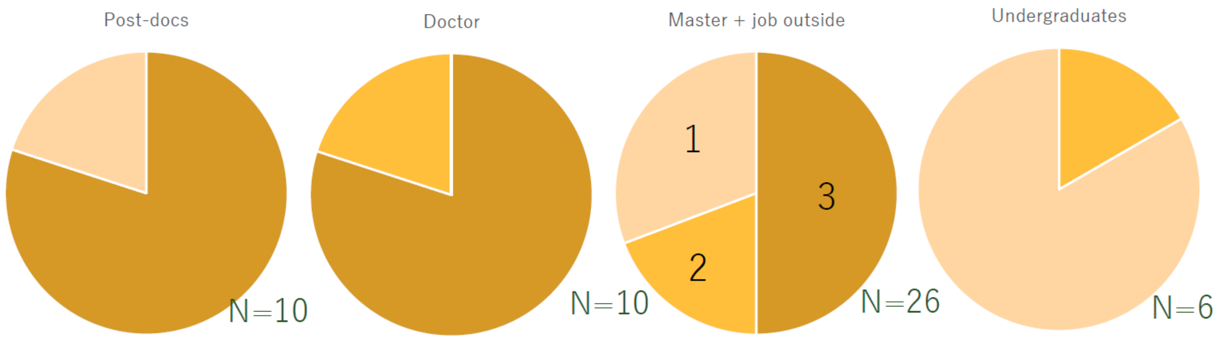

Fig. 9: Answers to “Your participation in the OISTER (optical IR inter-university workshop) science meeting. 3: Make a presentation on your own research, 2: Participate in the meeting (and had discussions with staff members and/or students from other institutes), 1: Have not participated.

More than three quarters of postdocs and doctoral students have made presentations and participated in discussions in OISTER workshops. Such discussions often extend to frequent exchanges with members in other institutes beyond the workshops. Opportunities for more frequent and detailed discussions with staff members from other institutes can be stimulated under OISTER. The frequency of such opportunities is illustrated in Fig. 10.

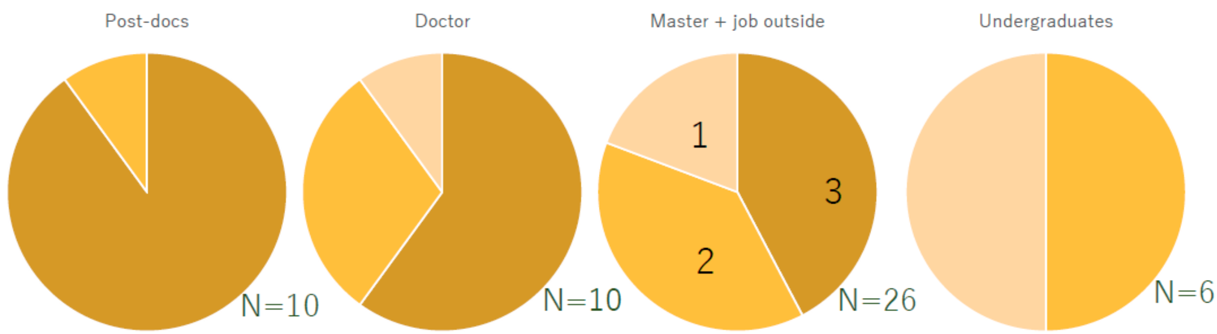

Fig. 10: Answers to “Your discussions outside your home institute”. 3: “Conducting research and staying long time (>a half year) in other institute than your affiliation” or “conducting research with staying short period (week - <a half year) in other institute than your affiliation”, or “conducting frequent discussions with staff and students in other institute”, 2: Not frequently, 1: Never.

An introduction in a workshop also has a positive effect on masters students; they feel more comfortable entering into discussions with faculty members in other institutes (as described in their interviews with us). Even for doctoral students and postdocs, the OISTER science discussions covering topics related to optical and IR observations presented good opportunities to learn about other astronomy fields beyond their expertise.

It is clear from our interactions that OISTER is hugely beneficial to the young people, staff and students, who participate. It is particularly important to the smaller institutions as it provides first class learning and networking opportunities. The short-stay learning programs allowed students to learn about spectroscopy and instrumentation, as well as about data reduction, and were greatly appreciated. Under the COVID-19 restrictions the opportunities for face-to-face interaction were greatly decreased. This severely affected the early stage graduate students, (i.e. masters course and the first year of the doctoral course), who did not already have connections established. OISTER needs to find ways to accelerate the interaction of these students; one possibility could be a student-led focused science workshop.

5.5 Skills development

The educational opportunities provided by OISTER cover a very wide range for masters students, including observing, data handling, and hands-on instrument development. The participation in OISTER observations provides great opportunities for a realistic observing experience, something that is becoming increasingly difficult in the era of service- and automated-observations. The opportunities are well taken care of by OPOC. The numbers of participating undergraduate students depend on the institute, and opportunities for undergraduate students are quite limited.

The area of skills development through the project was specifically asked about with items of “Observation experience”, “Leading collaboration”, “Data analysis”, “Development of instrument”, and “Others”. The distributions are shown in the histograms of Fig. 11. In addition to the answers, “project management” was also mentioned in “Others”, by a post-doc.

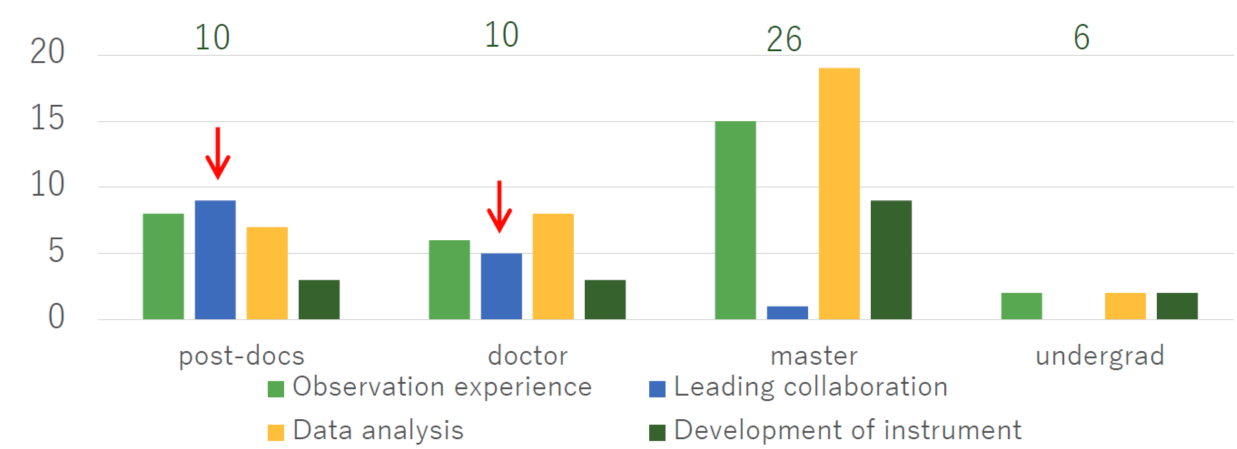

Fig. 11: Answers to “Select educational opportunities provided by OISTER that have given you useful skills (multiple choices can be selected)”.

Among masters students, experiences of observation and data analysis are recognised as the main area of skills development. For doctoral students and postdocs, OISTER offers a training for small- to mid-scale collaborative science projects. Experience in leading a collaboration is recognised as an important skill, which is greatly appreciated by those involved. Project management opportunities are also provided for postdoc members, especially in the OPOC.

We note that a very large number of participants (over 120) were accommodated in the 2020 (*Innovation in Collaborative Observation*) and 2021 (*Summary and Future of OISTER*) workshops, which were held on-line because of the Covid pandemic [S10]. This is an indicator of a high level of interest, and OPOC are to be congratulated on adapting to the situation and making it work.

It was disappointing to see, at least in certain universities, how few students participated in OISTER observing ([S09] one in twelve in FY2021 at Hiroshima), although many more would make their own observations.

Systematic training opportunities for the doctoral students and postdocs are currently limited, although a real experience of conducting research collaborations can be obtained. Guided experience in project management and systems engineering are important to establish skills in these fields. The importance of such skills is being increasingly recognized for various science projects. OISTER, especially the JC, should consider how such opportunities can be arranged for the doctoral students and postdocs. Project management experience with a wide range of authority and responsibility would be an important opportunity for the OPOC members.

For some students, especially those who are not engaged in instrumentation in their home university, the application form, which requires a detailed study plan for the short-term training program, is hard to complete. Introductory hands-on opportunities related to instrumentation could be considered as a new program.

The current educational programs provided by OISTER are very biased towards observational astronomy, lacking coverage of theoretical astronomy topics. Such coverage can be emphasised especially for masters and undergraduate students.

5.6 Science outcomes, publications

The publication list provided by OISTER [S03a], included a few refereed papers that are led by a student as the first author. Furthermore, several student-led papers are among those published by the OISTER collaboration [S03b]. Considering the number of PhDs per year, the publication rate can be evaluated as successful.

The number of refereed papers published with the postdocs who are specially-appointed for the OISTER project (shown in Management Plan [DD01]) as the first author is limited in [S03a] and [S03b]. In order to obtain insights on how to improve the observational network as one united system, the EEC encourages the OPOC members to consider the full exploitation of the unique observing opportunities provided by the OISTER framework, i.e. transient and monitoring observations in multi-modes, to conduct their own research.

According to [S16], in the two years for which data were available (2019-2020) there were five PhD, 20 Masters and 29 Bachelors' theses written based on observations obtained with the OISTER telescopes.

5.7 Career path

The plan for the future career is also asked and the answers are summarised in Fig. 12.

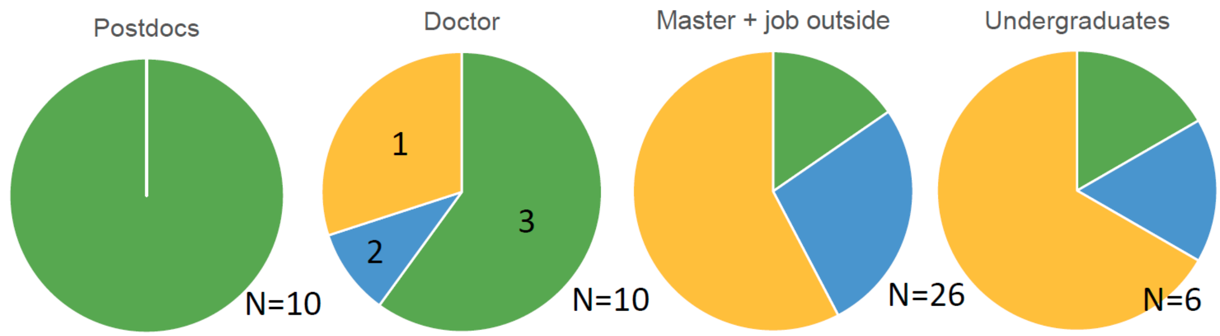

Fig. 12: Answers to “What is your career plan for future”. 3: Planning to be a researcher in an educational establishment or in a research institute, 2: Planning to get a job outside of the research field, 1: Have not planned yet, or No answer.

Both the results of the questionnaire and the statistics shown in the OISTER project summary [S06] indicate a similar career path from masters and doctoral courses to postdocs. Three quarters of students who completed masters courses move into fields other than astronomical research. It is clear that the wide range of educational opportunities offered by OISTER support skills development beyond astronomy.

On average a few people complete a PhD every year, and roughly one moves outside astronomy, while two get postdoc positions. The postdoc positions provided by OISTER are one obvious career path choice for the PhD from the project.

Large numbers of postdocs, 9-10 in the 3 years, are hired using OISTER funding. This means that, on average, three postdocs need to find permanent jobs every year. The EEC recommends that the JC consider how to make the postdoc positions of OISTER attractive career paths. In addition to contributing to the science output, further skills development opportunities could be considered. Some thought should also be given to creating some permanent posts.

The EEC were concerned that OISTER students (and some staff) may not get sufficient theoretical background to their studies. They should have some knowledge of topics such as stellar evolution, binary evolution, gravitational waves etc. Possibly those theorists who are members of OISTER could contribute by offering on-line courses open to all OISTER students and staff.

Some of the people interviewed thought that OISTER might open its education activities to non-members. They seem to be so successful that it would be worth investigating if this could be done without overwhelming the organisation. [S13]

Recommendations

The following recommendations are a result of discussion with the students and/or their responses to the questionnaire. Despite the fact that they were broadly very happy, the students had many suggestions. The EEC appreciates that it may be impractical to implement many of them in the short term, nevertheless we hope OISTER will find them useful as you evolve the various educational activities. They are not in order of importance, although the first one is urgent.

R 5.1 Compensation for COVID restrictions: Consider a student-led focused science workshop or some other activity that brings students physically together as soon as it is safe to do so. This is urgent.

R5.2 OISTER Information Session: As not all students seemed to be well informed about OISTER opportunities the EEC recommends an annual information session aimed at new students, possibly by the institutional members of the Joint Council.

R5.3 Observing: It is worth exploring what it is that discourages students from (1) wanting to observe for OISTER and (2) submitting their own application for telescope time. Possibly consider allocating a small amount of time for certain telescopes for student observing, not necessarily related to transients.

R5.4 Skills training: Look for ways to offer doctoral students and postdocs training in project management and systems engineering, and/or similar high level professional skills.

R5.5 Basic Instrumentation Skills: Consider an introductory course offering hands-on opportunities to students who have no, or very little, instrumentation development experience, particularly those from institutions where no instrumentation work is done.

R5.6 Research by OPOC postdocs: In order to obtain insights on how to improve the observational network as one united system, the EEC encourages the OPOC members to consider the full exploitation of the unique observing opportunities provided by the OISTER framework, i.e. transient and monitoring observations in multi-modes, to conduct their own various researches.

R5.7 Improved learning of theory: those theorists who are members of OISTER could offer on-line courses open to all OISTER students covering such topics as stellar evolution, binary star evolution and gravitational waves.

R5.8 Open OISTER training: it would be worth investigating if the OISTER courses could be opened to other universities without overwhelming the organisation.

6. Spillover effects from the OISTER project

6.1 Spillover in research publications

To make some estimate of the spillover in research we looked at publications with first authors outside of OISTER using the data OISTER provided [S03].

Results from the OISTER Network [S03a]: There are two papers between 2019-2021 with first authors who are not members of OISTER, out of a total of 13 papers; both are very well cited.
1. *X-ray quasi-periodic eruptions from two previously quiescent galaxies*, by Arcodia et al. (2021), with 23 authors including Schramm, M., and 25 citations by 04/2022. It does not mention "OISTER" explicitly.

2. *X-Ray and Optical Monitoring of State Transitions in MAXI J1820+070*, Shidatsu et al. (2019) with 7 authors including Murata, K. L., Adachi, R., Kawai, N., Ueda, Y., and 36 citations by 04/2022. OISTER is mentioned in the text.

There are 57 out of 89 refereed papers that use data from OISTER funded telescopes, or are by OISTER funded researchers, but in which the first author is not a member of OISTER [S03b].

Undercounting of papers that use the OISTER facility: One example is papers from the IRSF in South Africa. Up until March 2022 Nagoya University maintained the IRSF website which included a list of papers published between 2002 and 2019. Unfortunately the web page was no longer available by April 2022. We are aware of five papers in 2019, two in 2020 and six in 2021 that use data from IRSF, but not one of these is listed in [S03].

6.2 Spillover in education and skills development

A significant fraction of OISTER students (more than half the undergraduates and masters students) leave academia and get jobs in a range of occupations, mostly in IT and manufacturing, but also in teaching and the financial services etc. [S06][S17].

It is clear from our survey of students and early career researchers, as well as from our conversations with them, that they appreciated the skills they acquired, or further developed, through OISTER, and that those skills positioned them to find good jobs. Mentioned in particular were coding skills, statistics and project management. All the people that we spoke with seemed to have had very little difficulty finding satisfactory jobs. Those staff members who discussed this with us agreed, indicating that they did not have to help their graduates find jobs.

It is not easy to be quantitative about this aspect of the spillover, but it is clear that the OISTER collaboration is providing the Japanese workforce with people who have high level technical and managerial skills.

The importance of educating teachers, and instilling in them a positive attitude to astronomy, should not be underestimated. These teachers potentially reach many thousands of children during their career lifetimes. Astronomy can help them produce not only scientifically literate children but also voters and taxpayers who will have a positive attitude towards astronomy.

Recommendations:

R6.1 Reuse of OISTER Data: Make non-proprietary OISTER data FAIR to the international community, and insist on an acknowledgment to OISTER when it is used.

R6.2 Undercounting of papers: Find a better way of identifying papers that use OISTER data so that there is no undercounting. Perhaps a clearer acknowledgment (ADS does not always identify the words specified in [S12]), or a footnote to the title would help, but this is obviously a challenge.

R6.3 Engage with the employers of OISTER (and other astronomy) graduates to find out what it is about astronomy graduates that makes them employable/valuable. Also ask where the main knowledge gaps are for astronomers going into industry. If the results are interesting, consider extending the survey outside of Japan. What is done with this information depends on what you find out, but we hope you can use it to help convince government of the spin-off value of astronomy. While industry should not drive university curricula, it might also prove useful input into curriculum reform.

7. Other matters: budget and safety

At the open meeting of the EEC on 3 March, we were asked by the Chair of the Project Review Committee to include some discussion of the OISTER budget allocation and about safety, in our review.

7.1 Budget

OISTER has a budget of 65,000,000 yen each fiscal year of 2019-2021. The amount allocated to each institute and the details are listed in [S08]. A large part, between 70 and 80%, of the budget is used to employ a total of about nine FTE staff/postdocs per year. Most of the rest is spent on running costs, with a very small fraction going towards equipment.

There appears to be very little room to decrease the budget without impacting on the educational programmes and/or the operation of the telescopes. The EEC does not have sufficient detail to say more than this, but we do note that extra funding will be required if many of the recommendations made in this review are to be followed (however, see R8.1 and R8.2 below).

7.2 Safety

The EEC were provided with a document about the Safety Compliance Assessment [DD04] that indicates items that should be included in the safety compliance assessment of each institution. These are all reasonable and important items. In view of the limited information at our disposal and the fact that we did not visit any of the OISTER institutions in the course of doing our review, we feel unqualified to say very much about this important matter. We do note that none of the people that we interviewed brought up safety as something they were concerned about, although neither did we specifically ask them.
We are aware that some of our recommendations, in particular R3.2 and R3.3, have serious safety consequences that should be thoroughly thought through before any new systems or procedures are brought into action.

8. OISTER: Future prospects and funding

OPOC [S04, S10] presented the following as the main scientific themes for OISTER during its next term:

1. Search and follow-up of electromagnetic radiation from GW events
2. Stellar evolution of the compact binaries in NS-NS/BH merger events
3. Identification of high-energy neutrino sources
4. Constraining the origin of fast radio burst

The EEC were very concerned about the apparent disconnect between the specified scientific priorities of OISTER (past and future) and the actual interests of the staff and students we interviewed. This is also illustrated by the very impressive range of publications over the last three years, covering such topics as Earth-shine, asteroids, Pluto, dwarf novae, novae, flare stars, spectroscopic binaries, black-hole candidates, extrasolar planets, pre-main sequence stars, Mira variables, LMC variables, AGNs, Quasars, and more. The finance from OISTER is used almost exclusively for people who work on instrumentation and software, not on priority science. We understand the need to employ people who can keep the telescopes and instruments functioning but doubt that OISTER will reach its potential without at least some staff (and students) whose primary interest is one or more of these four topics.

The EEC were told about some exciting technical developments that will open up new phase space in time domain studies. The Science CMOS detectors that are in use in the Seimei 3-band imaging camera, offer really exciting possibilities for very high speed photometry, and eventually also for spectroscopy. To function effectively these will require new approaches to data reduction, transport and storage.

OISTER also needs to be able to repair/update its near-infrared detectors, and if possible make this facility available at more telescopes. Infrared observations are important for a wide variety of transients including those which occur in obscured regions.

There was no clear involvement of theorists in OISTER, but this is important both for the science and for the education of those students who are going to stay in research. If such partnerships do not exist already, we suggest OISTER involves theorists in the development of their strategic plan.

The EEC also recommends that NAOJ consider appointing a devoted staff member who could provide scientific leadership for OISTER and connect members with other expertise and resources. Such a person could organise OISTER so as to ensure that sufficient resources, human, observational and theoretical, were devoted to studying the primary targets. They could also organise collaborations with other divisions of NAOJ, including the Astronomy Data Center, the Advanced Technology Centre and the Division of Science, who together could enable OISTER to be an international leader in time domain astronomy.

Recommendations:

R8.1 Scientific Priorities and Staffing: There is a real need to employ astronomers and train students in the priority areas for OISTER (four topics listed at start of section 8). This may mean encouraging those employed to change their research field, or employing some new people with relevant expertise. Alternatively, it could also mean adding to, or changing, the scientific priorities for OISTER. Those are decisions that should be made by the Joint Council. However, it seems very unlikely that OISTER will fulfil its promise, or provide leadership in transient research if the majority of people working for OISTER are not strongly engaged with its scientific objectives.

R8.2 Strategy: The EEC recommends developing a strategy for OISTER that is closely linked to the Japanese strategic plans in related areas of astrophysics and particle physics and include input from theorists. It should also be informed by the plans of international groups involved in transient follow-up. This would articulate observing priorities (beyond GW and neutrino sources). It should also describe the resources that are required to make/keep OISTER internationally competitive over the next 10 years; which could include upgrading detectors, automating telescopes, data archive facilities, upgrading software, including AI software to make

observing decisions, computers, personnel, etc. It should also consider how OISTER will interact with, possibly collaborate with, other similar networks around the world.
R8.3 Scientific Leadership: A dedicated staff member at NAOJ could provide the leadership to ensure that OISTER strategic priorities were followed. They could also provide links to the other divisions within NAOJ which have the capacity to provide the technical support which is essential for OISTER's scientific mission.
R8.4 OISTER Web page: An English version of the OISTER web page would improve its visibility and help build international collaborations.

9. Conclusions

Overall the EEC concludes that OISTER is doing an extremely good job on the educational side, by training young astronomers and in preparing people for the hi-tech workforce. Its scientific output is adequate in terms of quality and quantity, although rather little has been possible in terms of its priority targets. OISTER will be able to continue its excellent educational programs and operating its telescopes if funding is continued. The students have been disadvantaged by their lack of personal interactions during the COVID-19 pandemic and we recommend getting them together as soon as it is safe to do so.

The EEC recommends that OISTER produces regular self-assessment reports from individual institutes as well as from the project as a whole. We also recommend that the Joint Council takes cognisance of the scientific objectives of OISTER when appointing scientific staff (i.e. postdocs, teaching staff etc).

OISTER should be preparing to be among the leaders in international follow-up of transients and to do this will require a significant transformation, in terms of staff, equipment, and leadership. We encourage OISTER to develop a detailed scientific and technical strategy that will justify the increase in funding required to make the project world class.

Acknowledgments
The EEC are grateful to all of those we interacted with during the course of this review: those who prepared the various documents, the students who completed the questionnaire, the staff and students we interviewed and the office of the project review committee. Everyone was most helpful.
Date: 16 May 2022, revised 15 June 2022

Appendixes

1. Review Plan including Interview schedule

2. Form of the questionnaires to students and early-career post-docs

3. List of Documents examined (identical to "20220405 List of Review Documents.doc")

4. Complete list of recommendations, roughly in order of priority