

Improving IT infrastructure to ensure better access to research

Review of a pilot project to enhance the training capacity of national research and education networks in Tanzania, Uganda and Zambia

Much has been made of the digital divide limiting progress in developing countries, with an emphasis on the importance of online access to find and share research and to participate in increasingly global research networks.

In research and higher education, this divide is particularly pertinent. Without access to online research information, researchers, academics and students cannot benefit from - or contribute to - the wealth of online knowledge. This can limit their countries' capacities to meet critical development challenges.

High-speed internet connectivity, however, is not enough: unless university campus networks are properly configured and managed, the considerable improvements that have been made to broadband infrastructure across Africa will not lead to better access at the desktop. The right hardware is obviously important, but to ensure that developments in infrastructure lead to improvements in access for researchers, academics and students, it is also important to



DEA training in Uganda

build human capacity and skills. Robust and reliable networks need skilled staff to build, manage and maintain them.

About this document

As this was a pilot project, INASP built in a structured review process to capture lessons learned, both to assist in designing the next phase of the project and to inform other similar projects. This publication has two parts: part one is a brief summary of the project and the review, with suggestions for the way forward; part two gives more detail from the review itself, outlining what worked as well as what could be improved, and including comments from project participants. The document could be useful to anyone working at or with research networks and IT professionals at universities in developing countries, and national, regional and international organizations that invest in IT infrastructure.





What are NRENs? (National Research and Education Networks)

NRENS are not-for-profit, specialized internet service providers (ISPs) that are dedicated to supporting the needs of the research and education communities within a country. They deliver services to institutions which have advanced research support and education requirements that are not generally satisfied by the offerings of private-sector ISPs. NRENs are often located within major universities. They are independent of specific suppliers, thus trusted by their community to deliver high-quality services at a reasonable price. The Boards of NRENs often comprise vice-chancellors of the major higher education institutions in a country. NRENS are able to bring the benefits of collective buying power to universities by procuring networks and services on a national basis, thereby providing savings for individual institutions. There is a strong sense of ownership among those involved in NRENs, which is a major driver of their success.

INASP launched a pilot project in 2013 to provide advanced training to national research and education networks (NRENs) in three countries (Tanzania, Uganda and Zambia). The project aimed to increase the knowledge and skills of NRENs so they can in turn provide better support to campus IT engineers. It also involved helping NRENs to follow up their training with Direct Engineering Assistance (DEA): hands-on workshops with network engineers from different institutions. who work to renovate and improve their network infrastructure. Integral to this work are efforts to encourage greater collaboration with librarians, to ensure that technological improvements lead to better access to online information.

Introduction to the project

The project aims to improve access at the desktop for researchers, academics and students to electronic journals, e-books and databases. This involves strengthening technical expertise and training capacity of NRENs so that they can train campus engineers. These IT engineers can then improve their local campus networks, manage their available bandwidth more effectively, and contribute to the development of solid IT infrastructures and policies. Efficient, faster and more secure campus networks will contribute significantly to improved access for research users.

INASP also has strong relationships with national library consortia, which are responsible for securing and managing access to online research information. INASP encourages greater collaboration between the NRENs and their respective library consortium, and contacts librarians at universities where campus IT engineers will be trained, to encourage them to work together to solve problems at the institutional level.

Finally, the project helps to extend the benefits of advanced training by facilitating Direct Engineering Assistance (DEA). This is direct, practical support to campus engineers provided by the NREN staff, to assess the gaps in campus networks, reconfigure the network as necessary, and enable them to put into practice what they have learned during the advanced training.

This project is a collaboration between INASP, UbuntuNet Alliance (the regional Research and Education Networking organization for Eastern, Central and Southern Africa) and the Network Startup Resource Center (NSRC), which provides training as well as network hardware. It has been undertaken in partnership with three NRENs: ZAMREN (Zambia), RENU (Uganda) and TERNET (Tanzania).

Review highlights

The advanced trainings for NRENs and the DEA have stand-alone benefits, and are complementary, with DEA reinforcing the learning that takes place during training. NRENs report that the campus networks they support are improving. Some also indicate that their memberships, status, reach and financial stability are also improving, though it is unclear how much of this is a result of this project. The review found some evidence of improved relationships between engineers and librarians (meaning more appropriate IT solutions to library needs), and some evidence of increased regional collaboration.

In terms of sustainability, the NRENs report that they are able to provide DEA support relatively cheaply, and that they all have strategic plans to become self-sustaining, including providing fee-based IT consultancy services. If INASP decides to expand support to a new country, the current project-partner NRENs may be in a position to provide peer support to the new country.





The way forward

This review provided insight into what has been learned during the first two years of the pilot project, and discussions are ongoing about what type of assistance should be provided to NRENs in the coming years. It is clear that IT capacity affects all of INASP's programmatic work, so there is strong support for continuing this initiative. It might be in the form of a package of support, chosen from a 'menu' of components that would be tailored to the readiness or capacity of each country. This menu might include the following elements:

- Continuation of all 3 core programme activities
- An e-readiness audit, which would enable NRENs to determine which institutions would most benefit from direct support
- Support for internship programmes to enable new IT graduates to develop their skills, which would help to prepare the next cadre of skilled engineers for universities
- Secondment of IT engineers to other NRENs, to learn from each other and promote regional collaboration
- Organization of country-level events that bring together different stakeholders to discuss problems and identify possible solutions, and foster stronger working relationships on campus (e.g. university leaders, librarians, campus engineers, NRENs)
- Helping NRENS to demonstrate their value to higher education institutions, for example, by providing communications training or support
- Encouraging universities to invest in IT and IT staff, through dialogue at institutional level to get commitment and buy-in

Detailed review of the pilot project

Background

This NREN project was originally designed to test two approaches: directly supporting training of campus engineers to enable them to improve their local networks, and developing the training capacity of NRENs, to enable them to train campus engineers at member institutions. After a review at the end of year one of the project, it was decided to focus on providing support at national level by working with NRENs. Where a university had sufficient IT staff and skills, it would also be possible to provide further, more hands-on support through DEA. This was seen as the best way to embed capacity in national organizations and ensure that capacity could be sustained and developed beyond INASP's involvement.

While staff members who manage IT networks at the campus level play a crucial role as the first link in the networking chain, the NREN is the body that interconnects these campus networks of research institutes and higher education institutions in each country. They work with their regional network (UbuntuNet Alliance or WACREN in the case of Africa) to provide connectivity between NRENs within the region; leverage numbers to secure cheaper access to commercial Internet providers; or in the most advanced cases, lay their own dedicated fibre optic networks exclusively for research and higher education use. NRENs also play an important role in the training of campus IT network engineers. They represent a community dedicated to cooperating and working together for the common good of research and education. For all of these reasons, working with and through NRENs, rather than directly with institutions, was viewed as the most efficient and

effective way to reach the project's stated goals.

Purpose and methodology of the review

This review aimed to measure the extent to which the project activities during the 2014–2015 period contributed to reaching the project's goals. It also considered whether focusing on NRENs is working (or likely to work) as a sustainable approach, and whether it should continue to be the focus of the project.

The research questions were formulated based on programme documents and discussions between the programme manager, programme colleagues and those from the Evaluation, Learning and Communication (ELC) team. The information to answer the questions was collected from activity reports and email questionnaires from, and



Skype interviews with, NREN staff, campus engineers and campus librarians . There is a slight bias towards Uganda in this report due to the generous amount of information provided by engineers from the Ugandan NREN (RENU) and Uganda Christian University. Quotes in this report have been anonymized at the request of some respondents.

Activities so far

Advanced training for NRENs

Advanced training is offered at regional conferences and is designed for IT specialists who already have a high level of knowledge. In May 2014 each NREN nominated two staff members to attend the African Network Operators' Group (AfNOG) training workshop in Djibouti. Of the six that were selected, four were NREN employees and two were campus engineers endorsed by their NREN, who were willing and deemed competent to work with NREN staff at the national level to support future training activities.

In November 2014 six NREN staff participated in an UbuntuNet Alliance training workshop and conference in Lusaka (three from ZAMREN; two from RENU and one from TERNET). A second TERNET engineer was funded by Africa Connect and a fourth from ZAMREN by the NSRC. This was a good example of collaboration between different agencies working through the UbuntuNet Alliance.

These trainings keep the NREN staff up-to-date on the latest technologies and working methods. As one NREN CEO explained:

"One of the challenges that NRENs

face is up-to-date skills in an everchanging technologically driven industry. The ability to design, install and manage complex networks is paramount so that the NREN can provide advanced ICT services that are technologically appropriate and cost-effective in relation to commercial service providers."

The workshops covered a wide range of subjects, including the following, which were five-day workshops offered by AfNOG in May 2014:

- Advanced Registry Operators
 Course
- Advanced Routing
- Computer Emergency Response Team (CERT)
- Network Management
- Scalable Network Infrastructure
- Scalable Internet Services
- As well as providing training in



Subsea fibre optic cables provide east Africa countries such as Tanzania, with high speed internet access.

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technical skills, NREN staff reported that they provided an opportunity for people to meet and establish connections – they were networking opportunities that support research collaboration. One respondent explained that connections that were made during one of these training workshops led to a leading NREN member institution hosting a successful conference on trauma medicine, partly using video conferencing, with a Japanese university.

Local workshops for campus engineers

These workshops are run by NREN engineers for campus engineers in their country, and designed to focus on one particular aspect of campus networking. During the past year, two campus networking training workshops were held in Zambia, two in Uganda and one in Tanzania, in total involving about 90 participants. These campus network management workshops focused on a variety of issues. ZAMREN offered one on campus networking and one on switching and routing; RENU offered one on scalable network design and a second on campus networking. One of the major benefits of these workshops, as with the Advanced Training for NRENs, is that they encourage human contact. Both RENU and ZAMREN spoke of the importance of these networks in promoting collaboration among engineers from various member institutions of the NRENs. They are a valuable space for people who are members of the same NREN to get to know each other.

Direct Engineering Assistance (DEA)

NRENs followed up training workshops by running hands-on problem solving sessions (known as DEA), over several days, for network engineers from different institutions.

One NREN respondent explained that DEA provided a platform for members to implement, with expert assistance, the theoretical concepts taught in the trainings. "Most institutions have badly designed networks; DEA provides capacity building and network redesign at almost no cost, except for the upkeep and catering during the workshop."

While the NRENs cannot tell campus engineers what to do – they can only guide – the NRENs reported that many campus engineers do follow

> "Robust and reliable networks need skilled staff to build, manage and maintain them"

their advice. The networks work hard to follow up training workshops with DEA support. The NRENs "work closely with [the campus engineers] in supporting and guiding them." One NREN respondent elucidated further on the strength of DEA support:

"DEA is one of the visible measures you can use to apply the knowledge gained in real life. And it gives engineers confidence to implement changes on their networks. This is because one of the key challenges that has been highlighted is engineers fearing to make changes to their networks; but with DEA it's very easy since the activity involves experienced engineers. DEA has been one of the best tools in creating awareness [at] institutions about the work of the NREN community."

One of the engineers who benefitted from DEA explained:

"The training and DEA helped me to improve my skills and confidence in working on our servers. Specifically, I have been able to carry out System Administration work more confidently. The second training specifically gave me a deeper understanding of security in systems and on the network. I realized that we were not being as cautious as we should in terms of security on our network. We have been able to implement some of the security measures that were emphasized during the training."

Between October 2014 and January 2015 TERNET conducted a needs assessment (e-readiness survey) of their members to enable them to tailor DEA support to the campuses, both in terms of capacity building and equipment. One NREN representative describes how useful their needs assessment survey was:

"The survey which was done ... enabled us to understand the gaps, the needs in our campuses and those who are ready to cooperate with TERNET. Hence, we are now ready to provide DEA to those who need it most. Also [we can] plan for the training workshops according the feedback we received during the survey."

Both ZAMREN and RENU have similar aspirations.

Findings of the review

Assessing the project components

What is the importance of the components of the intervention?

Advanced training for NRENs and DEA were both seen as being relevant and beneficial for achieving the project's



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goals. NRENs also reported that the project activities led to an increase in their membership (for ZAMREN and RENU), and improved the status and reach of their work. This has improved their financial stability by helping them to retain members and attract new members, because they can offer more services. There were also indications of increased regional collaboration. For example, a member of ZAMREN reported individual research and education institutions. This produces a pool of skilled campus-based engineers that share skills and experience with each other because of friendships that start during the local workshops. The Direct Engineering Assistance (DEA) expedites the building of efficient campus networks while entrenching hands-on skills of trainees through doing.

The mixture of activities is seen

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visiting Uganda to support training and network reconfiguration.

How do these components complement each other?

These three project activities complement each other well. Advanced training for NRENs produces local instructors/ trainers and creates core teams of collaborating experts in various specialties of network engineering. Workshops for campus network engineers enable NREN trainers to build the skills of the staff of as appropriate by the NREN representatives questioned. As illustrated above, each part of the process feeds into and strengthens the other.

What is the least useful of these components?

While there are differences in skills and experience across NRENs, most participants reported that each of the components was as useful as the other. A participant from RENU identified the advanced training for NRENs as the least useful of the three, while ZAMREN identified DEA as least useful

What other activities could INASP support? Of these, what would be the NREN's one priority?

Other activities that INASP could support included additional knowledge/skills in specific IT areas (e.g. network security) and connecting to regional research and education networks as institutions are still struggling with finances. But the main priority and focus for the NRENs was capacity building, including through training of trainers, as suggested by one of the NREN respondents: "We feel that with a good crop of trained trainers, we can enhance skills capacities to more engineers cost effectively."

RENU also prioritized training and capacity building, to give engineers the skills necessary to raise awareness among the institution's management of the importance of investing in the network infrastructure:

" ... once engineers are equipped with the knowledge and skills, it becomes easy for them to convince management of their respective institutions to invest in the network infrastructure, because in most cases management lacks awareness on such [issues]."

Another area that was identified for future INASP support was working with librarians to become more technical. As one NREN respondent explained: "Lots of content is now digital libraries are the direct interface between researchers and IT on campus."

RENU does try to work in collaboration with librarians and other campus staff, for example by facilitating the forums for directors of IT and for research and graduate schools, and collaborating with the librarians' forum. However, RENU







Group photo, UbuntuNet training participants

believes that more can be done to explicitly strengthen the relationship between IT support and campus librarians.

Assessing the direct impact of training

The goals of the NRENs, in terms of the changes that they wold like to see at campus level, are in line with the project aims:

"Enhanced competence and confidence of network administration staff, improved network performance with regards to access, resilience and security, [and] increased collaboration and access to online research and education resources."

The NRENs are aware of the challenges in reaching these goals, and cite two variable aspects that they cannot control: bandwidth and quality of network management. Despite working with campus engineers to improve networks, one NREN respondent explains that "if the network is badly managed, then the network capacity can be eaten up by students."

As well as improved e-learning and availability and access to e-resources in institutions and campuses, the NRENs want to build confidence and improve collaboration. RENU, for example, works to improve collaboration with librarians by attending each other's workshops and forums (the librarians attend the non-technical workshops that RENU runs), but is aware that collaboration is limited.

Do the NRENs follow-up after training workshops? If so, how?

There is a strong and ongoing relationship between the NRENs and the campus engineers, as one campus engineer explains: "RENU being our ISP, we are always in touch to make sure that the Internet connection is stable and can go on improving."

The NRENs follow up training workshops by providing direct support to campus engineers through the DEA component of the project. The NRENs work closely with the engineers to provide support in making changes in their campuses, both remotely and, in some cases, by visiting the campuses.

Respondents from RENU, in particular, reported that they would like to conduct a survey to find out if there has been any significant impact as a result of the training workshops they have conducted.

What changes have been made to campus networks or at institutions following training?

Campus engineers have reported practical changes as a result of the training and support they received





University of Zambia library

from the NRENs, and suggest that campus networks are improving.

The project activities appear to have enhanced both the technical and training skills of campus engineers and led to the development of network infrastructures. Campus engineers reported that they are able to relate the changes that they have made to their networks.

"Following the recommendations during DEA, we have been able to change our network structure. For example, initially, all network packets were being routed through PacketFence³ (network access control system), but now selected packets are routed through PacketFence³. Users experience better access to network services. Also, authentication of users has become easier. We are now using [lightweight directory access protocol] (LDAP) to authenticate users. EDUROAM⁴ was also tested by guests, and it was exciting when it worked. In terms of security, first and foremost, our Network Operating Centre is physically secure; only authorized users can access the server room. We also patched/updated most of our systems." (Campus engineer).

These interventions by the campus engineers at the Uganda Christian University have resulted in concrete changes, with improvement in access to the network. Students and staff can now access e-resources while off campus.

In terms of improved collaboration between campus engineers and librarians, there are positive reports from campus engineers including one instance of collaboration with campus librarians to set up Dspace (repository) and EZproxy which supports off-campus access to library resources.

One of the campus librarians that provided information for this review is well-aware of the project aims and reported significant changes in access to information at the desktop over the past 12 months:

"Our campus network has tremendously improved in terms of speed; availability [of Wi-Fi access] is more reliable and provides us with stable public IPs which ensure stable access with the publishers. E-journal articles and e-books are downloaded faster but apparently, as the network has improved, so has the number





of users. The peak hours tend to get the downloads slower but with a better band rate than previously."

This campus librarian also reports collaborating with two of the campus engineers:

"I am in constant consultation with our network engineers. I report any network slow-time, and downtime and often discuss improvements. In some instances, I have been advised that we do not have the adequate or appropriate equipment to efficiently run the network fully. They are extremely helpful."

Even if concrete collaboration has not taken place, there is a belief that improved collaboration has been achieved indirectly through greater awareness, as one NREN CEO explains:

"The activities improved awareness in general, indirectly leading to improvement of information access (and collaborations) on the campuses."

However, not all NREN representatives were so confident in their assessment.

"Except in a few institutions, there isn't sufficient collaboration (such as joint innovation efforts) between librarians and campus engineers."

One NREN CEO recognized that there is a difference in how trainings and proposed changes are received in different universities. He explained how he would like to bring librarians together, but there is a resistance to this in some universities, which is seen as a generational divide:

"Young librarians want to engage in digital content – it is a generational thing – but young people do not hold much sway in their institutions."

A similar sentiment was echoed by a Library and Information Science lecturer who stated that new, private universities are much more flexible "The activities improved awareness in general, indirectly leading to improvement of information access (and collaborations) on the campuses"

and willing and able to embrace change, especially around IT development.

Even among those proactive institutions which have prioritized IT skills development, staff retention is poor because network engineering staff members are not well remunerated.

Assessing project sustainability

What are the conditions needed for NRENs to continue this work without INASP support and how can we achieve these conditions?

The NRENs are able to offer training workshops and provide DEA support

relatively cheaply. They are well aware that external funding is limited and they all have strategic plans to become self-sustaining. INASP could help the NRENs become self-sustaining by assisting them in demonstrating the value they provide to members.

RENU and TERNET both have plans to provide IT support on a consultancy basis. They appreciate that they have a very well-trained core of engineers who also know how to build others' capacity.

"TERNET is a non-profit, member organization. As long as there is a need in our member institutions, we intend to use collective efforts to provide our support as needed

"ZAMREN's response to the sustainability question is a longterm approach that seeks to institutionalize IT development by securing government funding and embedding IT policy in institutions"





Uganda's Gulu University engineers in action

by working with partners who have the same vision and missions, by charging moderate fees [for] our services, provided there is need/ market for those services, and also by providing other services such as research and consultancy to the ICT industry in general."

The other strategy for generating income for the NRENs is to ask member institutions to contribute with annual fees. RENU plans to:

" ... progressively get institutions to contribute to workshops. They now only contribute a small membership fee. RENU would like big universities, such as Makerere, to pay for additional people that they send to workshops."

ZAMREN's response to the sustainability question is a longterm approach that seeks to institutionalize IT development by securing government funding and embedding IT policy in institutions. According to ZAMREN:

"The solution is to have government institutionalize ICT budgets in the education. Most member institutions do not have ICT structures or even a budget line targeted for ICT operations. As ZAMREN, we have been encouraging member institutions [to] improve on what we are terming 'ICT Maturity Level': this looks at ICT policy developments and strategies that need to be embedded in the institutions."

It is not clear how ZAMREN hopes to achieve this long-term goal.

If this project expands to another country, what would be the best/most cost effective intervention?

Each activity plays a role and the sequence is right. If the project were to expand into a new country, INASP

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would seek advice from UbuntuNet as to which NREN is ready for this kind of support or investment. The current project-partner NRENs could provide peer support to the new country. This review has also shown what other activities may be useful, for example, e-readiness surveys to develop a better knowledge base on which to build training and DEA workshops.

Additional findings from the review

NREN members and campus engineers are dedicated but face challenges

The review found that NRENs seem to be composed of dedicated and enthusiastic individuals, who are grateful for the support of INASP in helping them with their work and development. An INASP Senior Programme Manager who visited TERNET in November 2014 and came away from the meeting with this impression, seems to summarize the impression created by each of the NRENs:

"TERNET seemed a very dynamic organisation, doing a lot with fairly minimal resources and a lot of energy and enthusiasm. Their ethos is one of low cost/affordable support, which fits ours. They have clear ambitions and are achieving things."

The review also revealed that campus engineers are dedicated individuals. They participate in the trainings (in some cases also voluntarily organizing them as well) and carry out network improvements despite the challenges of limited manpower and pressure from the users to make the changes quickly:

"The biggest challenge was that of staffing. Changing our network structure was quite some work (re-configuration and deployment of equipment), yet the man-power

Skills, employment, institutional change

Support for internship programmes

One activity that arose as being important for the NRENs (specifically RENU and TERNET) is the internship programmes that they support. Interns are typically recent IT graduates from local universities. They receive a stipend and training support from the NRENs in which they are based. These internship schemes have two aims: to equip the intern with skills and experience to further their careers, and to contribute to the work of the NREN during their internship:

"Last year TERNET ... started a six month ICT internship programme. We had two major objectives on this initiative: [to] provide exposure to graduates so that they can acquire experience to enable them [to] get employment easily; [and] to increase TERNET manpower at lower cost. We support with about US\$200 a month. We trust that if we can afford to get more interns, keep them in our office for a month and then send them for five months to needy institutions to provide IT support, we can inspire those institutions to hire them after the end of those five months. Most importantly, they will have made a difference/change in those institutions so that even if they are not hired, the institutions can plan for a permanent solution."

available was not sufficient. We are actually still in the process of moving some network segments to the new set up. Another challenge was from the side of users whose expectations were quite high. They expected that as soon as DEA was over, the entire network would be changed in a few days, which cannot be the case." (Campus engineer).

Additional needs of NRENs

The review found that NRENs are responsible for monitoring and evaluating the project activities, and are keen to work with INASP to develop skills in this area. It also revealed that the needs assessments that the NRENs are carrying out to identify gaps/needs of networks are very important. RENU, in particular, wants to do an e-readiness survey to be able to follow-up activities and provide better, more tailored support

Promoting further collaboration

One suggestion (originating from RENU) is that NRENs be assisted in tackling the issue of networks skills at source by collaborating with selected undergraduate programmes. And finally, one campus engineer noted that she would like to see more sharing of best practices:

"For example, if a particular university has implemented a solution that would benefit other institutions, RENU should facilitate the process of knowledge sharing among these universities/ institutions."

This suggests that the NRENs and their member institutions might benefit from opportunities to collaborate and share ideas through a regional community of practice.

Conclusions

Much of the support which INASP provides, and the services that our partners offer to their own researchers and students, relies on good internet connections and robust IT networks. The pilot has enabled us to explore ways in which INASP can support the development of such IT capacity, and NRENs are obvious partners for such work.

The review suggests that all three components of the project- advanced training for NREN engineers, training for campus IT engineers, and hands-on direct engineering assistance – have been valuable and would be required if INASP were to extend this support to additional countries.

The review has also highlighted other activities which could help NRENs to strengthen their services, and target resources most effectively, such as e-readiness audits, secondments or internship programmes.

Ensuring that improvements to IT networks translate into better information access for researchers and students could be achieved through fostering stronger working relationships between IT professionals and librarians, at institutional and national level, and between IT professionals and university leadership.

References

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²See www.ws.afnog.org for more details

³PacketFence (www.packetfence.org) is an open-source network access control (NAC) system, which is used to keep unauthorized and non-compliant devices off of a network.

⁴EDUROAM is a secure, world-wide roaming access service for the international research and education community. It allows students, researchers and staff from participating institutions to obtain Internet connectivity across campus and when visiting other participating institutions.

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