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***This Technical Note provides a description of the OE Global Award winning *OERu Learning Environment*.**

Open For All: The OERu's Next Generation Digital Learning Ecosystem[1]

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Abstract

This paper describes the functionality, scalability, and cost of implementing and maintaining a suite of open source technologies, which have supported hundreds of thousands of learners in the past year, on an information technology infrastructure budget of less than US$10,000 per year. In addition, it reviews pedagogical opportunities offered by a fully open digital learning ecosystem, as well as benefits for learners and educators alike.

The Open Education Resource universitas (OERu) is an international consortium made up of 36 publicly funded institutions and the OER Foundation. The OERu currently offers first-year postsecondary courses through OER-based micro-courses with pathways to gain stackable micro-credentials, convertible to academic credit toward recognised university qualifications. The OERu, adhering to open principles (Wiley, 2014b), has created an open source Next Generation Digital Learning Ecosystem (NGDLE) to meet the needs of learners, consortium partners, and OERu collaborators. The NGDLE—a distributed, loosely coupled component model, consisting entirely of free and open source software (FOSS)—is a global computing infrastructure created to reach learners wherever they are. All OERu services are hosted on commodity FOSS infrastructure, conferring significant advantages and creating opportunities for institutions adopting any of these services to enhance education opportunities at minimal cost. The NGDLE can also increase technological autonomy and resilience while providing exceptional learning opportunities and agency for learners and educators alike.

Keywords: open source, learning environment, ecosystem, OER, equity, ICT

The OERu's Open Source Next Generation Digital Learning Ecosystem

The Open Education Resource universitas (OERu) is an international consortium of 36 publicly funded institutions, which, together with the OER Foundation, form a worldwide network. The OERu currently offers first-year postsecondary courses assembled from OER as micro-courses, with pathways to gain academic credit toward recognised university qualifications.

The OERu adheres to open principles with their emphasis on the "5Rs"—reuse, revise, remix, redistribute, and retain (Wiley, 2014b)—which are themselves inspired by the four essential freedoms of free software (Free Software Foundation, 1996–2021; Wiley, 2014a). In line with these principles, the OERu has created a Next Generation Digital Learning Ecosystem (NGDLE), built entirely with free and open source software (FOSS), to meet the needs of learners, consortium partners, and OERu collaborators. All OERu services are hosted and delivered via this infrastructure.

The OERu uses the term FOSS to acknowledge the crucial "free software" principles underlying what is now more commonly referred to as "open source software" (Open Source Initiative, n.d.). Over time, the term open source software has evolved, primarily as a result of the influence of commercial entities rather than communities, to downplay these crucial principles, and focuses instead merely on a development methodology, losing the Commons focus and community values.

This paper sets out the significant advantages of this FOSS approach and shows how, if emulated by OERu partners and other academic institutions, it could both enhance the digital services used in education and substantially reduce costs for institutions. In addition, we suggest that this approach can increase the autonomy and resilience of technical solutions, while building digital skills for learners and educators alike.

This paper begins by describing the OERu's FOSS technology infrastructure and explaining its advantages and challenges. It then reviews the functionality, scalability, and cost profile of this implementation, currently capable of supporting thousands of learners (in addition to registered user participation, the OERu's anonymous Website statistics indicate that more than 200,000 learners participated in OERu courses in 2020 in total) on an information technology (IT) infrastructure budget of less than $10,000 per year (about $0.05 per learner/year in 2020). Furthermore, the implementation promises to scale to millions of learners with only very small increases in infrastructure capacity required. The cost-to-learner ratio does not increase in a linear fashion, for example, because of the way most Web services are designed. The capacity to serve users increases more rapidly than the cost; so, ten times the number of active learners could be served for only double the infrastructure cost. Ultimately, the OER Foundation, responsible for maintaining the infrastructure, thinks the cost per learner could fall below $0.01 per year as a result of the economies of scale possible. All costs are in U.S. dollars unless otherwise noted.

Why a FOSS NGDLE?

By 2014, 99% of universities in the United States alone were using a learning management system (LMS), with 74% of staff feeling they were "useful instructional tools" (Baule, 2019). However, the LMS is "focused

on the institution and the course" (Conde et al., 2014, p. 189), rather than placing the learner at the centre of their learning experience.

In 2014, EDUCAUSE ran a series of focus groups investigating digital learning environments and how they could better support learning and teaching (Brown, 2017; Maas et al., 2016). This research resulted in the April 2015 white paper (Brown et al., 2015) on "next-generation digital learning environments," or NGDLE. As Brown et al. (2015) highlight, "higher education is transitioning from the transmission model of education to one built on concepts such as active learning, personalisation, hybrid course designs, and new directions for measuring degree progress," calling for "an ecosystem of sorts" (p. 3). The white paper acknowledges that "the challenge for the NGDLE is supporting this diversity while retaining the necessary technological coherence. But in this challenge also lies the opportunity. Clearly, we [higher education institutions] need to invent new architectures that support a digital confederation" (Brown et al., 2015, p. 4). Brown (2017, para. 7) urges institutions to think beyond their digital learning environment towards "strategic destinations..., new directions, and opportunities," and this is one ability and strength of the OERu.

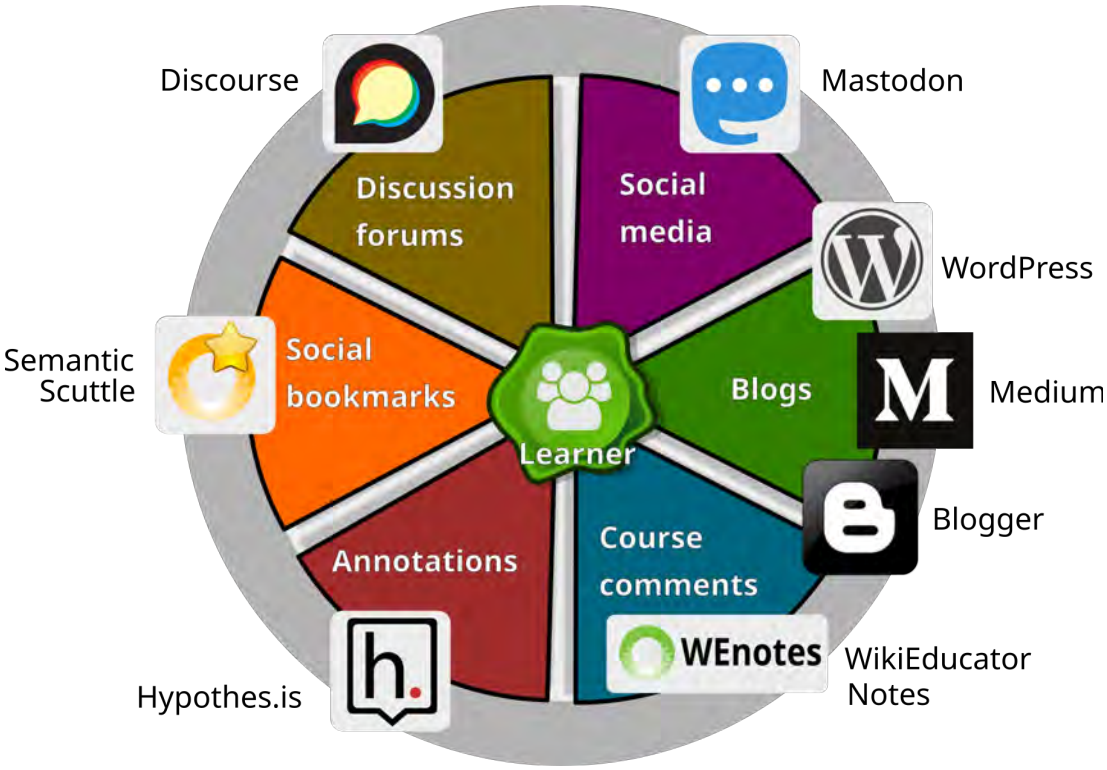
The OERu draws a distinction between an "environment," which is simply a place that may or may not support life or experience growth, and an "ecosystem," which is an inherently dynamic *living* environment in which the place and its inhabitants are interdependent, and their many interconnections enable the living parts to grow in diverse ways. The OERu's NGDLE exists to encourage a thriving ecosystem.

The OERu has determined that one way of supporting learners to develop digital and associated learning literacies for the 21st century is to employ in learning systems the very same technologies in which these learners need to build digital fluency to learn effectively. This contrasts with the cloistered digital experience of an LMS environment. The OERu approach of "learning on the Internet" has more moving interactive parts and is less constrained than an LMS environment, but that added complexity also offers advantages:

- Content is created collaboratively with detailed version control and not limited to participants from a single institution.
- Learners can maintain control of their own work (digital artefacts) both during and following completion of their study.
- OER materials can be shared among institutions regardless of which LMS, if any, they have adopted.
- Learners actively employ and experience the technologies, conventions, and practices of the "real" digital world rather than a model environment constrained to a single application. The learner-facing part of the OERu's NGDLE is constantly evolving, which is also a characteristic of a thriving ecosystem, rather than being a fairly static environment. Figure 1 shows the current set of the learner-facing services.

Figure 1

Learner-Facing Services Within the OERu's Next Generation Digital Learning Ecosystem



The OERu's NGDLE, then, is an example of a global infrastructure created to reach learners wherever they are and to place them at the centre of their learning experience.

Service Provision

These services are hosted either by independent Internet communities or on the OERu's FOSS infrastructure. The OERu's current set of learner and educator accessible tools includes the following:

- **Mastodon** is a social media tool and OERu's alternative to Twitter, allowing posts of up to 500 characters. Unlike Twitter, Mastodon is non-commercial, FOSS, and distributed, with thousands of independent implementations around the Internet that "federate," linking together to help their users "follow" (i.e., communicate seamlessly with) people on other Mastodon instances. With this community-driven model, there is no advertising or threat to learner privacy (Mackintosh & Cooper-Taylor, 2018b; Mastodon, n.d.).

- With **blogs**, learners can post in more depth and include other media, such as images, audio, or video. The OERu encourages the use of three gratis blogging tools—WordPress (which is also FOSS), Medium, and Blogger—but learners can use any blogging tool they wish. Learner blog posts are aggregated and shared with OERu learners (if their creator has given their post the appropriate course-specific tag).

- **WEnotes** is a micro-blogging tool, developed by the OER Foundation, included on course pages so that learners can make comments or ask questions right inside the page[2] (Lane, 2017 (August); Mackintosh & Tittsler, 2013).

- **Hypothes.is** can be used to annotate or discuss any published Web page or PDF document accessible publicly via the browser, including the ability to organise research, take personal notes, and search for others' contributions based on topic tags (Cooper-Taylor & Mackintosh, 2018a; Hypothes.is, n.d.; Wood, 2020).

- **SemanticScuttle**, a social bookmarking tool, enables learners to add, annotate, edit, and share bookmarks of Web documents (Cooper-Taylor & Mackintosh, 2018b; Slashdot Media, 2021).

- **Discourse** is the OERu's learner forum tool for persistent, discoverable discussion and collaboration (Discourse, n.d.; Mackintosh & Cooper-Taylor, 2018a).

In addition, the OERu's component-based platform uses its WEnotes aggregator, internally developed software,[3] to create a feed of learner posts and comments originating from all of these distributed interaction technologies.

Advantages and Challenges of a Component-Based Infrastructure

The OERu believes its NGDLE demonstrates that, by accepting a small increase in architectural complexity (relative to conventional all-in-one monolithic LMSs), the OERu can achieve better functionality, flexibility, and scalability, as well as an advantageous cost profile. It also reduces the OERu's liability by achieving technological, supplier, and geographic diversity in its infrastructure without dependence on any specific commercial suppliers.

The Challenge of Complexity

When compared to conventional LMSs, the OERu's NGDLE appears more complex. Instead of fitting everything into a single platform as an LMS does, the NGDLE comprises an ever-evolving array of largely independent FOSS technologies, each developed and maintained by its own communities, working in concert for the benefit of all.

Rather than requiring expertise in a single LMS product, running the OERu's NGDLE requires a capable technology "conductor" to orchestrate dozens of technologies that work together. Typical developers of proprietary software have an incentive to block would-be competitors so they often make it purposefully incompatible to stymie them —for example, Microsoft has a reputation for what they internally refer to as

"Embrace, Extend, Extinguish," or EEE (Deadly embrace, 2000) to disrupt compatibility of competing software.

FOSS developers, by contrast, have no incentive *not* to employ open standards and open design conventions in their software, greatly facilitating integration and, perhaps surprisingly, consistency of approach. FOSS components, then, generally play harmoniously with one another because there is no incentive for them not to do so. There are no deterrents or obstacles to building integrations or extending FOSS components for anyone with the means to do so.

A technologist familiar with these conventions and standards can rapidly and reliably deploy NGDLE technologies, combining them into, from a learner's perspective, a well-integrated, consistent suite of learning and collaboration services (Brooks & Pomerantz, 2017; EDUCAUSE Learning Initiative, 2015). The underlying complexity accompanying this technological diversity is, then, not nearly as confounding to a learner as it might first appear.

Functionality Advantages

A component-based approach means selecting only the "best-of-breed" FOSS options, often from among several mature contenders (such as in the collaborative chat space, where contenders include Mattermost, Rocket.Chat, Element/Matrix, NextCloud Chat, and Zulip). This means that specialised platforms for each niche, including learner identity management, course presentation, document management, chat services, discussion forums, collaborative OER assembly, email automation, open badge management, Website annotation, and course assessment, can all be sourced individually by assessing their fitness-for-purpose and the strength of their supporting communities. This is in contrast to the conventional practice, where the only available components are those specifically built for the LMS (whether FOSS or proprietary) to which an institution has already committed itself; those components are seldom best-of-breed.

Flexibility Advantages

Another major advantage of the OERu's NGDLE is the ability to replace existing components whenever members of the OERu community identify functionally similar components they think offer advantages for learner usability, application stability, maintainability, scalability, and other criteria. If they build a sufficiently compelling case for a change, the OERu can make these evolutionary leaps because FOSS applications (like a non-proprietary version of Lego®) typically implement open standards for integration. These include interfaces and protocols like HTTP/HTTPS (for encrypted Web content transfer), OpenID/OAuth2 (single sign-on technologies), WebSockets (for live updates to content like social media feeds), RSS/Atom/JSON feeds, and various others. Through FOSS project Website feeds, chat platforms, mailing lists, and social media, the OER Foundation continuously monitors existing, emerging, and novel FOSS solutions relevant to the OERu NGDLE. When a better component for a particular area of infrastructure emerges through OER Foundation testing, the OER Foundation can create a complete local replica of the entire OERu infrastructure (minus private user data) at no cost, thanks to its FOSS nature. The OER Foundation can then trial swapping an existing component for a new one, testing to ensure that the change is possible and the benefits outweigh the costs.

Scalability Advantages

The OERu started small, with just over 2,000 learners from 113 countries participating in courses during the OERu's minimum viable product phase (May 2018–May 2019). This placed a modest load on the OERu infrastructure while allowing the OER Foundation's technical team to validate that everything was working as intended. In many conventional proprietary software implementations, even these small numbers would have challenged the ability of the infrastructure to supply a usable service, namely one that is fast, seamless (e.g., performing the same way across learners' diverse array of computing platforms), and reliable enough to feel trustworthy and credible to learners. A major advantage of this loosely coupled component model is that each component is in active use in other contexts. Every component has already had its "trial-by-fire" at "Internet scale," serving many thousands or even millions of concurrent users, and has already evolved technically to meet those challenges. The OERu's confidence has been further bolstered by the fact that, in 2020, with no increase in overall NGDLE infrastructure capacity, it provided services to 200,000 learners with no impact on performance.

Although the applications chosen are products of different communities, different developers, and different technologies, they all adhere to a set of well-tested, robust, and scalable Internet software service patterns. The OERu's key technologies, such as MediaWiki (the technology on which Wikipedia, and the OERu's WikiEducator are built (WikiEducator, 2016)), WordPress, Drupal, Silverstripe, Mastodon, Discourse, and Mautic, among others, are well proven, even at the scale of tens of millions of users.

All have separate data stores (mostly databases, including MariaDB, PostgreSQL, MongoDB, CouchDB, and SQLite), themselves decoupled from the containers doing the computing, usually running scripting engines (OERu components make use of PHP, Ruby on Rails, Python, and Node.JS). Data is manipulated in a "stateless" way, with the software's logic—by design—not being tied to a single piece of infrastructure. This makes these Web services inherently amenable to scaling up horizontally just by adding more servers.

Advantages of Adhering to Open Conventions

This shared practice is the culmination of many years of testing at Internet scale and makes it possible for the OERu to simply "dial up" all of these services as required by adding more low-cost commodity computing containers. The required replication of functionality is facilitated by the use of Docker, a FOSS technology allowing self-contained computing units that can easily be created, copied, removed, or moved among computing environments.

The adoption of FOSS technologies, then, allows us to maintain a stable, flexible, scalable infrastructure with inherent technology diversity united by the open technology standards and conventions to which they all adhere and created by collegial communities motivated by providing utility for themselves and other users rather than by profit. In addition to being more cost effective by avoiding any per-user costs (e.g., seat licence costs), this approach reduces the costs of ongoing software maintenance because it is effectively shared among other institutions and organisations that adopt the FOSS and have a shared interest in its stability and continued improvement. This sharing tends to diversify contexts in which the FOSS is used, thereby broadening the scope of its development. Wide adoption of specific FOSS also creates strong incentives for independent developers to improve their own capabilities with FOSS in general, while imposing no barriers thanks to both the software *and developers* being completely open.

Cost Advantages

All of the technologies in the OERu's stack are free from licence fees. The only costs associated with them are the costs of commodity-hosting infrastructure and the time OER Foundation staff spends setting up and maintaining them. This means that the cost of a given set of components is a low fixed cost, sustainable even with a remarkably low number of learners and which, crucially, does not increase significantly as learner numbers grow. This means the cost of the OERu's learner numbers going from a thousand to a million (a hundred-fold increase) might only carry a five-to-ten-fold infrastructure cost increase. That should be extremely attractive to any higher education institution.

Return on Investment

Return on investment can be achieved in a number of ways, including through investment to improve productivity or by reducing costs, or, ideally, a combination of both. The OERu has created and maintains its capabilities with a very small budget for infrastructure and targeted development. This is accomplished by adhering to four key principles:

1. using commodity FOSS hosting to allow for rapid movement between hosting providers with minimal trouble or disruption to services;

2. for software-as-a-service (SaaS) solutions, employing only FOSS options that provide a safety valve if the pricing model/service does not suit present needs in order to eliminate vendor lock-in;

3. ensuring any external commercial service has a fixed price that does not increase with the number of users; and

4. accounting for internal staff time in cost of ownership calculations.

The OERu currently uses three hosting providers on three continents, all commodity FOSS platforms, without adopting any proprietary features of those services. The OERu does not exceed the (generous) in-built data and storage allotments, so costs are fixed and predictable. The OERu's entire annual infrastructure/IT costs are summarised in Table 1.

Table 1

The OER Foundation's Technology Infrastructure Budget in 2021

Category	Supplier	Annual Cost (USD)
Hosting infrastructure	Hetzner (Germany)	384.00
	Digital Ocean (US)	6,840.00
	CatalystCloud (New Zealand (NZ) - sponsored)	$0.00
Software-as-a-Service	Kanboard* (project management)	384.00
	ServerSMTP (email services)	180.00
	Total	7,788.00

Note. *Kanboard is an open source project management tool implementing the "Kanban" process. It is provided as a commercial Software-as-a-Service product, similar to Mautic.

Some of the OER Foundation's hosting infrastructure costs are covered by sponsorship: the Foundation receives up to NZD500 per month of sponsored hosting services from the New Zealand–based hosting provider, Catalyst Cloud, which offers a fully FOSS cloud-hosting infrastructure (Catalyst Cloud, n.d.). Because the OERu runs FOSS GNU/Linux on all servers (using both Ubuntu and Debian distributions), there is no cost involved for the operating system; so, the OERu can run as many servers as required without incremental software costs. Only the cost of the technologist's time and the relative computing resource requirements are variable. However, those costs do not increase at anywhere near the same rate as user numbers. For example, 10 times more users might require twice the staff time (a linear increase would be 10 times the staff time) and perhaps twice the direct computing infrastructure resources.

Case Study: SaaS and the Value of FOSS

Mautic is a FOSS "marketing automation" tool (Acquia, 2020), chosen to automate email communications with both existing and prospective learners and partners. Initially, to test its functionality, the OER Foundation opted to use the $30 per month entry-level SaaS offering from the commercial service provided by the Mautic company, which allowed the Foundation a single login to gain immediate access to the software and assess Mautic's fit to the OERu's requirements. This service allowed for up to 2,000 contacts, with a modest cost increase for additional contacts.

After a few months using the service, the OERu determined Mautic was an excellent fit for communicating with both current and prospective learners, as well as partners, and began to build its capabilities into the suite of OERu tools. Around the same time, the Mautic company's salespeople contacted the OER Foundation to say that their pricing model was changing and that the Foundation's costs would rise by more

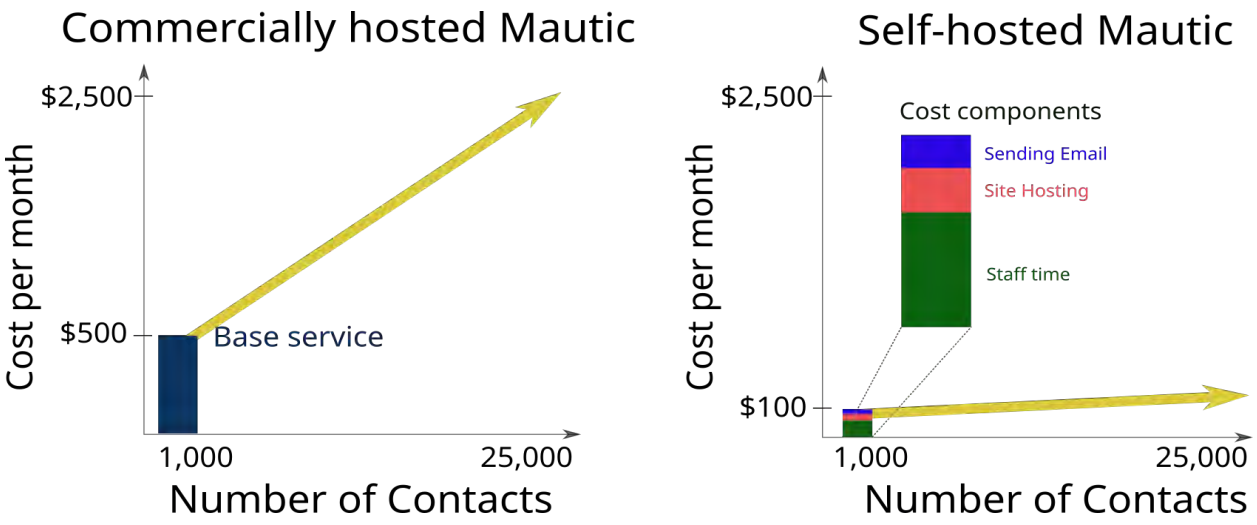
than 10 times, to $500 per month. In addition, there would be a more substantial increase for additional contacts. For example, 10,000 contacts would cost $1,000 per month. This placed the Foundation in an uncomfortable position: having found Mautic to be a very useful tool and having invested substantial time in making it central to OERu services.

However, because the Mautic application itself is FOSS, the Foundation was in a position to mitigate this uncomfortable dependence on a third-party hosted software application by assessing the prospect of self-hosting its own Mautic instance. This would not have been an option with proprietary SaaS offerings. It took less than two days to implement and document a self-hosted OERu Mautic instance (Lane, 2017 [March]). The self-hosting places a negligible additional load on the OERu's infrastructure, and the OERu also benefits from Mautic's capabilities being continually improved by the Mautic developer community via updates that the OER Foundation can apply to the OERu instance when convenient. It takes less than one hour per month of the OER Foundation technologist's time to keep up with changes. Moreover, the foundation has effectively joined the Mautic development community, simply by contributing things like bug reports to improve the platform to ensure it meets OERu requirements.

The self-hosted cost profile for Mautic is far more favourable than that of the SaaS. Cost estimates include technical staff time (averaging about $70 per month), a component of hosting infrastructure, and outgoing email costs. The approximately 200,000 emails sent over the past year using Mautic via an external email SaaS provider cost the Foundation about $15 per month. The OERu has subsequently gained 25,000 contacts—all having completed a double opt-in process to ensure GDPR[4] compliancy (European Commission, n.d.)—and, as shown in Figure 2, the cost comparison for that of SaaS versus self-hosted is about $2,500 versus $100 per month, or $30,000 versus $1200 annually. This means that self-hosting in this case provides a $28,800 annual saving, or 96%, compared to the SaaS offering. That saving alone is several times greater than the OERu's total annual infrastructure budget, and these savings will only increase as contact numbers grow. The OER Foundation believes this validates the FOSS self-hosted approach, and represents a huge opportunity for others, particularly for higher education institutions in emerging economies or dealing with COVID-19–related budgetary cutbacks.

Figure 2

Cost Comparison Between Commercially (3rd party) Hosted and Self-Hosted Mautic (up to 25,000 Contacts)



The Benefits of Diversity

As with any living ecosystem, lack of diversity in technology infrastructure increases fragility and therefore risk. A technology monoculture (i.e., a single-vendor proprietary computing environment that only supports integration with software created by that vendor and/or its designated partners) means that a security failure can render an entire infrastructure vulnerable to hostile exploitation by third parties or even simple vendor incompetence (Cullinan et al., 2010). In recent years, there have been thousands of examples of this phenomenon, particularly related to the Microsoft Windows monoculture. A notable example: the catastrophic failure of the United Kingdom's National Health Services in the face of the "Wannacry" ransomware, which exploited common security flaws in the Microsoft Windows operating system deployed throughout the organisation, creating an effective monoculture (Deane-McKenna, 2017).

Similarly, a supplier failure (where a supplier goes out of business, is acquired, alters or discontinues a key product, or changes its pricing model) can render an entire infrastructure unsupportable, or, in the case of pricing changes for proprietary software or services, economically unsustainable. If the institutions making that software available to their learners cannot remedy that liability by migrating to another technology without, for example, loss of data or access, this can have a massive negative effect both on learner confidence and on institutional reputation.

To mitigate this risk, the OERu has no proprietary supplier dependencies for any of its services; its only commercial relationships with technology providers are for commodity hosting of GNU/Linux computing infrastructure. As such, the OER Foundation can transfer any or all of the OERu services from one provider's infrastructure to another's with minimal downtime, no data loss, and minimal cost.

Finally, as the OER Foundation's home country New Zealand has experienced environmental and social disasters (including earthquakes, fires, floods, and terrorism), the Foundation is acutely aware that lack of geographic diversity is a major infrastructural liability. The OER Foundation has therefore chosen to host Web services in multiple facilities around the world. The aggregate cost of those services is approximately $10,000 per year (including the value of sponsored hosting services that the Foundation receives). As a result of policy changes of one former infrastructure provider that actively disadvantaged FOSS solutions, the OER Foundation moved services that were previously hosted there to infrastructure provided by a more amenable hosting provider, incidentally gaining a further reduction in infrastructure costs in the process. Again, this is something the OERu can do with minimal time, cost, or risk and with little, if any, disruption to learners.

Pedagogical Opportunities

The OERu philosophy embraces "learning on the Internet" rather than learning via any particular platform, with "participatory technologies [being] integral to openness" (Blomgren, 2018, p. 57). This means that learners have complete control of their course artefacts rather than having them locked into an institutional system. This control enables learners to "navigate their own journey through content to achieve desired learning outcomes" (Bossu & Willems, 2017, p. 24) and is the first principle of the "Open Empowered Learning Pedagogy" (Smyth et al., 2016) framework.

For learners using OER, the advantages include the development of self-directed skills (Lin, 2019), textbook cost savings (Blomgren, 2018; UNESCO, 2019), a variety of dynamic OER materials in different languages (King et al., 2018), mobile learning (Chib & Wardoyo, 2018; Lin, 2019), and the promotion of lifelong learning (Melnikova et al., 2017; Misra, 2018).

Alongside advantages for learners, the use of OER also provides opportunities for teaching staff and learning designers. The European Framework for the Digital Competence of Educators (Redecker, 2017) identifies a key competence for all educators as the ability to "effectively identify resources that best fit their learning objectives, learner group, and teaching style, to structure the wealth of materials, establish connections, and to modify, add on to, and develop themselves digital resources to support their teaching" (p. 20). As well as building digital literacy skills (Bossu & Willems, 2017), these resources help learners and educators alike understand open licences and the use of OER (Preradovic & Posavec, 2019; Weller et al., 2018). As Bossu and Willems (2017) assert, OER can "provide opportunities for collaboration, promote curriculum innovation and student-led content development, as well as contribute to . . . teachers' much needed continuing professional development" (p. 22). In addition, cost efficiencies for course developers (King et al., 2018; Menon & Bhandigadi, 2018) should not be underestimated.

Educators developing OERu micro courses build new skills in wiki editing and writing for the Web, using FOSS tools, finding openly licensed content, and adopting pedagogies embodying "free-range learning" (Lopes & Porter, 2018; Morgan et al., 2012; Parry, 2012). Writers are pushed to consider the audience more than ever before, knowing that OERu learners are spread across six global regions. Content needs to appeal to, and be clear to a global audience, many of whom are not native English speakers.

The OERu's international network also demonstrates its potential by collaborating on content writing, assessment moderation, and idea generation to ensure a meaningful experience for OERu learners. In practical terms, this means that educators and developers in New Zealand, for instance, may draft course content or an assessment that is then shared with OERu network colleagues in Africa, Canada, the United Kingdom, or the United States for feedback. As well as strengthening connections between collaborators and the OERu network in general, this also builds capability across the OERu community and ensures robust moderation processes amongst experienced staff working in different contexts. As García-Holgado and García-Peñalvo (2018) emphasise, "people are not only end-users but also an important component of a learning ecosystem" (para. 7) This is certainly the case in the OERu.

Transnational collaboration helps OERu partners consider intercultural dimensions of the learning experience and integrate internationally relevant issues into OERu content (Caniglia et al., 2017). This also facilitates contribution to two of the United Nations Sustainable Development Goals (United Nations, n.d.), specifically Goal 4, "Quality Education," and Goal 17, "Partnerships for the Goals." With the principled facilitation of the OER Foundation, led by the UNESCO Chair in OER and former Chair of the International Council for Open and Distance Education (ICDE) in OER, the OERu network fully embraces its mission to connect people through "the fostering and sharing of ideas" and "building the knowledge and capabilities needed to ensure a better future for all" (New Zealand National Commission for UNESCO, 2013, p. 6).

Conclusion

The OERu's NGDLE experience suggests that the status quo for IT infrastructure in higher education institutions is neither the only way to do things nor always the best way. With the OERu unbound by historical decisions, conventions, or vendor lock-in, it is able to pioneer new approaches. Driven by open principles and constrained resources, the OERu only needs to fulfil its clear vision: to build a rich, ever-evolving infrastructure for learners and OER collaborators alike, operating at the scale required to reach large numbers of learners distributed across the globe. Implementing a FOSS end-to-end service gives the OERu a unique perspective and experience, when compared with organisations that implement only the occasional FOSS component among an IT infrastructure dominated by proprietary commercial software which has more restrictive terms and typically features per seat or per instance licence fees.

The advantages of the OERu's component-based NGDLE are both technological and pedagogical, enabling their communities of learners and educators across the globe to thrive. It demonstrates both remarkable cost-effectiveness at scale and the ability to adapt rapidly to meet evolving learner needs, while gently immersing learners in precisely the digital environment in which they need to gain confidence and virtuosity to thrive in furthering their education or as qualified professionals in an increasingly digital world.

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[1] This paper is an update of a paper presented at the 28th ICDE World Conference on Online Learning, 3–7 November 2019, Dublin, Ireland.

[2] For an example, see course feed for LiDA101, https://course.oeru.org/lida101/interactions/course-feed/

[3] See WEnotes-Aggregator, OERu, https://git.oeru.org/oeru/wenotes-aggregator

[4] The OERu endeavours to pro-actively implement best practice regarding learner privacy, which we believe is currently reflected by the European Union's General Data Protection Regulation (GDPR). For more information, see "General Data Protection Regulation, Wikipedia" https://en.wikipedia.org/wiki/General_Data_Protection_Regulation. To see the OERu's GDPR compliance statement, see OERuPrivacy Policy, https://oeru.org/privacy