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Open Textbooks in Higher Education Teaching

Rebecca Pitt

Abstract

Open Educational Resources (OER) are learning materials available under licensing terms that enable their use, sharing, reproduction, and often adaptation without needing further permission from the author or copyright holder. Whilst OER are available in many different formats, open textbooks—complete course books available on open licenses—have been particularly successful in facilitating widespread use of OER in some regions, such as North America. This chapter surveys the current extent and future potential use of open textbooks in Higher Education (HE), examining how open textbooks are used to address challenges in HE and describing opportunities for connecting and enabling institutional and extra-institutional communities through the use of open textbooks. While open textbook ecosystems are well developed in some countries, elsewhere the role of open textbooks remains emergent. This chapter examines the nuances in open textbook use and what lessons can be learnt from both more mature ecosystems and those where open textbook use remains limited.

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1   Introduction

The COVID-19 pandemic has sharply highlighted and deepened existing inequalities in education (e.g., Adams, 2021; Bozkurt et al., 2020; Czerniewicz, 2021; Saavedra, 2021; Xiao, 2021). In Higher Education (HE), the move to teaching at a distance and the challenges of rapidly moving to online teaching and learning have both revealed previously ignored or hidden inequalities whilst simultaneously demanding that these are addressed. With regard to learning materials, library access has often been restricted and, consequently, supporting students with relevant books and materials online has become even more critical (França, 2021). As Czerniewicz (2021) observes in her assessment of the impact of the COVID-19 pandemic on HE, "now that the impacts of inequality are clear and visible, they must never again be rendered unseen." One consequence of the pandemic, and the centring of what may have been "unseen" by some but was a lived experience for many, is that discussions on pedagogical approaches which centre equity, care, and social justice have come to the fore (e.g., Bozkurt et al., 2020; Xiao, 2021).

It is one of these inequalities, access to textbooks, and one solution, open textbooks, which are the focus of this chapter. The idea of open textbook initiatives as ecosystems is not new (e.g., Baraniuk et al., 2017), and both emergent and mature examples of these have an important role in providing examples of who and what is involved in sustaining the production and use of OER such as open textbooks. Moreover, as will be seen, open textbook ecosystems are by necessity and design 'open' in different ways, drawing on wider community experiences and more established initiatives or technologies, whilst acknowledging these as a contrast to commercial publishing models.

This chapter surveys the development and focus on open textbooks in some regions of the world, examining the factors that have led to or hindered their use. What factors have enabled well developed open textbook ecosystems to emerge whilst elsewhere their role is emergent? What lessons can be learnt from different contexts? Moreover, how can open textbooks be used to address the current challenges in HE whilst also offering the potential to connect and enable communities both within and outside HE institutions in their development and use?

2   OER Ecosystems

Understanding who and what supports and sustains the use of OER at certain points and the possibilities for their future development are important in shaping strategy and focus for organisations, government bodies, and institutions.

In their analysis *The Open Educational Resources Ecosystem…* The Boston Consulting Group (2013) identified, categorised, and analysed levels of awareness, provision, and different uses of OER and open pedagogies and institutional and legislative support for the use of OER. Through this analysis, key areas enabling "mainstream adoption" were identified. The analysis and recommendations were reflective specifically of the US context and particularly reflected the emergent importance of open textbooks for potentially enabling widespread adoption of OER.

Five years later, and reflective of the accelerated development and adoption of OER (in particular open textbooks) within the US context, Huttner et al. (2018) published their report *Seeking a sustainable OER ecosystem*. This analysis is reflective of the maturity of the ecosystem; the growing availability and range of curriculum-aligned OER specifically developed and produced for the USA context, support for use of OER, as well as recent governmental support and funding for initiatives (Huttner et al., 2018; SPARC, n. d.b). The focus of this analysis is how to ensure longevity by identifying and collectively addressing challenges which have emerged, including the financial sustainability of OER initiatives.

Huttner et al. (2018) present a model which draws on, and combines, two different approaches to OER ecosystem models to date, those which are "values-driven" and "incentive-driven" (pp. 2 & 11). Aligning those involved in sustaining "the essential processes of a sustainable OER commons" at different points and alongside key activities shows that whilst sustainability may not involve a radical shift from existing structures and requirements (e.g., "use tech and data to increase engagement and track results"), OER ecosystems should reflect and integrate openness, for example through the use of open pedagogies (Huttner et al., 2018, pp. 8 & 17). "Five core challenges" (resourcing, institutional support, adoption support, educator support, and open pedagogy and the dominance of North American/English language OER) are also discussed and different possible responses to them explored (Huttner et al., 2018, pp. 2 & 13–18). Some potential compromises (such as "accepting the inclusion of organizations driven by profit or other factors") are also highlighted as possibilities as the OER ecosystem continues to develop (Huttner et al., 2018, p. 3).

Both The Boston Consulting Group (2013) and Huttner et al. (2018) analyses are focused on the USA context, and therefore American OER ecosystems, specifically. Within this context, there is a focus on open textbooks as the driver for OER adoption and specific contextual considerations and challenges. However, whilst OER may initially be created for specific audiences and educational contexts, OER are also shared publicly, with no barrier to access and can, therefore, (putting aside issues of findability/visibility) potentially be used more widely

than just by their intended audience(s). Consequently, there are also critical wider issues that should be reflected and acknowledged by OER ecosystems. Huttner et al. (2018) acknowledge this in their fifth "core challenge" and their discussion of the dominance of North American/English language OER (pp. 17–18).

Developing OER ecosystems that reflect current practice while also potentially offering alternatives to, or reimagining and extending, existing educational practices is by necessity nuanced and contextually specific. Whilst more mature OER ecosystems can provide potential inspiration, for example by suggesting collaboration with a range of education providers (see Huttner et al., 2018, p. 18), existing successful approaches should not be prescriptively applied across varied contexts (see also Baraniuk et al., 2017). Thus, in tandem with the possibilities that openness presents, there is the possibility of a fusion of multiple OER ecosystems: a criss-cross of organisations, individuals, and systems which have the potential to support various ecosystems with their platforms, tools, and resources, depending on their relevance to specific contexts and requirements.

3   Why Open Textbooks?

Open textbooks are a type of open educational resource (OER). More specifically, open textbooks are complete resources, presented in textbook format and either created from scratch or by partially or wholly curating existing OER. They are created in different ways, authored by individual educators, groups of experts, or even by students as part of their course assessment. Open textbooks are 'open' as they utilise open licences (such as Creative Commons) to enable users to reuse and often adapt the content without needing to seek further permissions from the copyright holder. 'Open' textbooks are typically made available digitally at no cost to the user.

Farrow et al. (2020) describe two main drivers for the popularity of open textbooks (p. 230). The first is the high cost of textbooks, which has been a long-standing concern and acted as a focus for advocacy, particularly in North America. Whilst textbook costs have outpaced inflation since the late 1970s, they have also accelerated in recent years. SPARC, for example, reports that "College textbook prices rose 82% between 2003 and 2013, approximately *triple the rate of inflation* in overall consumer prices (CPI) during the same time (27%)" (SPARC, n. d.a). Where available, complete resources, such as open textbooks, offer an immediate and accessible solution to expensive hardcopy or e-book materials. Whilst textbook costs are a long-standing issue in a number of countries, as will be seen later in this chapter, the sharp increase in the cost of

educational resources during the COVID-19 pandemic has further compounded this issue for students and institutions. The second driver for open textbook use is the pedagogical possibilities that are granted through the open licence itself. These permissions enable the adaptation of resources to better suit learner and educator needs.

Addressing the issue of textbook costs depends on a number of factors, and the success of open textbooks partly depends on both an awareness of and response to the changing strategies used by publishers as they attempt to reconfigure the publishing playing field and preserve market share. A recent analysis of the publishing industry (Aspesi et al., 2019) outlines a range of publisher strategies and interventions intended to both diversify and maintain control of educational textbook markets in response to reduced spending by libraries and students. Some of these strategies, for example analytics, ensure that textbook publishers exert far greater control over institutional decisions and infrastructure than previously (Aspesi et al., 2019).

A clear picture of OER awareness and use over a sustained period is available in a limited number of regions, tending to those where more mature open textbook ecosystems are present. Research by Seaman and Seaman (2021), for example, has documented USA educator awareness of OER over a number of years, whilst the periodic Florida Virtual Campus (n. d.) survey of students charts textbook perceptions and use. In their latest report, Seaman and Seaman (2021) note the continual increase in US educator awareness of OER over the 2014–2020 period. For example, during 2019–2020, 58% of educators surveyed said they had at least some familiarity with OER in comparison with 34% in the 2014–5 period (Seaman & Seaman, 2021, p. 31). As above, this is reflective of increased advocacy for open textbooks, changes in federal and state level policies, increased availability of ready-to-use open textbook material that is curriculum-aligned over this period, and, as Seaman and Seaman report, institutional support (Seaman & Seaman, 2021, p. 42). Moreover, whilst there have been concerted efforts to foreground how open resources, such as textbooks, meet expected standards (through, for example, peer review of open material in repositories or clearer explanations of the process by which open textbooks are created), such long-standing concerns regarding quality (e.g., Hilton, 2020) appear to remain an issue for educators who have not yet used OER (Seaman & Seaman, 2021).

Whilst in the USA, there is year-on-year improvement in the number of educators who are aware of OER, in the UK awareness of OER remains low. In their 2018 survey of UK HE educators, The UK Open Textbook project revealed lack of awareness of OER and open textbooks, but enthusiasm for their potential use (see Farrow et al., 2020; Pitt et al., 2019, 2020). However, although in general

awareness of OER is low and there is a lack of national OER policy, a number of UK universities have OER policies and initiatives such as Open Scotland advocate for national policy and sector wide change (Open Scotland, n. d.). There is great potential; as seen in the case of open access (OA) publishing in the UK, changes to national, funder and university policy (see e.g. UK Research and Innovation (UKRI), 2021), impact on educator awareness and practice.

As open textbooks have established themselves over the past decade, there has also been a concerted effort to increase the amount of research on their impact. In a synthesis of current research into the impact of OER, Hilton (2020) notes that "results across these studies suggest students achieve the same or better learning outcomes when using OER while saving significant amounts of money" as well as a wide range of other positive impacts.

4   Open Textbook Ecosystems

As noted earlier, publishers have continued to diversify their offerings (see Aspesi et al., 2019). Seaman and Seaman's (2021) report on the USA context summarises a number of changes that occurred around the 2015/6 time and transformed the terrain of textbook publishing. These include increased educator awareness of the impact of learning material cost on students, proprietary publisher responses to this growing awareness, a shift in marketing strategy and offering which requires more centralised and less educator decision making around resources, and educator willingness to use more digital resources and the subsequent rise in provision of these (Seaman & Seaman, 2021, p. 9). Some of these changes, such as an increase in digital resources associated with a textbook, have resulted in changed educator expectations and, consequently, a need for open textbook publishers to formalise and increase the development of ancillary resources provided.

By developing comparable offerings to those available via commercial publishers, there is a move towards an OER ecosystem that offers the 'complete package' and removes barriers to the use of open textbooks (Baraniuk, et al., 2017, p. 222). Baraniuk et al. (2017) highlight the importance of understanding and responding to commercial publishing strategies in their discussion of how OpenStax, based at Rice University and publishers of over 60 open textbooks aimed at US HE audiences, developed their "successful, sustainable OER model." This involved identifying and responding to two challenges commercial publishers were facing: "digital rights management (DRM) restrictions and the lack of collaboration among providers in the market" (Baraniuk et al., 2017, p. 222).

The result is a strategically developed "distributed ecosystem model" that contrasts with the "one size fits all" closed approach of publishers (Baraniuk et al., 2017, p. 223). OpenStax partner with a number of non-profit and for-profit providers who, as OpenStax Allies, provide a variety free and costed add-ons to open textbooks, for example labs, simulations, and homework systems. Consequently, "the ecosystem model spurs choice by allowing the educator to decide which resources best align to their curricular goals." (Baraniuk et al., 2017, p. 224). In addition, other resources, such as PowerPoint slides and materials created by other educators, are also available to support textbook use. OpenStax also offer educators a paid platform for a selected number of textbooks that enables customisation and presentation of textbooks into complete courses.

As an open textbook ecosystem develops and matures, strategies for engaging different stakeholders require consideration. The OpenStax website states they offer "free and flexible textbooks and resources" (OpenStax, n. d.b); a clear, meaningful offer, regardless of awareness of OER, and which focuses on pertinent issues rather than on 'open' in and of itself (see Baraniuk et al., 2017). South African based open textbook providers Siyavula took a similar approach (Lambert, 2019). This strategy is particularly important given varying levels of OER awareness in different regions.

In instances where open textbooks are curriculum aligned and therefore complete resources, their use does not necessarily require any adaptation or localisation and therefore awareness of open licensing. As Jhangiani (2017) notes, focusing on cost, whilst initially "appropriate, even pragmatic," requires recognition that this message is not only context and stakeholder specific, but could also potentially hinder adopter engagement with the full possibilities that OER offer (p. 142). Whilst subsequent adaptation and localisation of material often occurs once the resource has been used initially (e.g., Pitt, 2015), how to both initially and continually engage appropriately with different users and stakeholders as they use and engage with OER and open textbooks in different ways is critical.

The OpenStax ecosystem has emerged and been refined since 2012, from the first textbooks and educator sharing of resources to support the use of specific textbooks (see Pitt, 2014) to today's multi-faceted and layered offering building on the core, free textbooks, and featuring revenue streams for sustainability and cost-effective packages of resources and technologies to better compete with proprietary offerings (Baraniuk et al., 2017). The OpenStax strategy has been highly successful, with the impact and use of these resources more widespread than US HE; whilst OpenStax textbooks are now used by 60% of all USA colleges and universities, they are also known to be use in over 120 countries (OpenStax, n. d.a).

Another open textbook ecosystem that has emerged and developed iteratively over a sustained period is The Open Education Network (formerly The Open Textbook Network). A membership organisation, the network has developed to include extensive support and networking for educators and institutions who are developing, publishing, and sharing open textbooks. The network also hosts an extensive curation of, at the time of writing, over 900 open textbooks (Open Textbook Library, n. d.). The curation of materials, which can be easily searched and assessed by educators, addresses long-standing perceived barriers to OER uptake including quality and visibility of resources.

These mature open textbook ecosystem examples are focused primarily on the national level, providing different types of support for the use of open textbooks. In the first instance, support is via an ecosystem of USA curriculum-aligned resources and technologies (e.g., Baraniuk et al., 2017) whilst in the second, support is through networks of educators and programmes to further the implementation, adaptation, and development of resources (Open Textbook Library, n. d.). Both provide different, successful approaches to addressing identified barriers to the use of OER and open textbooks (Pitt et al., 2019; Farrow et al., 2020).

Elsewhere, similarly mature ecosystems have emerged from different funding and support structures. In their discussion of Canadian OER initiatives, McGreal, Anderson and Conrad (2015) note that education is completely devolved to each province. Consequently, open textbook and OER initiatives are funded at, and focus on, the province level with the Canada OER Group serving as a connecting point for work across the country (BCcampus, n. d.). Canadian open textbook ecosystems also originate and are aimed to primarily serve students within a specific province. In British Columbia, BCcampus has seen a series of province-funded grants from 2012 onwards to support the development of open textbooks where there is "skills gaps or projected skills gaps" or for courses with large numbers of students and support their further localisation at colleges and universities across the region (Burgess, 2017, p. 228).

As Burgess (2017) describes, developing an ecosystem with educators, students, and the wider community, alongside experienced open textbook advocates and publishers early in the project enabled it to flourish and become established and, over time, engendered widespread support for open resources and practices. Directly addressing concerns, such as lack of ancillary resources for open textbooks, was also critical and the development of these through co-creation also brought educators together from across the province. Finally, it is of note that Burgess also describes an "ecosystem of technologies" that BCcampus drew on to help support textbook development and implementation, providing features to support ease of use (Burgess, 2017). Again, large scale textbook initiatives

involve a close understanding of barriers to open textbook use and draw on the wider community and technologies to support their development.

Elsewhere in Canada, eCampusOntario support open textbook use amongst educators and institutions across the province. Their *Open Library* enables educators in the province to easily find high enrolment discipline materials and customise these. Educator reviews of materials and reporting material adoption are also encouraged. Training and materials to support and promote OER use are also available (Open Library, n. d.).

5   Emergent Open Textbook Ecosystems

Mature and/or large open textbook ecosystems display a number of similar characteristics. They are open and interconnected, drawing on national and/or international community expertise and resources to develop material and connect with partners or providers who can support additional technologies. They are also aware of, and responsive to, the potential barriers to, and expectations of educators and students regarding open textbook use. An awareness of the wider challenges faced by the publishing industry and how different open textbook models can address these is also key to developing effective strategies for open textbook development, curation, and support.

The applicability or success of open textbooks in different contexts in HE depends on a number of factors. When the pilot UK Open Textbook project tested the applicability of two mature models of USA open textbook adoption (OpenStax and the Open Education Network) within the UK HE context, it was clear that despite lack of awareness of OER, there was a high level of interest in this type of resource (Farrow et al., 2020; Pitt et al., 2019, 2020). Whilst further research is needed, "textbook cost is an increasing area of concern" within wider discussions on the high cost of UK HE (Farrow et al., 2020; Pitt et al., 2019, p. 5, 2020). However, unlike North America, at UK universities there is less focus on one specific textbook for a course, which means open textbooks are likely to be utilised differently within this context (Farrow et al., 2020; Pitt et al., 2019).

A closer look at different open textbook initiatives around the world highlights some of the differences in both context and requirements for instigating initiatives that curate and create open textbooks. Open Textbooks for Hong Kong, for example, created and curated open textbooks for all education levels (Open Textbooks for Hong Kong, n. d.) Describing the process to set up the initiative, it is notable that textbooks were at that point primarily hardcopy, with a reluctance of publishers to move to online provision (Cheung, 2016). This aligns with the lack of a

platform to support the sharing and use of open content (Cheung, 2016), revealing specific local challenges to be addressed.

In Poland, governmental support for a nationwide open textbook initiative has focused on early years and compulsory education, where whether materials are up-to-date and their cost are a concern (Hagemann & Hugyecz, 2016). As in Poland and elsewhere (e.g., Pitt et al., 2019; Farrow et al., 2020), the cost of textbooks is not a problem unique to HE. Curriculum-aligned and accessible, there is a range of materials currently available (Zintegrowana Platforma Edukacyjna, n. d.). Alongside this national initiative, specific publishers such as OpenStax have focused attention on HE. Working with Katalyst Education, OpenStax have published 4 textbooks in Polish alongside their English language offerings since 2015 (OpenStax Polska, n. d.). OpenStax textbooks are currently in known use in 134 universities across Poland (OpenStax Polska, n. d.), over one third of the 349 HEIs in the country (European Commission, 2022). Understanding where existing textbooks could be localised and translated for use is critical; a sub-section of Polish universities have courses that could utilise a remixed version of the *University Physics* textbook, for example (Ruth, 2017). This strategy could potentially be replicated in other contexts, for example the UK, if there was sufficient institutional coordination and collaboration. Elsewhere, in South Africa, support at government level took a different form and facilitated the distribution of Siyavula mathematics and science open textbooks across the country to 2.5 million primary school children (McGivern & SF Team, 2017; Lambert, 2019).

Whilst the issues of access and cost are central to open textbook uptake, their use is often critical for disadvantaged and underserved populations who face multiple barriers to participating fully in their studies. As Seaman and Seaman note, within the US context, "minority-serving faculty have a clear lead in the rate of OER adoption" (Seaman & Seaman, 2021, p. 38). A number of projects now centre on social justice in open textbook advocacy and use. For example, Digital Open Textbooks for Development (DOT4D) at the University of Cape Town, South Africa evaluates and supports open textbook development at both the institutional and national level (DOT4D, n. d.). Central to the project is an acknowledgement of the legacy of apartheid and colonialism and dominance of Global North narratives and resources within education and underlying the inequalities that persist today and which underpin the lack of access and cost issues in HE (e.g., Cox et al., 2020). Involving students in the creation of textbooks and developing models of textbook production which reflect the experiences of the project's 11 open textbook creators are also in development (Cox et al., 2021). Elsewhere, in Australia, the Australian Open Textbooks as Social Justice project

(2020–2021) builds on open textbook research done by projects such as UK Open Textbooks to explore and focus on social justice, particularly with regard to marginalised and indigenous learners (Australian Open Textbooks as Social Justice, n. d.)

6   The Future of Open Textbooks

Textbook publisher responses to the pandemic have resulted in an increase in e-book costs, as many students across the world are studying remotely rather than in face-to-face classes. The impact of this on institutions, educators, and students is emergent; however, it is clear that, in some instances, this has accelerated demand for open textbooks and institutional responses to this issue. The issue of textbooks has become "seen".

In the UK, over the 2010–2019 period, it was estimated that £1 billion was spent by universities on resources from the largest 10 publishers (Grove, 2020). However, during 2020, lack of access to physical textbooks and the corresponding rise in demand for e-books, coupled with a rapid rise in their cost, forced UK institutions to engage intensively with the issue of textbook costs (Fazackerley, 2021; França, 2021). Whilst free access was granted to e-books by publishers for a limited time, subsequently shifting from printed to e-books has highlighted a number of issues; as França (2021) explains "Whilst the issues around e-textbook access are complex, the overriding barrier to making these titles available to our students has been one of cost…" (p. 3). Similarly, within the US context, a US Public Interest Research Group (PIRG) survey of 5000 District of Columbia students in September 2020 revealed that the impact of the pandemic on student employment had, in turn, impacted on students' ability to purchase online course materials, including access codes which allow not only access to textbook material but to assignments and other course materials (Nagle & Vitez, 2021; Shalabi, 2021).

In the UK, this has crystalised in a range of activities during the 2020–21 period. The pandemic has accelerated some universities, such as University College London (UCL), to publish their own open textbooks using their open press; planning to develop a "membership coalition" to benefit UK HE more generally in future (Anderson et al., 2021). As reported in March 2021, "…UCL had to find £3 million extra and recurrent funding in 2020 (because of the pandemic) to support students whilst libraries were closed" (Anderson et al., 2021). Similarly, The University of Edinburgh's collaborative *Open eTextbooks for Access*

to Music Education project remixed existing MOOC content to produce a music theory open textbook (Campbell, 2021). Whilst responding to existing sectoral challenges, the increase in e-textbook costs during the pandemic is cited as giving even greater importance to this pilot project (Campbell, 2021). At a national level, the librarian-led UK #ebookSOS project has acted as a focal point for increased high cost of e-books during the pandemic and its impact on the sector, and has received support from thousands of higher education professionals (Campaign to Investigate the Academic eBook Market, n. d.).

Whilst prior to the pandemic a number of factors had led to accelerated use and focus on open textbooks in some regions of the world, such as North America, as can be seen within the UK context, the pandemic has led to coordination and advocacy around e-book costs and highlighted previously recognised but largely "unseen" issues such as the cost of textbooks. As Anderson et al. (2021) note, this is a pivotal moment: "…the current situation with e-textbooks feels like the situation with OA to research materials 15 years ago." As noted earlier, familiarity with open access (OA) in UK HE is high compared with that of OER and open textbooks, as a result of changes in policy. The work of the UK Open Textbook project showed "potentially fertile ground" for open textbooks (Pitt et al., 2019, p. 2, 2020; Farrow et al., 2020) pre-pandemic. As shown in the examples of emerging UK open textbook ecosystems described above, the pandemic has led to a renewed focus on the possibilities of open textbooks.

Within the USA context, Seaman and Seaman (2021) report that whilst there was an increase in OER awareness in 2020 during the pandemic, this did not translate to an increase in use of OER, in contrast to previous years (Seaman & Seaman, 2021). Whilst use of OER as "supplementary" continued to increase for foundation level courses, it reduced slightly during the latest survey for all courses taught (Seaman & Seaman, 2021). The reasons for this are currently unknown; however, it is arguably the case that many educators were focused on supporting their students and colleagues and shifting their teaching online over this period, rather than reviewing or reworking open materials for use in the classroom (see Seaman & Seaman, 2021). It is of note, however, that OpenStax report interest in their materials during the pandemic having accelerated the development of materials (OpenStax, n. d.a). This increase in interest in open textbook content, whether from students or educators, also reflects the broader interest in OER and open educational practices reported during the pandemic (see Bozkurt et al., 2020).

7   Conclusion

Whether emergent or established, open textbook ecosystems are by their nature collaborative and coordinate the actions of diverse stakeholder groups. Whilst open textbooks provide a solution to textbook costs and equitable access, they have also created a timely opportunity for connecting and enabling communities internationally both within and without institutions.

The OER and open textbook ecosystem models explored in this chapter reflect the contextual differences and needs of different communities, as well as the nuances of education systems. As shown by successful, mature ecosystem examples, iterative evaluation of the needs of specific stakeholder groups, an understanding of publisher models, and identification and engagement with current and emergent challenges are vital to ensure a functioning, effective ecosystem. The 'open' aspects of these ecosystems provide further possibilities, and whilst more mature ecosystems provide potential examples for other contexts, these should not be taken as prescriptive or definitive; ecosystems continually develop to both reflect and support changing and emergent practices and needs.

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