Developing an Open Resource Bank for Interactive Teaching of STEM: Perspectives of school teachers and teacher educators

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Abstract: Much of the current literature related to Open Educational Resource (OER) development and practice concentrates on higher education, although a growing body of work is also emerging for the primary and secondary school sectors. This article examines the user perspectives of teachers and teacher educators, regarding: discovery of teaching resources; what they know about OER; their sharing practices; and their perspectives on resource quality and trust. The research was done in the context of the Open Resource Bank for Interactive Teaching (ORBIT), a JISC-funded Phase III OER project at the University of Cambridge. ORBIT is an OER Resource Bank containing more than 200 science, technology, engineering and mathematics (STEM) focused lesson

ideas for primary and secondary teachers as well as serving as a resource bank of OER to be used by teacher educators in a variety of settings.

Keywords: Open Educational Resources, teacher education, teacher practice, teacher experience, teaching resources, science, mathematics, digital technology

Introduction

In our view, discussions around Open Educational Resources (OER) are part of the wider discourse about ownership of and access to quality education. Is it the educators, or those seeking education? Historically, going back at least to the middle ages, our society has found different answers to this, sometimes relying more on learner-organised education and sometimes on institutionally organised education (Peter and Deimann, 2013). The question of who owns education is linked to the question of who owns educational resources, and thus Open Educational Resources. The question of whether materials should either be Open[1] or need to be protected in some way goes back to the technological advance of book printing, and is expressed through the notion of copyright, dating back to the 17th century. The first emergence of Open content is linked to another technological advance, namely the advent of computers, networking, the internet and subsequently the world-wide web, and can be traced back to Project Gutenberg (during the 70s and 80s)[2], the free and Open source software movement and Open source licenses[3]. The term 'learning object'[4] galvanised thinking that digital materials could be designed and packaged such that they can be reused more easily, including appropriate provision for metadata, and led to the idea of Open Content (in 1998) and the foundation of Creative Commons in 2001. Since then OER have been developed in higher education (e.g. OCWC[5], CNX[6]), and to some extent, for primary and secondary education too (CK12[7], Siyavula[8]). OER have long been recognised for the potential to improve access to and quality of education (D'Antoni, 2009; OECD, 2007; Cape Town Open Education Declaration, 2007; Paris Declaration 2012), and are also used for lifelong learning.

We should at this point clarify how we understand OER. Legally speaking OER are situated in the spectrum between copyright and the public domain, typically using Creative Commons licences permitting sharing and reuse. A common definition of OER draws on the 4R framework (Wiley, 2006), considering the (legal) rights to reuse, revise, remix, and redistribute. However, in our view a purely legal conception of OER is limited. For instance the Access2OER discussion (Haßler, 2009) drew out three aspects of Openness or freedom, namely: legal freedom; technological freedom (including accessibility); as well as freedom in terms of education and participation - inviting dialogue, rather than transmission. In other words, resources should not just be legally Open, but aspects of technological Openness and educational Openness need to be considered.

Despite the fast growing OER movement, relatively little research has been conducted on the development and use of OER, particularly for teacher professional development or in primary and secondary education settings. The present research is situated in the context of the **Open Resource Bank for Interactive Teaching (ORBIT)**, supported by a JISC-funded Phase III OER project (conducted at the Faculty of Education at the University of Cambridge, and funded for the academic year 2011-12). ORBIT (http://oer.educ.cam.ac.uk/wiki/ORBIT) is an OER resource bank containing over 200 science, technology, engineering and mathematics (STEM) focused lesson ideas for primary and secondary school teachers, plus resources for teacher educators and professional development leaders in a variety of settings. ORBIT is arguably unique in that each lesson idea is connected to a pedagogical rationale (and teaching strategy), and many resources have links to a particular digital technology that can be used with that idea. ORBIT is hosted using MediaWiki[9], and content is openly available for reuse and modification under Creative Commons (with a choice of licence as CC-By-SA or CC-By-NC).

The ORBIT resources derive from a variety of sources. However, many were specifically developed by (or in conjunction with) teachers and teacher educators. They are organised according to subject, topic, teaching approach, age, as well as what (if any) ICT is used. Contributions to ORBIT are prepared using a flexible template, and they are reviewed and edited by the project team to ensure that they are of high quality and clearly formulated, with explicit learning objectives and interactive pedagogical approaches.

Resources are fully searchable and classification of resources also offers indexing; as a community is built, developing and adding resources, a reputation management system and social rating tools would be possible. ORBIT also includes difficult to find archived materials; these are high quality resources which were highlighted by stakeholders as useful (e.g. via the Higher Education Academy list), but had become difficult to access, for example in the National Archive.

Given the success of some non-OER resource sharing repositories, such as the prominent Times Educational Supplement (TES) free resource bank for teachers and student teachers, research on the use of OER for teacher education is important. In contrast to much other OER research, the work presented here focuses on the perspectives of classroom teachers and teacher educators. Central to our research are their prior familiarity and existing practices with OER, as well as opportunities for, and potential resistance to, adoption of OER among teachers and teacher educators. Our findings are based on a questionnaire for practitioners in higher education (HE), i.e. teacher educators, as well as practicing teachers, in addition to a number of in-depth semi-structured interviews conducted with each stakeholder group. The three OER freedoms mentioned above map well onto some of the themes considered in our research, namely resource discovery and usability, resource adaptation for particular students and to the curriculum, as well as teachers' (and teacher educators') understanding of OER. We also considered questions of quality, trust, and reputation management. Our findings helped us to reflect on our experience of developing ORBIT,

and informed further development.

Literature review

'While much work has been done to create, disseminate, and champion OER, relatively little theory-based, generalizable research has been done to examine its use and impacts.' (Bateman, Lane & Moon, 2012)

As Bateman et al. note, there is little research on OER. Where research exists, it has tended to focus on OER production and policy - particularly in HE - rather than the experiences, quality perceptions, learning, and educational practices of OER users and producers. Indeed, the direct advantages of truly Open resources compared to other similar (non-OER type) resources can be elusive. For instance, it is difficult to disentangle the impact of Open resources compared to just free resources, as well as the impact of Open digital resources vs. other digital resources. In some cases, the same advantages apply to both Open and non-Open resources. A related question is to what extent OER can be used to support and enhance new (Open) pedagogical practices, such as collaboration on public materials, that may be harder or impossible with copyrighted or just free resources, because these (by definition) do not allow adaptation. For instance, the Institute for the Study of Knowledge Management in Education (ISKME, 2005) suggests that much OER content within their study of the Connexions repository of 17,000 learning objects or modules for school-level learning in the US was created individually (authorship is completely Open), and raises the question of to what extent OER repositories can facilitate more group authorship and participation. For a wider discussion of OER practice in HE, see for example Glennie, Harley, Butcher and van Wyk (2012) and references therein.

Turning to the UK, and specifically looking at the primary and secondary school sectors, as well as teacher education, we note the Digital Futures in Teacher Education project [10] (DeFT). This project took place concurrently with ORBIT and was likewise funded through the JISC OER programme; it explored the opportunities and challenges of creative and innovative approaches to digital literacy. The project created an Open textbook, embedded in a customisable "thinking space", enabling the creation of personalised versions of the book according to context and needs. ORBIT and DeFT interacted and enriched each other.

Otherwise, however, there is little research on: how UK teachers (and teacher educators) discover and access teaching resources (including OER); what they know and think about OER; their sharing practices; and their perspectives on resource quality and trust. We now look at those themes in turn, and ask what their implications are for the development of an open resource bank.

Effective discovery and flexible access

An important element of OER (compared to more traditionally copyrighted resources) is

that they are publicly available, and can be explored with public search engines. Such engines (e.g. Google) may not be the best way to discover in all circumstances, but they simply offer a predominant way for teachers and teacher educators to find resources. For instance, Brent et al. (2012) contrast use of Google searching (by 81% or more of participating teachers), Google Scholar (75%), YouTube (40%) and Wikipedia (32%), with use of more specialised repositories (such as Jorum or Merlot, only used by 7% or less of the respondents). Of course, discovery through search engines applies to all resources that are publicly available, as long as they are technically presented in such a way that they are index able. Some teachers however do use some specific teaching resource banks (including TES; as well as TeachFind and Teachernet: see Pountney and Gruszczynska, 2012). The question of effective discovery does need to be investigated further (for instance, teachers' use of social media: ibid.). The question of discovery pertains widely to many different kinds of resources. [11]

OER are available free of charge, which means that access to such resources has the potential to be more straightforward than access to non-free materials. In the context of Open textbooks for community colleges [12], for instance, Hilton and Laman (2012) (regarding the adoption of a psychology textbook by 690 students) and Bliss, Robinson, Hilton and Wiley (2013) (involving 80 community college teachers and 490 students) note that an OER textbook means that all students have access to the textbook, regardless of their ability to pay. They have access to the book at any point prior to or during the semester (and indeed throughout their life: before, during, and after their entire degree). Having a legally Open resource also means that the resource can be presented in different ways, offering students a variety of methods of access (e.g. from different locations and devices). The ability to present an Open resource digitally (as opposed to on paper) also means that students can search the text easily, as well as copy and paste relevant sections. A number of studies show that students will use the online version (if available), that those students may be more interested and engaged, and may learn better; c.f. Bliss et al. (ibid.), Hilton and Laman (ibid.), Hilton and Wiley (2010, 2011).

Apart from free searching, teachers also browse by topics and subject, e.g. Clements and Pawlowski (2012). There are difficulties associated with finding OER, and users can benefit from browsing resources not only by keyword or topic, but also by pedagogic approach, activity or assessment type (Brent et al., 2012). The pedagogic approach usefully serves to record, for instance, how to use the resource (including any prerequisites needed) for independent learning, as well as advice for students using the resource. In the context of DeFT, Pountney and Gruszczynska (2012) likewise indicate that users often struggle with descriptions that do not meet their needs (e.g. because they do not mention a specific topic or curriculum area), and that being able to filter searches, e.g. with assessment objectives, level, and provenance (UK vs. non-UK) is helpful.

The importance of Open

As already mentioned, it can be elusive to determine the precise impact of Open, as compared to free or simply digital resources. It is certainly the case that student and teacher perceptions about the use and quality of OER are easily coloured by their more general perceptions about areas connected to OER, such as the use of technology in education generally (Bliss et al., 2013). It is also clear that many teachers do not have great familiarity with the concept of Open Educational Resources (Pountney and Gruszczynska, 2012). However, while some teachers are unaware of copyright regulations, some others do recognise that copyright issues make sharing more difficult.

Finally we note that students' views on features, usability and quality of resources can be approached via these categories (as noted by Bliss et al., 2013): technical flexibility and accessibility (including formats, convenience, searching), learning aids (richer media), customisation/alignment, cost, and general quality/presentation. These categories can be mapped in various ways onto the abovementioned OER freedoms, and are thus important both from usability as well as from a conceptual point of view.

Collaboration, adaptation and sharing of OER

An important element of OER is not just the (low-cost) availability, but also the ability to adapt the resources to specific student needs and learning objectives. For instance, teachers greatly appreciate that Open textbooks can be customised to include course-specific materials (Hilton and Laman, 2012; Bliss et al., 2013). This also means that new teaching practices become possible, enabling new kinds of conversations, for instance around the interactive, collaborative nature of Open textbooks, and peer-to-peer learning practices (ISKME, 2011).

In the context of OER the trust in reward is an important motivator for sharing. The Netherlands-based Wikiwijs ("wiki-wise") project survey of 1,568 teachers suggested that three key factors determine their willingness to engage in a specific sharing behaviour: the costs that are associated with it; the rewards that can be obtained by performing the behaviour; and the trust people have in obtaining this reward (Van Acker, van Buuren, Kreijns and Vermeulen, 2013). As a financial incentive is usually absent in the context of OER, their research considered altruism, reputation and reciprocity as the possible rewards, and suggested that knowledge self-efficacy, altruism and trust are the most important predictors of teachers' intentions to share educational resources.

OER quality and trust

With regard to trust important questions include how an author ensures the quality of their own OER, how users determine quality and trustworthiness of OER they access, and ultimately whether they become willing to use or share it. Clements et al. (2012) concluded that trust of materials is perceived by teachers as a key quality instrument and that it also facilitates the reuse of OER. Teachers tended to value resources that

come from an organisation with a good reputation, and also to make judgements on the basis of who else has used the resource. Some teachers may additionally use their own quality-based assessments (e.g. peer reviews, rankings or recommendations). In terms of quality, teachers also value simplicity, relevance, and organisation of Open textbooks (Bliss et al., 2012), as well as resources rich in multimedia (animations and simulations), and resources that fit lessons or curriculum of their country (Clements et al., 2012).

Research questions

We conclude from the research described above that teachers are interested in OER, but resource discovery and usability are important. We therefore ask:

a. How can resource discovery and usability be best supported (rather than just looking at a narrower legal definition of OER)?
b. What features of an Open resource bank are desirable to teachers and teacher educators?

The literature also indicates that teachers are interested in creating and sharing resources, but they can experience technical difficulties, and can lack full understanding of copyright. There are also concerns around quality, reputation and trust, which are important for encouraging sharing. Thus we ask:

- How do teachers' and teacher educators' discover and share resources?
- What OER knowledge do teachers and teacher educators have?
- What are teachers' and teacher educators' views on collaboration and resource sharing?
- What are their views on OER quality and trust?
- What are participants' views on ORBIT?
  What are the desirable features of such Open resource banks?

From the answers to these research questions we then extract guidelines for the further development of ORBIT and resource banks in general.

Methodology

The research study employed a questionnaire distributed to a wide sample of teacher educators in HE and school teachers. In addition, a small number of in-depth interviews were conducted with selected representatives from each of the two main stakeholder groups, in order to follow up the survey findings. The interview findings are used to elaborate and enrich the report on the survey data. At an earlier stage user testing of ORBIT was also undertaken, and the results of this were taken into account prior to the research reported here.

The surveys

Both surveys were divided into four sections exploring:

- respondent characteristics (demographic data),
- benefits and practices concerning collaborative development and sharing of teaching materials,
- views on Open content,
- knowledge and usage of OER materials

Survey questions were adapted from an instrument used in a JISC OER Phase II Impact study by Masterman and Wild (2011). They were administered using the SurveyMonkey online tool (www.surveymonkey.com). Two versions of the survey were developed for the target audiences - teachers and teacher educators.

Participants were recruited via email contact on the basis of subject association membership, prior contact with ORBIT or the research team, and through colleague networks. The sample included teachers and teacher educators working in a wide range of institutions (including our own Faculty) and geographical locations within England, in primary and secondary phases, and across the STEM subject areas of science, mathematics and ICT. A total of 55 teacher educators (66% response rate) and 42 teachers[13] participated in the survey. Details are presented in Tables 1 and 2 respectively. Four teacher educator respondents also worked as private tutors. Note that the teacher survey respondents were mainly full-time teachers (78%) but there was a minority (22%) of part-time teachers and others (private tutors and supply teachers).

Table 1: Teacher educator survey: respondents' roles

Role	Number of respondents
primary teacher educator	3
secondary teacher educator	32
specialist role (e.g. secondary mathematics PGCE co-ordinator)	5
subject specialist lecturer	13
teacher educator in higher education	17
not answered	5
n=55*	

*some respondents have more than one role

Table 2: Teacher survey: Respondents' roles

Role	Number of respondents
primary teacher	6
secondary teacher	23
Advanced Skills Teacher (AST)	4
specialist role (e.g. Special Needs or Mathematics Coordinator)	7
subject specialist	18
teacher educator	4
n=37*	

*some respondents have more than one role

The interviews

Six semi-structured interviews were carried out by the research team with 3 teachers and 3 teacher educators selected from the 22 teachers and 10 educators identifying themselves through the survey as willing to be interviewed and providing contact details: the first 3 locally located volunteers in each category who were imminently available were recruited (convenience sampling within the volunteers). The participants represented a range of sectors (independent and state, primary and secondary), and levels of teaching experience.

All interviews were carried out face-to-face in either schools or at the Faculty of Education, and they were audio recorded for transcription. Participants were assured that responses would be anonymised and they were advised that they could withdraw from the interview process at any stage. The interview questions were designed to explore the ORBIT research questions in more depth. They covered participants' understanding, use and adaptation of OER, attitudes to sharing materials, perceived added value of ORBIT and of an Open course book, ease of use and of discovering relevant and useful OER, suggested improvements to ORBIT, criteria for assessing quality of ORBIT, and importance of peer review. Qualitative data were coded and analysed thematically through a process of constant comparison (Glaser and Strauss, 1967) to provide insights into teachers' and teacher educators' understanding and attitudes.

Findings

Practices related to finding resources

Responses to survey questions on teaching materials demonstrated that most educators adopt a collaborative approach to the development of these resources, with the majority (98% of teacher educators and 100% of teachers) acknowledging that they used at least some materials which were developed using ideas produced by others. 27% of teachers used such materials for more than 50% of their resources. Patterns in both groups were similar with films/video clips and hand-outs/worksheets the most commonly shared resources.

The majority of respondents (90% of teacher educators and 100% of teachers) reported adapting teaching resources to suit their particular students or curriculum, confirming findings regarding relevance by Bliss et al. (2012). Also common was the use of resources as inspiration when creating their own resources (68% of teacher educators and 49% of teachers). Few respondents (28% of teacher educators and 36% of teachers) said that they sometimes used the materials without modification.

The internet was widely used to locate these materials: Google searches predominated (88% of teacher educators and 93% of teachers) but other approaches included YouTube (65% of teacher educators and 61% of teachers), subject association websites (57% of teacher educators and 41% of teachers), subject networks (50% of teacher educators and 48% of teachers), TES (48% of teacher educators and 46% of teachers), Google Scholar (48% of teacher educators and no teachers), email lists (38% of teacher educators and no teachers) and Wikipedia (38% of teacher educators and 39% of teachers), which resonates with findings of Brent et al. (2012) and Pountney and Gruszczynska (2012).

In response to the open question, 'What is the value of consulting other people's materials when designing your own?' answers from teachers included the following:

'You can both save time which can be used for more targeted preparation and ensure that you have approached the learning target from all useful directions. Often others have found a way of explaining a concept that is useful but that you would not have thought of independently.'

'The materials I most use are images - I look to find pictures, graphs & diagrams that illustrate the point I want to illustrate. I use exam [questions], mark schemes and examiners' comments to highlight exam techniques with classes in 4 & 5 [Key Stages 4 & 5 : ages 14-18].'

'To try to 'stand on the shoulders of giants'. I have some great ideas of my own, but other people also have excellent ideas that I will often want to edit or adapt.'

Knowledge of OER

The majority (73% of each group) surveyed did not know what Open Educational Resources are (which is in line with Pountney and Gruszczynska, 2012). 68% of teacher educators and 69% of teachers did not know what *Creative Commons* is, nor had they heard of other Open licences. Most (70% of teachers) did not actively seek openly licensed teaching materials, and only very few used such materials regularly (2% of teacher educators). However, 91% of teacher educators and 90% of teachers said that they would be likely to use a website that offered relevant 'permission to use' teaching materials.

61% of respondents had not accessed or used OER, but 22% used OER occasionally or regularly. Comments about the potential benefits of OER resources included the following Open responses:

'As I distribute many of the materials I create and in a professional capacity, I am most cautious to share things only if I know that I am able to do so in terms of licensing. So being able to draw from OER resources to build my materials is a good thing for me.'

'Being able to adapt resources for my classes without feeling guilty. Not having to pay upfront for "professional" resources that may well turn out not to be very useful without further adaptation.'

The majority of respondents said that they either were willing to share their teaching materials via OER or would consider doing so (91%), whether on a regular or occasional basis.

The above findings are corroborated by the interviews. Most of the 6 interviewees had some knowledge or experience of OER even if they were unfamiliar with the name or acronym:

'It's possible that I've seen the acronym [OER] and there are several, sort of, freeware acronyms that are used and so Copyleft was around ten years ago, although I can't recall seeing it recently. There's the GNU [a Unix-like free operating system].' (Teacher educator)

One recently qualified teacher explained that s/he had been introduced to OER during initial training and a primary teacher educator explained that OER provided a useful source of exemplars of different pedagogical approaches to show students. Teacher educators interviewed reported that they encouraged students to collaborate in creating teaching resources and promoted the sharing of ideas and resources amongst students through their institutions' VLEs. One experienced secondary teacher observed that their older colleagues with less technical expertise tended to be more reluctant to explore OER and would sometimes turn to other colleagues for advice and materials.

The issue of whether resources accessed online offered 'permission to use' or not was considered less significant than the discoverability, quality, adaptability and usefulness

of the resources themselves. Having an 'Open' resource bank was seen as a welcome step by all interviewees but most agreed that they had not always checked the copyright position on materials they had used. Some felt that using materials 'for educational purposes' was justifiable and some said they were unclear about how copyright rules operate. This corroborates other research findings that often teachers deliberately do not share outside the small circle of teachers they know, because of copyright issues, and because of the difficulty of seeking permissions (Pountney and Gruszczynska, 2012), in this way teachers aim for limited circulation, rather than adding resources to a repository (ibid.).

OER and collaboration

While most of the survey respondents were willing to share their own teaching materials with colleagues within their own institution, 30% of teacher educators and 37% of teachers said that they did not share resources with those outside of their institution. More teachers (36%) than teacher educators (28%) said that they had shared resources online. Repositories mentioned by teachers included: ORBIT (n=3), Primary Science Teaching Trust (formerly AstraZeneca Science Teaching Trust), TES, other JISC OER III projects, Association for Science Education School Science Review, the Institute of Physics, and email lists (such as the Physics Teaching News and Comment).

A wide range of materials was shared in this way and the most commonly cited were classroom activities, Powerpoint presentations, handouts and worksheets, film clips and experimental data. It was evident, however, in responses to the open question, *'To what extent is there a "culture" of sharing and reusing teaching and learning materials within your department and school/institution? And with other schools or organisations?'*, that both teachers and their institutions varied in terms of collaborative culture, as illustrated in the data extracts below.

'Primary school setting, so year group teachers share flipchart files and other resources, and reuse previous years' plans and resources stored on our network wherever possible. We don't share with other schools at present.' [Primary school teacher]

'Within [college], yes. We do that a lot. Beyond, not really. Unfortunately the sixth form college sector was set up to compete rather that cooperate in the early 1990s and the present funding mechanism does little to reverse that trend.' [Sixth form college teacher]

'It is there but the mechanics of it are a nightmare within my school. There is a sharp divide between IT literate staff and those who are not, [who] create massive sprawling folder trees and incoherent file names that make sharing a real issue... Resources are there but finding them often takes too long!' [Secondary school teacher]

'We all share resources on a regular basis - we can access everything that is shared.' [secondary school teacher]

The interview data further illustrated the issue of collaboration in sharing and creating

teaching materials in schools. As indicated in the survey, there are differing 'cultures' within schools and differences in individual teacher attitudes. Some teachers were willing to share their resources with others but this was essentially a one-way process: 'I don't use other teachers' materials but my materials are quite widely used by other teachers, within the school' (Secondary school teacher). Most interviewees, however, felt that sharing resources was a valuable and reciprocal exchange of ideas:

'I love sharing with my colleagues, I love picking their brains and I love throwing good things that happen to me at them and I love it when they use my stuff. It's a wonderful thing because it allows us teachers to interact with adults within the profession, because most of the day we are interacting with children and it's a different interaction, a different way of interaction, whereas sharing resources actually brings you out of the department and you exchange ideas and come up with new ideas. So, it's really lovely.' (Secondary school teacher)

In the interview sample, resources shared in this way were almost universally adapted to suit particular needs. One primary teacher explained that shared materials were 'ingredients' that could be used in a way that would be at 'the right level'. One secondary teacher expressed concern that his material might not be acknowledged: *'I do, potentially, have an issue with people taking my work, changing two words and passing it off as their own.'*

OER quality and trust

In the interviews, teachers expanded upon the repositories used (see above). They reported that they generally adopted a critical approach to OER and filtered their searches on the basis of 'trusted sources' to ensure that resources would be high quality, confirming findings by Clements et al. (2012). Some larger, commercially managed resource banks were criticised for lack of quality control and interviewees adopted a discriminating approach in evaluating OER. It was suggested that subject associations and subject specialist organisations offered some of the best material:

'NRICH[14] *I think is a good example of a resource that encourages you to make it your own and use it in a way you want to and it's not that there's a right way and a wrong way to use it but there are different ways.' (Teacher educator)*

'The TTRB[15] *project has a big bank of materials and we do refer students to that, particularly in relation to support for assignment writing.' (Primary teacher educator)*

'I very much trust CIMT[16] *and I trust NRICH. Yeah, I think that these are two well-established and dynamic … running for a few years now and cover … almost all the topics that I'm looking for. So, yeah, these two are very critical.' (Secondary school teacher)*

'Well, there are the big standards, like NRICH, and the good thing about the NRICH site

is that the activities, whilst they are mindful of the current context of statutory documentation, whatever, you know that they're actually steered by what makes good mathematics teaching.' (Teacher educator)

'If it's something I'm going to recommend to students, I tend to stick to the ones that come from very well respected organisations.' (Teacher educator)

Feedback from other users was regarded as a helpful means of evaluating whether materials were worth looking at:

'You'd look at comments other people have made, so you don't even have to download it sometimes. If twenty people have written 'This is rubbish. Please don't download this', that's very useful feedback; star systems or whatever that site uses.' (Secondary school teacher)

Teachers and teacher educators who had shared their resources online said that they had done so via subject association websites or through professional networks. Three interviewees had already given permission for ORBIT to upload some of their teaching materials. The opportunity to share resources with others was highly valued amongst interviewees and, as one teacher summed up, OER broadens horizons and the opportunity to share is worldwide: ' *And, I think last thing on OER is that […] it has no frontier. And that's good'.*

Perceptions of ORBIT features

One survey question asked if respondents were aware of the ORBIT website: of the teacher educators 6% were highly familiar with it, 24% were somewhat familiar, and 70% had not previously encountered it (the high level of familiarity reflects the sampling strategy which was not of course representative of the population of all teacher educators). Only 7 teachers (17%) had encountered it. However, ORBIT was either already known to the 6 interviewees or they were introduced to it prior to the interviews.

Survey respondents were invited to rate the importance of various features of ORBIT and responses are presented in Figures 1 and 2 below. Interestingly, tagging of resources according to subject, topic, learner age, etc. was of paramount importance to all, but being openly licensed for reuse and adaptation was equally important to teacher educators while offering a set of relevant and pre-filtered resources was particularly important to teachers. Over 40% of teacher educators but only 27% of teachers considered making underlying pedagogical approaches explicit to be at least fairly important. Overall, all features asked about were considered at least fairly important by over 40% of teacher educators but the range was only 27-38% for teachers. Respondents were also asked about the potential usefulness of the ORBIT digital course book and 75% felt that this would be a valuable resource for teacher education.
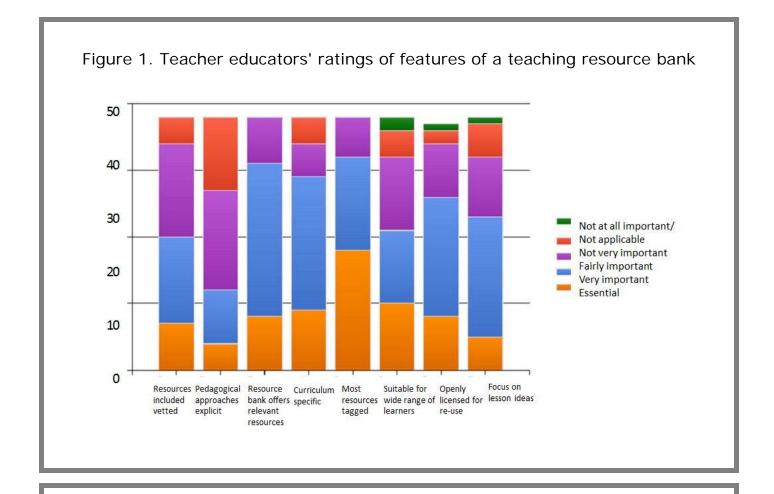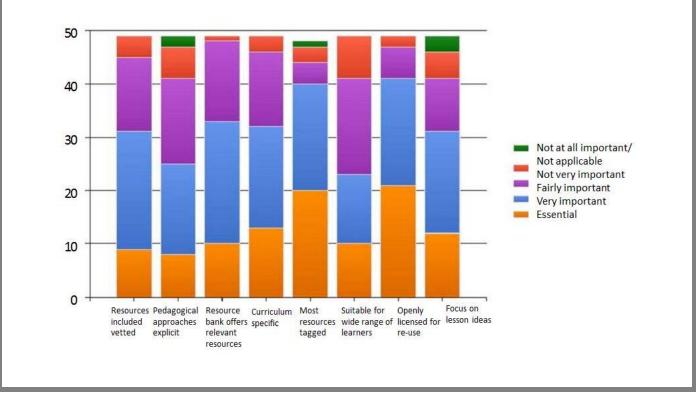
Figure 1. Teacher educators' ratings of features of a teaching resource bank

Figure 2. Teachers' ratings of features of a teaching resource bank

Guidelines for developing an Open resource bank

The participants surveyed and interviewed had substantial experience of resource banks. The questionnaire and interview data analysis allowed us to draw out some important recommendations for the future development of both ORBIT and other open resource banks, which we now discuss.

Importance of quality control and reputation management

Teachers and teacher educators do use online resources. In particular, all interviewees thought the ORBIT site would be useful to their practice in some way. The ORBIT wiki was welcomed as a potentially useful resource for interviewees in both primary and secondary sectors and in teacher education because it was regarded as offering Open access to relevant, high quality materials from a range of trusted sources. For example:

'I'm sure I'll use it regularly and I'll be happy to contribute to it regularly as well. You know, it will enrich my way of thinking and my ways of teaching. It'll give me new ideas and if it's a dynamic resource that is constantly under construction and more is being put on it … you know, if it's a live site it will bring variation to my teaching, so, it's a good thing.' (Secondary school teacher)

'What you want is that it ends up being a sort of, almost like a trusted brand model that we know if it's on that site then it's of good quality.' (Teacher educator)

Indeed, participants preferred to access OER through websites that they saw as being trustworthy and of high quality - subject specialist organisations especially, as mentioned above. The size of a resource bank was considered less important than its integrity, usability and accessibility.

In particular, the issue of quality control was regarded as a priority, because on many sites the low quality resources outnumber higher quality resources. As one secondary teacher explained, it is vital that the user can be quickly assured of the site's usefulness and integrity:

'You know, if you're trying to put together a bank of resources, you need to have really, really solid quality control. Because if I can't . . . If I look for something and the first five things that come up are rubbish, I'm crossing you off my list and I'm never using you again.' (Secondary school teacher)

Resources should not only be presented as materials to use but also the teaching objectives and learning outcomes associated with them should be made explicit to users, as they are in ORBIT:

'So … in an online activity, I would expect to see, in a good quality online activity, what likely outcomes might be. Not just about the activity itself, what you're going to encourage children to do. I want to know what are the children actually going to learn, what vocabulary are they going to develop?' (Teacher educator)

Importance of discoverability

Search facilities need to be robust and simple to use and interviewees made various suggestions about ways of improving the ORBIT search facility. In particular, a clear homepage and tagged browsing were singled out as useful features, elaborating the survey findings on searching and tagging as follows:

'You need to be able to find the right thing, so they … you know, the search needs to be quite fine grained. People don't tend to navigate around web pages anymore, 'search' is the homepage.' (Teacher)

'Some sort of taxonomy based on tagging, I've found, works quite well.' (Secondary school teacher)

These findings confirm the importance of tagging and clear descriptions, as highlighted by Clements and Pawlowski (2012), Brent et al. (2012), and Pountney and Gruszczynska (2012).

Importance of flexible file formats and expandability

Format and compatibility issues were also identified as being vital to ensure that all downloads would be useable for all. Having found what you need, you must be able to use it easily and ideally without the need for further (specialist) software. Adaptability of OER materials was seen as essential. As also indicated by the surveys, all interviewees said they preferred to tailor materials to suit their own purposes and match the needs of their students. Therefore the resource formats should be such that adaptation and incorporation is possible. A key recommendation for ORBIT was that resources should be provided in formats that permit easy adaptation:

'…compatibility is important and having stuff that I can use and that will work is important.' (Teacher educator)

'They need to be good resources and 'good' doesn't just mean, you know, looks pretty and whatever, but good in the terms of is useful to me, hopefully, because they're open and, you know, the graphics are vectored so I can take things out rather than embedded bitmaps and the file size is reasonable and it's not saved in Adobe Illustrator format that I don't have. . .using free and open source software as much as possible, you know. So being able to find stuff where I don't have to go and buy software.' (Secondary school teacher)

Interestingly, one secondary school teacher suggested that raw experimental data be included on ORBIT as a resource for schools, pointing out that access to this kind of material is currently very limited on the Web:

'So, one of the things about dark matter is, okay, it's a problem to do with…rotation curves, bits of galaxies are spinning faster than they should be, and so on. It took me ages to actually get the raw data so I could plot my own graphs…If it is available, why

isn't it easy enough for me to find? You know, why isn't there an Olympic data for schools web page, where I go on and I grab all of the Olympic data?' (Teacher)

Teacher educators also recognised that a flexible, open resource bank is able to connect with other initiatives, and to grow over time:

'The idea of sort of starting small and gradually expanding or … the way in which they're linking to other projects, which, again, offers opportunities for expansion. I think there's a lot of potential in the site.' (Teacher educator)

These findings also link to those of prior work on students' preference for flexible digital materials, c.f. Bliss et al. (2013), Hilton and Laman (2012), Hilton and Wiley (2010, 2011).

Conclusion

The teacher educator and teacher surveys and interviews generated quantitative and qualitative data concerning practitioners' usage of OER and their attitudes towards this kind of collaborative practice. Both teachers and teacher educators look to OER for inspiration to extend the quality and creativity of their teaching materials. This is seen not only as a way of saving time and effort but, more importantly, as a way of accessing new ideas and well-produced presentations that could not easily be generated by practitioners themselves. Most practitioners prefer to adapt resources obtained in this way to meet their curricular and student needs.

Quality of resources is a paramount concern for practitioners and the use of 'trusted sources' (such as subject association websites and professional networks) was regarded as a way of ensuring that materials would be of a high standard. Despite common practices of sharing resources internally, there is currently wide variation between schools in the extent of collaborative development of teaching resources and the survey responses indicate that resource banks such as ORBIT would be welcomed as a means of promoting collaborative practice.

Although practitioners desire to share resources, the issue of licensing was not regarded as a priority amongst teachers, many of whom said that they had used online materials without checking their copyright status. However, the majority of teachers and teacher educators said that they would use a website that specifically offered 'permission to use' materials.

Importantly, practitioners expressed belief that a resource bank like ORBIT would make the discoverability of high quality resources easier and they would also have increased confidence in sharing their own materials through this means. According to our respondents the most important features of a teaching resource bank such as ORBIT are: tagged resources (by age, subject or topic); validation of resource quality; an appropriate range of materials for different age groups and curricula; availability of openly licensed materials; adaptability of resource materials. Specific modifications to

ORBIT were incorporated both during and after the funded period on the basis of participants' suggestions and user test observations.

In summary, our findings are generally in accord with prior work, indicating that:

1. Users want resources to be findable, easily, using typical methods such as searching and category systems on sites such as subject professional association sites;
2. There are many sources of resources; it is time consuming to find good resources, and users value being able to "try before you buy", that is, to see resources without additional effort;
3. Users value the ability to adapt resources - and indeed do this frequently with non-OER, although some note they would prefer the 'guilt free' knowledge that their adaptation was encouraged;
4. The value of adapting resources also relates to the ability of the resource bank to grow and develop over time - and adapt as curricula change;
5. Initial and continuing teacher education may offer good opportunities for introducing OER to teachers, as noted by some participants.

Extending prior work, we have elicited guidelines (rooted in research) for the development of Open resource banks. This included extending findings from OER use in higher education (c.f. literature review), as well as findings concerning access (e.g. Haßler, 2009) into the specific area of teacher education.

Outlook

In this paper we considered the attitudes of teachers and teacher educators. However, the research scope did not allow us to consider what OER means for students (in HE), pupils (at school), and their parents. For instance, a case study by Johnson and Hammond (2012) demonstrates that students in HE had some reservations. University students (given that they pay high fees) may want more 'bespoke' resources rather than ("off the shelf") OER. This may of course also be to do with how the OER are introduced. Interestingly though, in the DeFT project teachers commented on the fear that the HE professionals brought up a number of times - that students might end up feeling "cheated" that the resources have not been produced by the tutor but by somebody else. Another question is how a school teacher explains the idea of OER to children and parents? In the DeFT project, where pupils were contributing to resources, permissions from parents had to be obtained (Pountney and Gruszczynska, 2012). Parents were relatively unconcerned, but teachers expressed concerns about broader ethical implications of working in the context of research projects, using comments from pupils (for instance regarding digital footprints, cyber security). Further work is required to explore these stakeholders' perspectives in more detail.

Another key question is how using and sharing OER can increase quality in education. For instance, what are the factors that make learning with an Open textbook different from learning with a traditionally copyrighted textbook? Hilton and Laman (2012)

indicate that students who used the free online textbook scored higher on departmental final examinations, achieved higher grade point averages in the class, and had higher retention rates. However, their findings contrast with those of Wiley, Hilton, Ellington and Hall (2012), who found that there were no changes in state standardised test scores in trials with Open textbooks.

So a key question is, what are the additional affordances of Open licensing and Open distribution that have a direct effect on the quality of learning? To give a particular example, the DeFT project (Pountney and Gruszczynska, 2012) emphasised the importance of the textbook being embedded in a digital and customisable "thinking space", while the ORBIT book creator allows users to compile their own materials and export them in range of different formats. Some potential effects on learning are to do with being able to use the text more freely, such as everybody having access (digitally), and having access in different ways (desktop/mobile), being able to search and bookmark. However, even that flexibility could be possible with a commercially licensed text. Other uses are enabled more directly by OER, such the ability to reuse, share sections for discussion (e.g. through VLE or social media), instructors being able to remix the text with other resources. The greater flexibility afforded by OER is also helpful regarding anticipatory provision and accessibility (JISC, 2013).

OER clearly has the potential to contribute significantly to various aspects of education. Further engagement with and research on OER (and Open educational practices) are needed. The transformative potential of such practices is unlikely to be realised without a clear understanding of how Open educational practices (including the use, sharing, and adaptation of OER) can contribute to the quality of teaching and learning.

Acknowledgements

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[1]
We capitalise the adjective Open when it is used with formal meaning of Open ("libre", related to freedom), as in Open Educational Resources.

[2]
More information about the Gutenberg project is available herehttp://www.gutenberg.org/wiki/Gutenberg:General_FAQ and on Wikipediahttp://en.wikipedia.org/wiki/Project_Gutenberg, http://en.wikipedia.org/wiki/Michael_S._Hart.

[3]
More information is available on Wikipedia, e.g.http://en.wikipedia.org/wiki/Open_source_software, http://en.wikipedia.org/wiki/Free_software_movement,

[3]
http://en.wikipedia.org/wiki/Open-source_movement , and

[3]
http://en.wikipedia.org/wiki/GNU_General_Public_License .

[4]
Again see, e.g. http://en.wikipedia.org/wiki/Learning_object, and http://www.oecd.org/edu/ceri/36224377.pdf with references to ARIADNE, IMS, IEEE LTSC / LOM, SCORM.

[5]
OpenCourseware Consortium, http://opencoursewareconsortium.org

[6]
Connexions, http://cnx.org

[7]
The CK12 foundation is a not-for-profit organisation that aggregates high quality curated STEM content, including text books, see http://www.ck12.org/.

[8]
Siyavula offers open textbooks, including Grade 10 - 12 Mathematics and Physical Sciences textbooks: http://www.siyavula.com/.

[9]
http://www.mediawiki.org . MediaWiki is the software that runs Wikipedia and other Wikimedia Foundation projects.

[10]
See www.digitalfutures.org for full details of the DeFT project, and Pountney and Gruszczynska (2012).

[11]
C.f. also http://www.steeple.org.uk

[12]
For background on textbooks in community education in the USA see the Open Access Textbook Task Force Final Report (2010)

[13]
Response rate is not reported for teachers since in some cases the survey link was sent to known teachers and educators and the Faculty's PGCE coordinator who were asked to forward it further to appropriate colleagues; hence we cannot be certain how many recipients there were.

[14]
NRICH is a well known and highly regarded project providing mathematics enrichment resources: see http://nrich.maths.org/. While the NRICH resources are not OER as such, they could be considered "grey OER" (Brent, Gibbs and Gruszczynska, 2012). ORBIT collaborated with NRICH, and a number of NRICH resources were imported into ORBIT, and fully licenced as OER.

[15]
The Teacher Training Resource Bank

[16]
The Centre for Innovation in Mathematics Teaching, http://www.cimt.plymouth.ac.uk/