Chapter 14

Teacher professional learning communities: A collaborative OER adoption approach in Karnataka, India

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Summary

This chapter analyses collaborative Open Educational Resources (OER) adoption amongst Indian school teachers by examining the enabling and constraining techno-social, techno-pedagogical and sociocultural factors in an education context characterised by (1) low information and communication technologies (ICT) use in schools; (2) a "textbook culture" in which teachers often act as simply "content transmitters" of officially prescribed texts; and (3) diverse linguistic challenges, in which predominately English language OER may not always be relevant. The study addressed the following research question: Can a collaborative, "bottom-up" approach by teachers working together to create, adapt and share contextually appropriate resources provide a model of OER adoption?

This study adopted a mixed-methods approach – primarily through action research – in which the research team collaborated with 67 teachers and teacher educators on an OER adoption process. The team worked with the teachers between June 2013 and December 2015, utilising a combination of face-to-face workshops (19 in total), questionnaires, focus group discussions and online interactions. The participants were selected from different districts of Karnataka state, representing diverse geographic areas of the state and three subject disciplines: mathematics (26), science (18) and social science (23). The impact this collaboration had on teacher practices was compared with a Comparable group made up of 124 teachers who did not participate in the research intervention. Data analysis suggests that teachers are able to use digital methods to adopt OER and to contextualise (revise) OER to suit their needs, if given appropriate training. Their techno-social skills were advanced through greater knowledge and experience with digitally mediated collaborative OER activity. ▶

Their techno-pedagogical efficacy improved through greater networking with other colleagues and a sense of openness to having their materials adapted and revised, though teachers acknowledged that linguistic and quality challenges remained. The collaborative OER adoption approach also raised teachers' sociocultural knowledge concerning copyright and contextually relevant OER. In addition, the OER engagement processes have aided teacher professional development by building a collaborative environment with peers and introducing them to a multiplicity of educational resources.

The authors recommend that state education authorities implement a professional learning community approach to teacher professional development within in-service teacher education, implement a collaborative model for OER adoption, suggest that copyright regulations should position open licensing as the default, and implement a Free Open Source Software-based ICT programme in school education.

Acronyms and abbreviations

CCE	Continuous and Comprehensive Evaluation
COA	Collaborative OER Adoption
DIET	District Institute of Education and Training
DSERT	Directorate of School Educational, Research and Training
FOSS	Free and Open Source Software
ICT	information and communication technologies
ITfC	IT for Change
KOER	Karnataka Open Educational Resources
MHRD	Ministry of Human Resources Development
NCERT	National Council for Education Research and Training, India
OER	Open Educational Resources
PAR	participatory action research
PLC	professional learning community
RMSA	Rashtriya Madhyamika Shiksha Abhiyaan
ROER4D	Research on Open Educational Resources for Development
STF	Subject Teacher Forum
TPD	teacher professional development

Introduction

Public education in India faces a serious challenge in terms of limited curricular resources. The textbook supplied by the government through the Department of School Education for each subject is usually the sole resource at a teacher's disposal. This aligns with the approach of the education bureaucracy, which views the teacher as a "minor technician" (Scheffler, 1973) whose role is to merely transmit the content of the prescribed textbook rather than use multiple resources to explore the concept in a deeper manner with students.

Open Educational Resources (OER) can potentially enrich a learning environment of this kind. The United Nations Educational, Scientific and Cultural Organization defines OER as "teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions".[1] While OER proponents may assume that the availability of free, good-quality learning materials is sufficient for OER adoption,[2] the use of open educational content in developing countries is relatively low (Hatakka, 2009). This chapter reports on an action research study on OER adoption in the public education system in the Indian state of Karnataka, which in many respects can be considered representative of the Indian national education context.

The Indian education context

India has more than 1.6 million schools, of which more than 70% are public (i.e. government) institutions (NUEPA, 2014). These government schools typically cater to children from the most marginalised sectors of Indian society as they offer free tuition as well as a range of support services, such as free textbooks, free school uniforms, lunch, bicycles and scholarships. Government schools face serious challenges in terms of the quality of education offered. The Annual Status of Education Report,[3] a nationwide study conducted by the non-governmental organisation Pratham, concludes that an unacceptably large percentage of children are unable to undertake even basic reading, writing and arithmetic. Moreover, the study also claims that around 70% of children in India do not pass Grade 10, and many of those who do, lack basic life skills and competencies.

Some reasons for the poor quality of learning in India are sociocultural. India has the largest population of illiterate adults in the world;[4] hence, many of the children who are currently attending school are first-generation schoolgoers who receive little or no support at home. Other factors impacting upon the quality of learning are pedagogical and structural, such as the limited availability of curricular resources (Kanwar, Kodhandaraman & Umar, 2010), inadequate school infrastructure and inadequate teacher professional development (TPD) (PROBE, 1998), all of which create an impoverished learning environment. When assessing the current state of Indian education, it is also important to consider the fact that universalisation of school education only received serious attention in India following the 1986 National Policy on Education.

India operates on a federal government system, with the federal (central) government functioning at the national level and provincial (state) governments operating in each of the country's 29 states. To support schools, the Indian education system has institutions established at central, state, district and block[5] levels. Education is a "concurrent subject", meaning that both central and state governments can legislate and implement education

1 http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CI/WPFD2009/English_Declaration.html
2 As discussed in the Research on Open Educational Resources for Development "Research Concepts Note", the term "adoption" is used in a comprehensive manner, and includes resource reuse, creation, revision, remixing and redistribution. The document is available at goo.gl/57tYfx.
3 http://img.asercentre.org/docs/Publications/ASER%20Reports/ASER%202014/fullaser2014mainreport_1.pdf
4 http://en.unesco.org/gem-report/allreports
5 The district is the unit of general and education administration below the state. The "block" (also known as "taluka") is the unit of education administration below the district (as per Table 1).

policy and programmes. However, in practice, the central government role is restricted to macro-policy aspects such as curricular frameworks, and actual implementation is undertaken by state governments.

Within the central government, the Ministry of Human Resources Development (MHRD) is responsible for education. The MHRD has different departments responsible for basic and higher education, which work with their corresponding departments in state governments. The state of Karnataka is the focus of this study. Its education structure is similar to other states and it has a Department of Education, which has structures/institutions at the state, district and block levels. Table 1 provides an overview of education administration and academic support structures in India.

Table 1: Overview of Indian education administration and academic support structures

Level of administration	Name of the administrative/ governing authority	Name of academic support institution	Number of institutions in India	Number in Karnataka
National	Ministry of Human Resource Development, Government of India	National Council of Educational Research and Training (NCERT)	1	N.A.
State	Department of School Education, Government of Karnataka	State Council of Educational Research and Training	29	1
District	District Education Office	District Institute of Education and Training (DIET)	Roughly 683	30
Block (taluka)	Block Education Office	Block Resource Centre	Roughly 6 000	176

Source: (NUEPA, 2015a)

Academic support institutions, such as DIET and the Block Resource Centre, are distinct from the administration institutions at each of these levels, and high levels of collaboration across institutions are required for coherent functioning. The size and complexity of the system makes coordination amongst the actors within the education system (teachers, teacher educators and education administrators) quite challenging, which has an influence on the efficiency of its overall function. Table 2 provides information on the number of schools, teachers and students in India and Karnataka in order to provide a sense of scale and the relative positioning of Karnataka in the national system.

Table 2: Number of teachers, schools and students in India and Karnataka state

	India			Karnataka state		
	Government	Private	Total	Government	Private	Total
Schools	1 180 622	498 645	1 679 267	50 934	25 780	76 714
Teachers	5 349 263	4 047 655	9 396 918	226 148	197 129	423 277
Students	135 887 920	100 080 588	235 968 508	5 065 175	5 047 563	10 112 738

Source: NUEPA (2015a; 2015b)

Linguistic diversity

The 2001 India census[6] data indicate that 13 languages are spoken by more than 10 million native speakers, 30 languages are spoken by more than a million native speakers, and 122 languages are spoken by more than 10 000 people in the country.

India is organised into states based on the language spoken and the Indian education system is also linguistically diverse. Typically, each state has one main language, spoken by the majority or at least a large percentage of its population. Invariably, many people in the border districts of any state also speak the major language of the neighbouring state. Indian education policy (Ministry of Law and Justice, 2009) requires that the state offer education with the first language of the learner as the medium of instruction. The state education system typically offers instruction in at least two languages – the official state language and English. In border areas, schools also offer the language of the neighbouring state as a medium of instruction.

In Karnataka, apart from Kannada (the state language of Karnataka) and English, government schools offer instruction in Urdu, Telugu, Tamil and Marathi languages; these are also the languages spoken in Telangana, Andhra Pradesh, Tamil Nadu and Maharashtra, respectively, which border on Karnataka state.[7] The multilingual nature of Indian society (and of the Indian education system) therefore provides a compelling context for OER adoption in multiple languages.

This chapter explores OER adoption within the Karnataka public education system in terms of techno-social, techno-pedagogical and sociocultural factors.

Techno-social factors

The term "techno" in this context refers to digital technologies, including infrastructure, devices, connectivity and software. The design and uptake of digital technologies is influenced by the social contexts in which they are utilised. At the same time, digital technologies also influence social contexts. Vespignani (2009, p.425) states: "We live in an increasingly interconnected world of techno-social systems, in which infrastructures composed of different technological layers are inter-operating within the social component that drives their use and development." The term "techno-social" in this study therefore

6 http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2014/ITU_Key_2005- 2014_ICT_data.xls
7 Urdu and Telugu are major languages spoken in Telangana; Telugu in Andhra Pradesh.

refers to the interrelationship between digital technologies and teachers' use thereof in OER adoption.

Reports from the International Telecommunications Union, the United Nations body responsible for global communications, reveal the poor availability of information and communication technologies (ICT) in the Global South in terms of physical access to ICT infrastructure, capacity-building for access and use, and maintenance of ICT infrastructure to enable continued access. The "Individuals Using the Internet 2005 to 2014" report[8] suggests that there is a large gap between developed and developing countries with regard to key ICT indicators. The availability of digital technologies is poor in Indian households and schools, and the lack of ICT infrastructure is a defining feature of the Indian education system (Thakur, 2014). Given the fact that OER are mostly digital in nature, poor access to ICT impacts access to OER, compromising the "free availability" feature of these resources.

Outsourced ICT implementation

The ICT@Schools programme of the government of India[9] aims to provide ICT infrastructure to all high schools in the country and has been outsourced to vendors in most states, including Karnataka. In this outsourcing model, the programme is implemented and managed by a private company which supplies the computers, sets up the labs, appoints and manages the ICT teachers, and provides the content for the ICT classes. The state of Kerala is an exception in this context, in that it chose to implement its ICT programme through the teachers in the education system.

The outsourcing model of implementation is widely regarded as a failure and state governments are open to exploring alternative models where ICT education is delivered by regular teachers. A study by the Central Institute of Educational Technology suggests that ICT use may not simply follow its provisioning. ICT integration processes therefore need to be carefully designed in order to encourage teacher use and participation (CIET, 2015).

Proprietary environment

A further limitation in developing the Indian public education system is the use of proprietary software (limited mostly to Microsoft Office applications) for generating content in the ICT@Schools programme[10] (Kasinathan, 2009b). The absence of tools for developing subject-based content has meant that creation of digital resources on the part of teachers is rare, as there is limited or no access to tools for resource creation. In response to this, India's *National Policy on Information and Communication Technology in School Education* (Department of School Education and Literacy, 2012) has recommended the establishment of a Free and Open Source (FOSS) approach and envisions that teachers will participate in the creation of digital resources.

This research investigates whether a participatory and FOSS environment where teachers collaborate in OER adoption can support teacher development and OER adoption.

8 http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2014/ITU_Key_2005-2014_ICT_data.xls
9 http://ictschools.gov.in/Policy/national-policy-ict-school-education-2012
10 The exception being the ICT@Schools scheme in Kerala, where the programme was implemented using open source software and applications.

Techno-pedagogical factors

"Techno-pedagogy" in this context refers to the integration of digital methods in educational processes. Mishra and Koehler (2006) suggest that knowledge of digital technologies influences and is influenced by teaching processes. The interaction between digital technologies and pedagogical processes can be termed as "techno-pedagogical". This study is concerned with two aspects – the availability and use of curricular resources in teaching, and teachers' networking for professional development. OER is digital by nature; increased techno-pedagogical knowledge may therefore have the potential to influence OER adoption in the Indian education system.

Curricular resources and OER

Content and process (curriculum and pedagogy) are generally acknowledged as the two intertwined components of learning. Eisner (1991, p.11) states: "Like the systole and diastole of the beating heart, curriculum and teaching are the most fundamental aspects … No curriculum teaches itself, it always must be mediated, and teaching is the fundamental mediator." India does, however, have what has been termed a "textbook culture" (Kumar, 1988), in that the textbook is seen as the single, definitive resource for teaching. There is therefore little focus on the use of other teaching materials and the interplay this usage may have with more advanced, effective pedagogy. In his "Origins of India's 'textbook culture'", Kumar (1988, p.452) writes:

> The second type of education system ties the teacher to the prescribed textbook. She is given no choice in the organization of curriculum, pacing, and the mode of final assessment. Textbooks are prescribed for each subject, and the teacher is expected to elucidate the text, lesson by lesson in the given order. She must ensure that children are able to write answers to questions based on any lesson in the textbook without seeing the text, for this is what they will have to do in the examination when they face one. The Indian education system is of the second type.

The textbook culture emphasises the state-published textbook as the vehicle of education, thereby "serving as a means through which the bureaucratic authority exercises its influence; it becomes the symbolic hub of the power structure that governs the teacher's daily routine" (Kumar, 1988, p.453).

The Education Department in most states supplies textbooks for all subjects free of cost to all teachers and students in government schools. This emphasis on the textbook is reinforced by the limited availability of alternative resources. Consequently, many teachers only use the textbook in their teaching. This practice informs teachers' perceptions of their role as that of being a "minor technician" (Scheffler, 1973), meaning that they merely utilise the resources and approaches made available through government channels. Scheffler (1973, p.61) writes:

> The transmission model of education coupled with the drive for increased efficiency tends to foster the view of the teacher as a minor technician within

> an industrial process. The overall goals are set in advance in terms of national needs, the curricular materials pre-packaged by the disciplinary experts, the methods developed by the educational engineers, and the teachers job is just to supervise the last operational stage – the methodical insertion of pre-ordered facts into the students mind.

The "content transmitter" perspective can influence teachers in limiting their engagement with additional or alternative curricular resources and teaching methods.

Another compounding factor in addressing curriculum development is the fact that the same textbook is provided for each subject and class to all schools across the state,[11] a situation which fails to address the diverse learning needs of students. In recognition of this challenge, the National Curriculum Framework 2005 document of NCERT has emphasised the role of technology-mediated teacher development and resource-creation processes in contributing to an inclusive and contextually appropriate learning resource environment. These collaborative processes of teacher resource creation have the potential to support teachers to collectively resist the notion of the "minor technician".

Teacher networking for professional development

In India, the provision of a school within or close to every habitation is a policy requirement. The Sarva Shikshana Abhiyaan (MHRD, 2008) (or "universal education") programme of the central government, adopted by all provincial governments, requires that lower primary education facilities (grades 1–5) and upper primary schools (grades 6–8) be located within 1km and 3km of every habitation, respectively. This has resulted in the public school system being vast and dispersed. Teachers therefore seldom have contact with their peers in other schools or with other educational institutions.

It has been recommended that spaces for sharing teaching experiences be recognised as an important principle of in-service teacher education (NCFTE, 2010). There is therefore a need to study how a technology-enabled professional learning community (PLC) where teachers network virtually can support OER adoption and teacher development by reducing teacher isolation and enabling peer learning. In other words, there is a need to understand in what ways collaborative, "bottom-up" approaches by teachers working together to adopt resources can provide an effective OER adoption model, and whether such collaboration can influence TPD and teaching practices.

Sociocultural factors

The "global" OER movement is located predominantly in the geopolitical North and most OER programmes as well as OER portals for accessing resources are located in Northern institutions. Given that educational systems in the North may be more advanced in terms of institutional maturity, as well as in their methods and processes of curricular resource design and development, their resources may *prima facie* appear superior. Wholesale ("as

11 The same textbook is provided in the medium of instruction of each particular state, however many languages that may be. For instance, in Karnataka, the mathematics textbook for a class is produced in the six languages which serve as medium of instruction in different schools in the state. This does not apply to the language subject textbooks, such as English or Hindi or Kannada.

is") adoption of these resources can, however, pose a risk in terms of ignoring local learning contexts, strategies and abilities of learners. OER adoption of this kind also stands to further strengthen the hegemony of the North in the global educational sphere by expanding the diffusion and reach of Northern resources. If OER is to be explored as a key mechanism for addressing education needs, it is important to understand whether and how OER models that are developed within the Global South can more effectively address learners' needs in contextually appropriate ways. Given its linguistic and cultural diversity, this issue of inadequate contextually appropriate resources is of particular relevance in India.

Local language and culture

In India, most OER are developed and available in the English language, with a far smaller percentage available in the local languages of the learners. For instance, when considering Wikipedia, the most popular OER site in the world,[12] Kannada Wikipedia has around 20 000 pages – in contrast to over five million pages in English.[13] This is one example of the paucity of OER in Indian languages, relative to English.

Albright (2005, p.12) states:

> OER are cultural as much as educational, in that they give users "an insight into culture-specific methods and approaches to teaching and learning" – a practical exposure to the way that courses are "done" in another country or by another instructor. Language is clearly intertwined with culture in this dynamic. The vast majority of Open Educational Resources are in English, which is spoken by perhaps 10 per cent of the world's 6.3 billion people. Not only does the English language dominate OER provision, but English-language content tends to be based on Western learning theory. This limits the relevance and accessibility of OER materials in non-English, non-Western settings. There is a risk that language barriers and cultural differences could consign less developed countries to the role of OER consumers rather than contributors to the expansion of knowledge.

There is therefore a need to study how bottom-up OER adoption processes with teachers can aid the design and development of more culturally relevant OER in local languages. It is also important that techno-social, techno-pedagogical and sociocultural factors are not viewed in isolation, and there needs to be an acknowledgement that there may be areas of overlap between them. For instance, teacher networking can be viewed as a component of techno-pedagogical factors (in the context of peer learning) or as sociocultural factors (impacting upon teacher isolation).

Therefore, the current techno-social (limited capacities of teachers to work with ICT and lack of a FOSS environment), techno-pedagogical (textbook culture and teacher isolation) and sociocultural (lack of OER meeting local needs in local languages)[14] realities in Indian education may not be conducive to the adoption of OER in the Indian public education

12 https://en.wikipedia.org/wiki/List_of_most_popular_websites
13 https://en.wikipedia.org/wiki/List_of_Wikipedias
14 It should be noted that there would be many more elements within these three factors; those identified are based on the perception of the research team of their importance in the study context.

system. It was therefore deemed necessary to implement and study a programme focused on teacher capacity-building that enables teacher collaboration with regard to OER adoption.

Background to the research

The Subject Teacher Forum (STF) is an in-service TPD initiative designed and implemented by the Directorate of School Educational Research and Training[15] (DSERT) under the Rashtriya Madhyamika Shiksha Abhiyaan[16] (RMSA) scheme with support from the United Nations Children's Fund in collaboration with IT for Change (ITfC), the organisational host of this research study.

The STF was initiated in June 2011, with TPD as its primary objective. Utilising a technology-enabled PLC approach, it aims to enable teachers to utilise ICT to support professional networking and peer learning. Besides training teachers in digital methods, the STF creates subject-oriented PLCs where teachers interact with one another on mailing lists to share materials, ideas and experiences. The PLCs comprise around 12 800 mathematics, science and social science teachers from government high schools across Karnataka state.

During the STF programme implementation, the paucity of high school mathematics, science and social science contextual materials that can supplement government textbooks was noted by the teachers as well as DSERT and RMSA. There was a particularly acute need expressed by the teachers in view of the revision to the textbooks for grades 8, 9 and 10 that was carried out by DSERT during this period. Responding to this need, DSERT began the Karnataka Open Educational Resources (KOER) project in July 2013 in partnership with ITfC for a chosen subset of teachers: 67 mathematics, science and social science teachers and teacher educators who were part of the STF PLC.

The aim of the KOER project was to support these 67 teachers to collaboratively create and adopt OER to develop supplementary digital resources for the recently revised textbooks. This was implemented in a context where curricular resource development had traditionally been centralised and digital content development was outsourced. The bottom-up approach to resource creation in this project was therefore an important departure from the traditional approach.

The aim of this research was to understand in what ways such collaborative, "bottom-up" approaches by teachers working together to adopt resources can provide an effective OER adoption model and whether such collaboration influences TPD. Utilising an action research approach, ITfC worked with these 67 teachers, referred to as the Collaborative OER Adoption (COA) group, training them in digital literacy and collaborative OER adoption. It designed and conducted workshops for the COA group of teachers during the 2013/14, 2014/15 and 2015/16 academic years.[17] The research explored collaborative OER adoption by examining the enabling and constraining techno-social, techno-pedagogical and sociocultural factors to address the following research question: Can a collaborative, "bottom-up" approach by teachers working together to create, adapt and share contextually appropriate resources provide a model of OER adoption?

15 DSERT is part of the Education Department of the government of Karnataka (see http://DSERT.Kar.nic.in).
16 RMSA is a nationwide programme run by the government of India to support secondary education.
17 The school academic year in Karnataka begins in June and ends in March of the following year.

IT for Change

Established in 2000, ITfC has worked consistently for the innovative and effective use of ICT to promote socioeconomic change in the Global South. Intervening at the levels of both discourse and implementation, ITfC has contested dominant information society theories from the perspective of equity and social justice. It engages in research, advocacy and fieldwork in the thematic areas of development and information society, community informatics, technology governance, gender, governance and education. In the course of this work, ITfC has partnered with many regional, national and international institutions, as well as activist groups and academics.

Education is an important domain for ITfC. The organisation conducts research on its own and other programmes on integrating ICT in education and has participated in action research as well as demonstration field projects.[18] It also participates in curriculum design programmes and policy-related committees at national and state levels. The aim of ITfC is to study and build models of teacher development through integration of digital technologies, and to support government school systems to adapt the same through policy advocacy and programmatic support. The ITfC researchers in this study were visiting faculty at the Tata Institute of Social Sciences for the ICT and Education course and similar courses in other pre-service teacher education programmes.

Literature review

OER are considered to have substantial economic benefit in terms of reducing the cost of accessing learning materials (Lane, 2008) and allowing for the distribution of materials at minimal cost to the user (Wiley, Green & Soares, 2012). By opening access to freely available, globally created resources, and enabling the revision and reuse of these materials through open licensing mechanisms, OER are also seen as having the potential to address existing quality gaps (Camilleri, Ehlers & Pawlowski, 2014). The adoption of OER and their potential to expand access to and improve the quality of education is one of the key emerging issues in educational discourse today, particularly as it relates to developing countries where there is a dearth of quality learning materials (Kanwar et al., 2010). While OER offer great potential in terms of addressing quality and access issues in education, "the real challenges facing readiness to adopt OER appear to be related to socio-economic, cultural, institutional and national issues" (Ngimwa & Wilson, 2012, p.398).

These challenges need to be studied and addressed in order to enable OER adoption, particularly as there is currently a gap in reliable evidence arising from on-the-ground experiences to support the claims that OER can help countries in the Global South to address quality and cost challenges (Daniel & Uvalić-Trumbić, 2012). Hatakka (2009, p.1) comments that: "OER initiatives are very commendable and needed ... open content is not being used by educational organizations in developing countries (or rather the usage of the free resources is low)."

As the actual adoption and use of available OER by institutions in the South appears to be limited, this study seeks to understand the factors that influence the adoption of OER

18 http://itforchange.net/education

in the Indian context. It investigates the influence of collaborative resource creation and sharing processes on the techno-social, techno-pedagogical and sociocultural factors of the Karnataka public school education. The literature review is organised according to these three factors.

Techno-social factors

The literature review of techno-social factors presented here is focused on three central factors. Firstly, that OER are almost always digital in nature, and that teachers therefore need to acquire digital literacy skills in order to adopt OER. Secondly, proprietary technology environments can influence the capacity of teachers to create and share OER. Thirdly, participatory models can elicit greater ownership on the part of the teachers compared to outsourced models of implementing ICT programmes in schools.

Information is increasingly being created, stored and transferred in digital formats. In 2000, 75% of stored information was in analogue format (such as video cassettes); by 2007, 94% of it was digital.[19] Digital tools and resources are easy to share, but proprietisation (or digital rights management) imposes legal and technological barriers to sharing.

A study by Kasinathan (2009b) comparing the outsourcing model implemented in Karnataka with the integrated model of Kerala suggests that the outsourcing approach bypasses regular teachers, creates dependence on technology vendors to provide basic ICT literacy to students, and has led to poor ICT uptake. This outsourcing model is based on the perceived inability or unwillingness of teachers to learn to use ICTs and integrate them into their teaching. With content being developed independently without any reference to the school curriculum, teachers have largely seen ICT as irrelevant and the ICT infrastructure provided by the ICT@Schools programme is often grossly underutilised (Kasinathan, 2009b).

Users do not own proprietary digital tools, even when we "pay" for them, as we only obtain a licence for their use. Barriers to revision and redistribution of these digital artefacts are high in the case of developing countries, as the cost of the required software can be expensive in large-scale adoption in public education systems (Kasinathan, 2009b).

Techno-pedagogical factors

It has been argued that the quality of teaching practices and the quality of learning outcomes can be improved by opening up OER adoption processes for formal peer review or informal interrogation through conversations with colleagues (Petrides, Jimes, Middleton-Detzner & Howell, 2010).

In a South African study, Sapire and Reed (2011) explored whether collaborative design and redesign of materials can enhance quality while containing time and resource costs, and whether such collaboration encourages buy-in to the use of OER as well as further redesign to accommodate the needs of particular teachers and students. They concluded that "collaborative redesigning of existing materials from a range of institutions offers one solution to these challenges" (2011, p.209).

19 http://www.bbc.co.uk/news/technology-12419672

Paul Stacey (2013) suggests that foundation grants typically focus on establishing exemplars and cannot be relied on for sustaining ongoing operations or generating widespread adoption. Since learning materials tend to be largely financed by public expenditure (Hylén, Van Damme, Mulder & D'Antoni, 2012), it is worthwhile investigating whether collaborative resource creation can be supported by public funding to support OER development as an ongoing model of TPD within the public teacher-education system.

In a survey of 196 elementary and secondary education teachers, Rothberg (1985) found that "over 80% of teachers felt their classrooms were private worlds entered only by themselves and their students", a finding which supports previous research on teacher isolation. Teachers in this study reported that formal and informal visits to their classrooms by observers or evaluators were rare, as were their own visits to the classrooms of other teachers. There is thus a need to investigate whether virtual networks can reduce teacher isolation in the Indian education context.

Sociocultural factors

"Meaning in context: is there any other kind?" asked Mishler (1979). Ferreira (2008, p.4) states:

> … it is yet unclear what types of learning OER may afford outside their original context. Different aspects of academic practice are inscribed in the resources being made available by OER initiatives ... This is critical for the OER movement because re-use (by teachers and learners alike) requires a double move of de-contextualization and subsequent re-contextualization under circumstances often quite distinct from the original location of the resources.

Hence, it appears naive to assume that OER can seamlessly be adopted across cultures and contexts. Translation of materials created into another language will make these materials accessible to those who speak the languages into which the materials are translated. Mere translation may, however, be inadequate, as there is often a need to recontextualise materials. As previously stated, context-appropriate education is a particular challenge in a large and diverse country such as India.

Methodology

This research adopts a mixed-methods approach (Creswell, 2014), in which lead researcher Gurumurthy Kasinathan and researcher Sriranjani Ranganathan along with other members of the ITfC research team collaborated with 67 teachers and teacher educators on an OER adoption process. The ITfC team worked with the COA teachers between June 2013 and

December 2015, utilising a combination of face-to-face workshops,[20] questionnaires, focus group discussions and online interactions.

An action research approach was considered most suitable for the study as the research team wanted to work with a group of teachers on a capacity-building programme for collaborative OER adoption while simultaneously investigating how this programme would influence specific techno-social, techno-pedagogical and sociocultural factors relating to OER adoption in the Karnataka public education system. As stated by Gilmore, Krantz and Ramirez (1986, p.161):

> Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of Social Science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process.

The project involved both programmatic processes (teacher capacity-building on OER adoption) and research (studying how the collaborative OER adoption processes would influence certain aspects of teachers' practices), reflecting a dual commitment to study the system as well as collaborate with teachers to transform it in terms of OER adoption.

Participant selection

The action research process adopted a criterion sampling approach (Palys, 2008) to select participants from the STF to constitute the COA group. The COA group comprised teachers in government high schools and were selected by the DIETs based on the following criteria stipulated by DSERT:

1. Participation in the PLC.
2. Subject expertise.
3. Basic familiarity with use of digital technologies.

A total of 62 teachers and five teacher-educators were selected from different districts of Karnataka, representing diverse geographic areas of the state. The 67 teachers and teacher-educators represented three subject disciplines: mathematics (26), science (18) and social science (23).

In order to determine the influence of COA processes on teachers' adoption of OER, there should ideally have been baseline data on the COA teachers prior to their participation in the teacher education programme. There was, however, a challenge in this regard: while the research process started in January 2014, the COA processes in the KOER project had

20 These workshops took place in the period between July 2013 and August 2015. A total of 19 workshops were held separately for mathematics, science and social science teachers in order to tailor the creation of resources by discipline.

commenced in July 2013. It was therefore not possible to conduct baseline research on the COA cohort of teachers.

In order to be able to understand the effectiveness of the COA processes, a cohort of 124 teachers, similar to the COA group but who had not been part of the STF programme, were identified as a Comparable group. The COA group and the Comparable group were thus mutually exclusive groups at the time of the study. Since the STF teacher training programme of the DSERT was ongoing during the research time frame, it was expected that the Comparable group teachers would eventually receive this training and be introduced to digital tools and methods. Hence, they have not been conceived of as a "control" group.

The selection of the teachers for the Comparable group was based on the following factors:

1. The Comparable group (like the COA teachers group) was comprised of government high school teachers from Karnataka state. The recruitment of teachers for government schools is centralised, which means that teachers from both groups have identical prerequisites for recruitment and identical processes in terms of job description, promotion, transfer, retirement, pay revision, etc. Thus, the employment contexts of both groups of teachers are identical.
2. COA teachers are from districts across the state, with rural and urban backgrounds. For the Comparable group of teachers, two districts which represented two extremes in the state (the Bengaluru Urban district and the Yadgir district) were selected. The Bengaluru Urban district is located in southern Karnataka and is predominantly urban (it includes the city of Bengaluru, the capital city of the Karnataka state), while the Yadgir district is in northern Karnataka and predominantly rural.
3. Socioeconomically, the Bengaluru Urban district is advanced, while the Yadgir district faces development challenges. The Human Development Index report of 2011[21] places Bengaluru Urban in first place in terms of development levels, while the Gulbarga district (which the Yadgir district was a part of at that time) is 29th out of 30 districts. The Raichur district, which neighbours Yadgir, is last on the list. Both districts belong to the North-east Karnataka region, which the Human Development Report identifies as the most underdeveloped region in the state. It was anticipated that selecting the Bengaluru and Yadgir districts as the location for the Comparable group of teachers would provide representation in terms of the teacher contexts across the state.

Based on these factors, it is assumed that the Comparable group of teachers could serve as the "quasi-control" group in order to provide an approximate "baseline" against which the influence of the COA processes on the COA group could be assessed. Figure 1 provides a graphical representation of the actors who participated in this study.

21 http://www.thehindu.com/todays-paper/karnataka-ranks-seventh-in-human-development-index/article3034473.ece

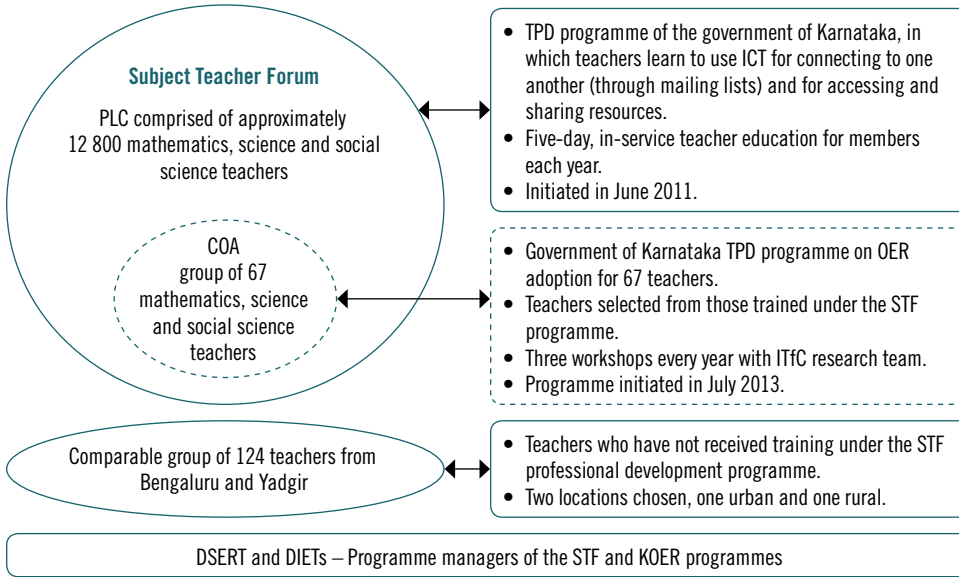

Figure 1: Graphic representation of actors and participant cohorts in the study

Parallel cycles of training and action research

The action research approach was comprised of two parts: the programmatic component of training teachers in the tools and methods required for OER adoption, and the research component studying OER adoption.

The cycles of action (STF workshops and mailing-list interactions) and reflection (individual and collective reflections of the 67 COA teachers and ITfC research team) constituting the action research process continued in an iterative manner over the two-year period of the study (January 2014–December 2015).

Programmatic teacher training component

In the programmatic component, COA teachers were trained by the ITfC team on accessing, creating and sharing OER in 19 separate workshops. Thereafter, they shared these resources via the mailing lists and uploaded resources to the KOER English and Kannada websites[22] under Creative Commons Attribution-NonCommercial-ShareAlike (CC BY-NC-SA) licences. In these workshops, COA teachers created OER in the language of their choice (some in English, some in Kannada and others in both languages) and uploaded them to the KOER websites.

The COA programme workshops were conducted in computer labs with a 1:1 teacher to computer ratio, with reasonably good internet connectivity. Some teachers also brought their personal laptops to the workshops. Subsequent to the workshops, COA teachers remained in touch with one another and the research team via mailing lists in order to

22 See http://karnatakaeducation.org.in/KOER/en/index.php and http://karnatakaeducation.org.in/KOER for the English and Kannada websites, respectively.

continue their OER adoption practice and participate in discussions on different issues of academic interest.

Resource materials were also shared on the KOER websites for participant access; print versions were usually not given to the participants (whereas in typical teacher training workshops, each participant would be handed a print copy of the training module at the start of training). Workshop feedback was also compiled digitally and shared with DSERT. This emphasis on the use of the digital for the design, implementation and reporting of the training programme made the systemic availability of ICT a prerequisite, thus altering the way teacher education was imagined. The programme required the maintenance of digital infrastructure in the ICT labs, which was taken care of by the DIETs, thus institutionalising technology integration at district level.

The COA teachers were trained in a variety of FOSS applications and platforms in the workshops and the agenda had a conscious emphasis on FOSS, both in terms of the theoretical implications (philosophical, pedagogical, technological and economic aspects) and practice (learning to work with FOSS applications). The use of FOSS was embedded within the COA processes based on the idea that if resources are to be adopted freely, the tools for adopting the resources should also be freely accessible.

The research team prepared a custom distribution of the Ubuntu operating system called "*Kalpavriksha*", into which more than 3 000 free and FOSS packages, including the educational software applications taught to COA teachers, were bundled. COA teachers had to pay a nominal amount (less than USD 2) for a copy of this custom installation, the amount collected was used to cover the cost of producing the DVD. The intention was to help COA teachers discriminate between the use of the word "free" as in "freedom" (to copy and reuse) rather than "gratis" (free of cost). COA teachers purchased the DVD willingly and some reported that they had redistributed it to their colleagues outside of the COA group. The custom distribution reduced installation time and effort, since all software applications bundled into the custom distribution were installed automatically along with the Ubuntu operating system. Proprietary operating systems will not allow such "free sharing" or "bundling". Appendix 1[23] provides a brief description of the FOSS tools that teachers were introduced to in the COA workshops.

This emphasis on the use of FOSS tools and processes enabled movement from the commonly used PowerPoint presentations to many other options. In a case study carried out on the STF-KOER as part of a Wawasan Open University project, Sharma (2016, p.65) states:

> The exposure to the free and open source software applications has introduced teachers to a variety of resource formats, enabling their movement from the common "power point presentations" to mind maps (using Freemind), interactive simulations (using Geogebra), text and presentations (using Libre Office), web links and video files (using RecordmyDesktop). They are also seeking and exploring multiple tools that can work on different devices and looking for convergent solutions - mobile upload of a solution to a solved problem (solved by hand), sharing recordings of broadcasts by teachers,

23 http://dx.doi/org/10.5281/zenodo.1036253

looking for mathematical teaching learning software for the smart phone, exploring Unicode font converters for local language typing or upgrading Geogebra from its 2D version to a 3D one.

In the typical, constrained environment of proprietary software (usually packaged with a personal computer with the Microsoft Windows operating system, Microsoft Office suite, internet Explorer/Edge and Adobe Acrobat PDF reader), the user is typically forced to limit his or her imagination to the functionalities of these applications ("What is it that I can do with the tools I have?"). In a FOSS environment, teachers often approach the issue from the perspective of "What do I want to do, and what tool will I need for this task?" They then search for the tool either in the Ubuntu software centre repository on their desktop or on the internet.

Research component: Data collection and analysis

As part of the research process, the COA teachers individually and collectively reflected on the COA processes in the workshops by responding to structured questionnaires, participating in focus group discussions and interacting via emails. While implementation and research processes were being undertaken with the COA group, these teachers were also interacting with the STF PLCs to share OER. Hence, a sample of the mailing interactions on the PLC mailing lists as well as the OER content published on the KOER websites was analysed by the research team. As a part of the research, key informant interviews were conducted with five officials from the Education Department to understand their perspectives on COA. Table 3 provides an overview of research tools used, objects of analysis and the focus of the various data collection activities.

Table 3: Overview of research tools, object of analysis and focus of data collection activity

Tools	Object of analysis	Focus of data collection activity
1. Structured questionnaire	67 COA teachers and 124 Comparable group teachers	Information about ICT use, resource adoption practices and teacher development processes
2. Focus group discussions	67 COA teachers in 10 focus group discussions	Sharing beliefs and perspectives on resources and key concepts (OER, KOER, TPD, PLC, etc.)
3. Mailing-list interactions	Emails sent to COA teachers on the PLC mailing lists	Reuse, creation, revision, remixing and redistribution of resources by teachers in PLC mailing lists
4. KOER content analysis	Select content reuse, creation, revision, remixing and redistribution by COA teachers	Creation, adaptation and sharing of resources by COA teachers on the KOER portal
5. Key informant interviews	COA teachers, teacher educators and senior department officials	Factors enabling and constraining the development of an OER model based on COA

Structured questionnaire

To assess the influence of COA processes on OER adoption and TPD, a structured questionnaire was designed and administered to COA teachers as well as the Comparable group. The questions covered different dimensions, such as demographic and professional profiles, technology habits and teachers' use of digital resources for teaching and their own learning. The demographic and professional profile component included questions on age, sex, educational qualifications and work experience.

The component on use of digital methods included questions on the following:

- Use of computers and the internet.
- Use of ICT for learning and for teaching.
- Creation, sharing, accessing and adapting learning materials in their work.
- Participation in teacher communities and forums for peer learning and sharing.

The questions on demographic profile were designed to establish if the COA and Comparable groups were similar in their basic profile and employment contexts (using statistical tests of significance). If the profiles of the two groups were found to be statistically similar based on responses to the questionnaires by the two groups, it would be possible to make inferences about the impact of COA processes on the digital habits, professional development (including adoption of OER), as well as participation in teacher communities of the COA group of teachers.

Interviewees' oral consent was obtained for the research as the culture of making interviewees sign written consent forms is not prevalent in India and individuals are usually wary of such procedures. The aims and processes of the study were discussed openly with the COA teachers in the workshops so that they were familiar with these principles before they participated in the survey and focus group discussions.

Printed versions of the structured questionnaire were provided to participants. It was administered amongst the 67 COA teachers in July 2014, and amongst the 124 Comparable group teachers in July 2014 (Bangalore Urban) and in September 2014 (Yadgir). Nineteen responses from the Comparable group were not useable; hence the number of responses considered for this group was 105. The Comparable group responses to the questionnaire serve as a proxy baseline for the project.

Responses to closed-ended questions were tabulated in a spreadsheet using the LibreOffice Calc software application. These responses were analysed using the pivot feature, which enables multivariate analysis. The information in the multivariate tables was subjected to chi-square and two-sample z-test statistical tests of significance utilising LibreOffice Calc. Chi-square tests were used when data included a distribution with two dichotomous variables, such as subject taught by teacher who was a member of the COA or Comparable group. In other cases, where the categorical variable was not dichotomous (e.g. work experience of teachers), the two-sample z-test was used. The sample size of the COA and Comparable groups for the structured questionnaire was 67 and 105 teachers, respectively. As the sample size comprised more than 30 respondents, sample variances were used as a substitute for population variances, based on the assumption that in a large sample the variances in sample and population will be similar. The z-test was selected because the sample size was larger than 30 respondents.

Focus group discussions

While the structured questionnaire attempted to identify changes in teachers' ICT habits and COA practices, 10 focus group discussions were conducted to capture teachers' experiences and expectations of the COA initiative as well as their perspectives on TPD. The focus group discussions were also used to explore the connection between the STF and COA processes. The discussions were conducted with COA teachers in periodic workshops[24] during the 2013/14, 2014/15 and 2015/16 academic years.

The first focus group discussion covered ideas for designing the collaborative KOER websites. The subsequent focus group discussions covered the following topics:

- COA teachers' experiences of COA processes and review of the collaboratively created resources.
- COA teachers' expectations of the resource repository and methods of integrating COA with the PLC.
- COA teachers' perspectives on the role of resources and COA processes on TPD.

The key ideas discussed in the focus groups are provided in Appendix 2.[25]

Focus group discussions were documented as a mind map utilising the Freemind[26] free software application. The mind map was projected during the discussions so that participants could see the points being recorded as they were discussed. These mind maps were later shared for review. Discussions were audio-recorded to support the analysis process. The record of the discussions (the mind map and audio recordings) was analysed by the research team and grouped on the basis of pre-identified themes for discussion.

Mailing-list interactions

The PLC was an important forum accessed and referred to by the COA teachers for understanding teachers' resource needs. Many COA teachers also shared their resources and experiences with the PLCs for reuse by and feedback from PLC teachers. A sample of PLC emails from the mathematics and science mailing lists, sent by the COA teachers,[27] was analysed to understand teachers' resource habits and requirements. Both mailing lists were public; members of the lists were aware that their mails could be accessed by anyone and that members of the ITfC research team were members of the lists.

The data analysis of the emails had two components: analysis of email headers (comprising select data elements such as sender, receiver, date–time, subject line, attachment status, word count and thread) for all emails on the mailing lists; a second detailed analysis of the emails was done for the three months of August 2014, February 2015 and August 2015.

In order to conduct the analysis of email headers, all emails in the mathematics–science and social science mailing lists were downloaded from the mailing lists (Google groups) into the Thunderbird free software email client. Using shell scripts and Thunderbird filter features, the emails sent by COA teachers were made available separately in defined folders so as to enable easy access and analysis. Once the data relating to headers were captured

24 The workshops were held separately for mathematics, science and social science teachers in order to focus on subject-specific dynamics of resource creation.
25 http://dx.doi/org/10.5281/zenodo.1036253
26 http://freemind.sourceforge.net/wiki/index.php/Main_Page
27 The mailing list for the mathematics and science teachers was mathssciencestf@googlegroups.com.

in a spreadsheet, these were analysed using LibreOffice Calc in order to obtain summary statistics on total emails sent in a month (across all months), number of mails sent by each teacher and number of mail threads.

In order to conduct the detailed mail analysis, mails of the mathematics–science sub-cohort of COA teachers sent in three selected months (August 2014, February 2015 and August 2015) were analysed. The selection of these months was based on the academic cycle – August being a "high transaction" month (after schools have opened for the academic year in June), and February being a "low transaction" month (as teachers are preoccupied with preparation for the examinations, which are usually held in March). Since the volume of the emails was very high, this analysis was not done for the social science mailing list. The following parameters were chosen for the analysis of emails:

1. Kinds of emails: This parameter indicated the nature of the email – requesting a resource, sharing a resource, providing feedback on a resource, or simply acknowledging the receipt of a resource.
2. Subject matter of emails: This parameter captured the subject of the email conversation – disciplinary subject, educational administration, larger educational issues and larger social issues.
3. Methods of sharing: This parameter captured how teachers were sharing the resources – either as an attachment, through web links or as HTML in the body of the mail.
4. Level of awareness of a resource as an OER: This parameter captured how many mails with resources were explicitly shared as OER with mention of an open licence, or shared without any explicit mention of open licensing.
5. File type of resources/files shared: This parameter ascertained the different types and formats of resources being shared (text, image, video, animations, etc.).

Actual analysis was done in a spreadsheet by recording the analytical values for the different analysis parameters for each email obtained from the email headers file. This analysis was done manually by examining each mail in the Thunderbird client.

KOER website content analysis

During the workshops, the teachers uploaded the OER that they created or accessed to the KOER website. After the workshops, some of them continued to upload content to the KOER website, while others shared the resources in emails via the PLC mailing groups. The ITfC research team uploaded the materials from the mailing lists to the KOER website.

Content analysis of the KOER website of the OER accessed and utilised by the COA group constituted an important research component. Content analysis of KOER resources had two components: first, the summary statistical data automatically provided by the MediaWiki software for KOER websites (providing data on number of pages, number of files uploaded, page views, etc.); and, secondly, the actual curricular content uploaded for mathematics, science and social science. For the first macro-statistical analysis component, both English and Kannada KOER websites were considered and listed in a tabular format and sorted using LibreOffice Calc.

The second component of data analysis, related to content analysis of the resource pages, entailed studying the mathematics and science resource pages in the English and

Kannada websites for grades 8–10. The content analysis consisted of identifying the different types of "resource units", such as concept maps, additional web links from the internet, audio segments, videos, images, text materials, simulations and animations that constitute the resource page. The social science resource pages were not included in this analysis.

Key informant interviews

In order to obtain qualitative information and perspectives relating to the aims, processes and challenges of the Education Department, interviews were conducted with five officials from the department – three senior officials from DSERT, one from the Bengaluru Urban DIET and the fifth a teacher. The discussions were intentionally kept open-ended in order to elicit the unfettered perspectives of the interviewees. The interviews addressed the following topics:

- Policies and practices relating to curriculum design and material development.
- Policies, structures and practices relating to TPD.
- Use of digital learning resources and OER.

Interviews were documented through notes taken during the process. The responses were analysed manually by clustering them according to the three themes listed above.

Findings

The impact of the COA action research process was analysed in terms of the techno-social, techno-pedagogical and sociocultural factors in the Karnataka state education system. Specific elements were chosen for analysis within each of these factors (Table 4). It is not suggested that these elements comprehensively cover all aspects of these three factors; they are, however, the elements which are considered to be most important in the context of this study.

Table 4: Elements analysed within the techno-social, techno-pedagogical and socio-cultural factors of the Karnataka state education system

Factor	Elements analysed
Techno-social	Capacity-building of COA teachers in using digital technologies Creation of a FOSS environment Systemic integration of ICT into TPD and OER adoption
Techno-pedagogical	Influence of COA processes on OER adoption Influence of KOER platform design on OER creation PLC as a site for OER adoption Impact of ICT on TPD Impact of COA processes on teacher practice Impact of COA processes on teacher networking
Sociocultural	Understanding copyright and open licensing OER to respond to teachers' and learners' contexts OER creation in the local language

Influence of COA processes on techno-social factors

Capacity-building of COA teachers in using digital technologies

The COA processes undertaken with teachers included basic digital literacy training, introduction to access and reuse of resources on the internet, creation and remixing of resources in multiple formats, and publishing on the KOER website. Training on a MediaWiki platform, which allows embedding of multiple resources, was an important component of the COA process. To understand the influence of the COA processes on use of digital technologies, data were collected from the COA group and the Comparable group of teachers through structured questionnaires.

It is necessary to assess the similarity between the COA and Comparable groups in terms of their demographic and professional profiles before using the Comparable group as a proxy baseline. The next section reports on the demographic profile and professional profile information captured through the survey process.

Demographic profile of teachers in the COA and Comparable groups

It was hypothesised that the following demographic characteristics had the potential to influence ICT and OER adoption: age, sex, educational qualifications, work experience and subject taught. If the COA and Comparable groups were found to be statistically similar in these characteristics, we could infer that they are comparable. This means that any differences between the two groups with respect to use of digital technologies could be associated with the COA processes. Other demographic variables such as religion and caste were not seen as relevant to this comparison, and were therefore not addressed in the questionnaire.

The **age variable** was sufficiently similar between the COA and Comparable groups to serve as a proxy baseline (Table 5). The use of a two-sample z-test established that the mean age was statistically similar for the two groups at a 5% significance level (p-value = 0.28).

Table 5: Age distribution of participating teacher cohort

Age (years)	Comparable	Percentage	COA	Percentage
Under 30	4	3.81	3	4.48
31–40	38	36.19	33	49.25
41–50	40	38.09	27	40.29
51 and over	19	18.09	3	4.48
Missing data	4	3.81	1	1.49
Total	105	100.00	67	100.00

Notes:
1. In order to enable easier reading of the data, the values for the Comparable group are provided first and followed by the corresponding values for the COA teachers in all tables.
2. The totals in a number of the tables are not exactly 100%. The difference of usually 0.01% is due to rounding off during the addition of the percentages, and is not an error.
3. The "Missing data" row refers to instances where respondents did not complete the associated field in the questionnaire.

Simple percentages show that the **sex composition** of the two groups differed: the Comparable group was 75% female and the COA group was 76% male (Table 6).

Table 6: Sex distribution

Sex	Comparable	Percentage	COA	Percentage
Male	26	24.76	51	76.12
Female	79	75.24	16	23.88
Total	105	100.00	67	100.00

In terms of **professional profile**, all teachers in the government schooling system were well qualified with a double qualification – one degree in a core subject area and a second degree in teacher education. The qualification parameter (highest qualification) was studied to analyse whether the Comparable group and COA group had similar levels of qualification, with educational qualifications being taken as a proxy for their investment in their professional advancement and inclination towards acquiring additional skills (Table 7). As per the chi-square test, the distribution of teachers based on their highest qualifications in the COA and Comparable groups is statistically similar, at a 5% significance level (p-value = 0.36).

Table 7: Comparison of professional qualifications

Highest degree obtained	Comparable	Percentage	COA	Percentage
Bachelor's	38	36.2	19	28.36
Master's	48	45.72	33	49.25
Masters in Education	16	15.23	15	22.39
No response	3	2.86	0	0
Total	105	100.00	67	100.00

With regard to **work experience**, both groups appeared to have similar profiles (Table 8). As per the two-sample z-test, the distribution of teachers based on mean work experience is statistically similar for the two groups at a 5% significance level (p-value = 0.51). This suggests that both groups were similar in terms of years of experience.

Table 8: Work experience comparison

Number of years work experience	Comparable	Percentage	COA	Percentage
0–5	6	5.71	3	4.48
6–10	27	25.71	22	32.84
11–15	19	18.09	6	8.96
16 and over	46	43.80	31	46.27
No response	7	6.66	5	7.46
Total	105	100.00	67	100.00

In terms of the **comparison of subjects taught**, data revealed that Comparable and COA groups taught similar subjects (Table 9). As per the chi-square test, the distribution of teachers across mathematics, science and social science subjects in the COA and Comparable groups is statistically similar at a 5% significance level (p-value = 0.85).

Table 9: Comparison of subjects taught

Subject taught	Comparable	Percentage	COA	Percentage
Mathematics	37	35.24	26	38.81
Science	32	30.48	18	26.86
Social science	36	34.29	23	34.33
Total	105	100.00	67	100.00

The data on demographic profile presented here indicate that in terms of their age, work experience, subject taught and professional qualifications, both COA and Comparable groups are statistically similar. Any difference in ICT usage habits due to these parameters can thus be ruled out.

The COA and Comparable groups are, however, different in terms of sex composition. In the overall population of government school teachers in the state, there is an equal distribution of sex. The *Secondary education in India: Progress towards universalisation* report (NUEPA, 2015b) indicates that the percentage of female teachers in Karnataka is 41.42%. The COA group had 76% male teachers, while the Comparable group had 75% female teachers. One factor that could have caused this difference is that the COA group was predominantly comprised of district-level resource personnel. Selection of district resource personnel tends to favour inclusion of male teachers due to the difficulties female teachers experience in terms of travel, accommodation, alternative child care, etc. Many female teachers tend to opt out of this role as it often involves additional responsibilities beyond regular teaching. Another factor could be that the Comparable group of teachers were from the district headquarters (Bengaluru and Yadgir town), where more female teachers tend to be appointed.

Given the fact that the two groups were similar in four out of five parameters, it was decided to use the Comparable group as a reference to analyse key parameters relating to use of ICT. The difference between the two groups with respect to sex composition is important, and the analyses and conclusions presented here should be read with this factor in mind.

ICT usage habits

The data captured on ICT usage habits include duration of computer use, internet use and ownership of a computer. Since the two groups were similar in their demographic and professional profiles, differences in ICT usage between the two groups could be associated with the participation of the COA teachers in the COA programme.

The data on ICT usage were captured in three categories to map to the programmes involved in the study, namely: less than one year (2013–2014); between one and three years (2011–2013); and more than three years (commencing prior to 2011).

The reason for this is that the STF programme had been operational since 2011 (three years prior to the start of this research study in July 2014) and COA teachers were part of the programme from 2011 to 2013. Participation in the STF PLC was one of the criteria for selection of the COA teachers. COA teachers' ICT use could therefore be related to the COA processes (less than one year), the STF programme processes (between one and three years), or before either of these two ICT training programmes was initiated. At the time of responding to the questionnaire, the Comparable group of teachers had, however, not been a part of the STF or COA programmes; their digital skills are therefore not associated with the STF and COA programmes. Differences in ICT usage could be associated with the participation of the COA teachers in the STF (one to three years) and the COA (less than one year) programmes.

Data relating to the **duration of computer and internet use** in the two groups were collected via the structured questionnaire. Findings show that 62 (92.54%) COA teachers were using computers, whereas only 12 (11.43%) Comparable teachers reported using computers. Nearly 66% of COA teachers were using computers before they joined the STF programme, compared to 3.81% of Comparable group teachers (Table 10). Approximately 18% of the COA teachers began using computers between one and three years before the commencement of the COA programme, whereas none of the Comparable group of teachers had, suggesting that participation in the STF programme has a positive co-relation with the use of computers.

Table 10: Duration of computer use

Duration of computer use	Comparable	Percentage	COA	Percentage
Less than one year	8	7.62	6	8.96
1–3 years	0	0.00	12	17.91
More than 3 years	4	3.81	44	65.67
No	93	88.57	5	7.46
Total	105	100.00	67	100.00
% of remaining teachers	**7.92** (8*100)/ (105-4-0)		**54.55** (6*100)/ (67-44-12)	

During the COA programme (less than one year), 8.96% of COA teachers began using computers, as compared to 7.62% for the Comparable group. In the one year of the COA programme, more than half the COA teachers who were not using computers began using computers (54.55%), compared to 7.92% of the Comparable group. This suggests that use of ICT is correlated with participation in the COA processes.

Sixty-one (91%) COA teachers were using the internet compared to 12 (11.43%) in the Comparable group of teachers. The COA group began with a higher internet use than the Comparable group (67.16% and 2.86%, respectively), and the increase in the number of COA teachers using the internet during the three years (which covers the period of the STF programme) is higher than that of the Comparable group (13.43% and 0.95%, respectively) (Table 11). As in the case of computer usage, about 24% of the COA teachers began using the internet either through the impact of the STF (13.43%) or the COA processes (10.45%).

Table 11: Duration of internet use

Duration of internet use	Comparable	Percentage	COA	Percentage
Less than one year	8	7.62	7	10.45
1–3 years	1	0.95	9	13.43
More than 3 years	3	2.86	45	67.16
No	93	88.57	6	8.96
Total	105	100.00	67	100.00
Percentage of remaining teachers	7.92		53.85	

In the one year of the COA programme, more than half the teachers who were not using the internet began using it (53.85%), compared to 7.92% of the Comparable group. The data presented here suggest that participation in the COA processes had a positive correlation with the use of computers and the internet.

Ownership of a personal digital device can be an indication that digital technologies are seen to be of value. In this sense, ownership of a computer or laptop by a teacher suggests that the teacher sees value in using computers. Almost 84% of COA teachers owned their own laptops or desktop computers, while only 20.9% of the Comparable group did (Figure 2).

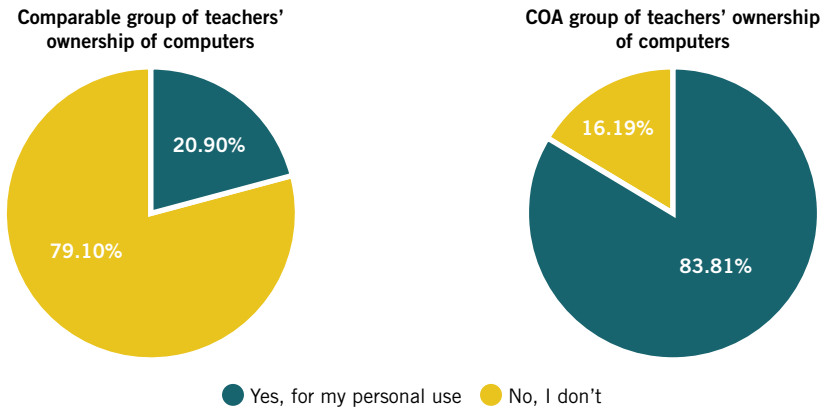

Figure 2: Computer ownership amongst COA and Comparable group teachers

The COA programme team encouraged teachers to purchase personal laptops and internet connectivity, providing input on various options available and cost-feature comparisons. While the mobile phone was seen as a personal necessity by all teachers (due to compelling benefits of being able to support voice and SMS communication), this was initially not the case with computers or the internet. During the course of the COA programme, COA teachers saw the value of regularly using computers and the internet. This persuaded them to purchase devices and connectivity for their personal use. This purchasing of their own devices can be seen as a powerful proxy for self-belief in their capability to use ICT, as well as in their perception of the value of ICT to their personal and professional lives.

Overall, the data in this section indicate that the COA teachers used computers and the internet to a much greater extent than the Comparable group of teachers.

Creation of a FOSS environment

The analysis of PLC interactions on the mailing lists revealed that teachers shared useful tools that they discovered with their peers on the virtual forums. For the FOSS desktop-based tools (such as free dictionaries, Geogebra and text editors) that they were already using, COA teachers identified equivalent free tools in the mobile environment and shared these on mailing lists. Overall, COA teachers used open format documents more often (86.5%) than proprietary or closed document formats (13.5%). The frequency of the use of multiple tools to create resources in multiple formats is shown in Table 12, which lists the number of resources shared on the mailing lists by COA teachers by the format of the files. Of the 173 resources shared, 151 (87.3%) were in open formats and 22 (12.7%) in proprietary formats.

Table 12: Frequency of open and proprietary formats utilised in resources shared on mailing lists

File type	Format	File description	FOSS	Proprietary	Total
Image	JPEG		23		23
Image	PNG		1		1
Video	FLV			2	2
Geogebra	GGB		30		30
Text	EML	Mail	24		24
Text	ODT	Editable text	18		18
Text	PDF	Non-editable text	42		42
Text	HTML	Web page	13		13
Text	DOC, DOCX	Editable text (proprietary)		8	8
Text	XLS, XLSX	Spreadsheet		7	7
Text	PMD			1	1
Text	PPT, PPTX	Slide presentation		4	4
Total			151	22	173

In focus group discussions, COA teachers articulated an expectation that educational resources must be freely available (i.e. at no or low cost) and open to revision for use in the classroom. Teachers recognised that digital formats had several advantages, including accessibility, adaptability and versatility to meet multiple purposes.

Systemic integration of ICT into TPD and OER adoption

The COA programme made design choices that emphasised digital processes. COA workshops were conducted in computer labs where the programme required teachers to have a 1:1 access to computers with reasonably good internet connectivity. Teachers were required to become familiar with multiple resource creation methods, use of different software applications, and learning to publish OER on a MediaWiki platform. Workshop

feedback was also compiled digitally and shared with the DSERT. This emphasis on the use of the digital for the design, implementation and reporting of the training programme made the systemic availability of ICTs a prerequisite.

The key informant interviews probed the experiences and insights of officials in the Education Department with regard to the core principles of the COA programme, including integration of digital technologies in an in-service TPD programme, use of digital technologies for OER adoption, and use of FOSS instead of proprietary software applications. The officials interviewed appreciated the benefits of using FOSS tools and the value of teachers receiving a single DVD containing the custom *Kalpavriksha* installation of the FOSS operating system containing all the software applications required. This "bundling" made software installation a simple process.

DIET personnel largely saw the integration of digital technologies in the programme as an important requirement for school education and were supportive of this. Many DIETs made special efforts to improve the ICT labs in their institutions, replacing dysfunctional hardware and boosting network connectivity. Some DIETs also identified ICT labs in other institutions (higher education institutions like engineering colleges, teacher training colleges, etc.) in order to increase their access to ICT infrastructure and allow more teachers in the districts to be trained in the STF programme, thereby growing the PLC.

In one of the key informant interviews, a DSERT officer in charge of the COA programme used an analogy to explain the importance of teacher preparation in the systemic integration of technology. He explained that in earlier ICT programmes, the department focused on providing ICT infrastructure to schools without adequately building teacher capacity to use the infrastructure for teaching activities. That approach did not work and only a small number of teachers used the infrastructure. When the STF and COA programmes focused on training teachers to use ICT, many teachers purchased personal computers, seeing the relevance and benefit of ICT for their professional development. The officer made the analogy that the department had earlier provided bicycles (i.e. computers) to schools, but did not teach people how to ride a bicycle – therefore nobody learned how to cycle. Teachers were now being taught how to cycle (i.e. how to use computers and the internet) and many were purchasing their own bicycles (i.e. devices). He suggested that while infrastructure provision and capacity-building were both required to enable the use of a technology, capacity-building was critical in terms of boosting the use of ICT by teachers, suggesting a change in the way teacher training and ICT implementation in schools could be imagined.

Techno-social challenges

Though the COA programme did influence the techno-social factors discussed above, teachers articulated several challenges and constraints in their interactions with the research team and on the mailing lists, including limited access to ICT infrastructure, nascent digital literary skills and limited time to gain technical proficiency.

Limited ICT infrastructure

The COA programme required that teachers be trained in the use of tools for accessing, creating and publishing OER on the KOER platform. Though the Education Department had provided labs, the actual number of computers was sometimes insufficient, internet connectivity was patchy and some computers were dysfunctional. Internet connectivity

was particularly challenging in rural areas where connectivity was poor and bandwidth was inadequate at schools and in homes. Online resource creation processes were therefore difficult to undertake. Power outages were also quite common in many areas, which made using desktop computers a challenge. COA teachers spoke of their difficulties in using computers and finding materials online. Internet connectivity was not available in schools and most parts of the state still only had 2G[28] internet access. While the Education Department provided ICT infrastructure for the COA workshops, ongoing resource creation and adoption was impacted by these constraints.

Nascent digital literacy skills

The OER adoption process required use of the KOER online platform to host newly created or revised OER, which meant that teachers had to become proficient in the use of multiple applications (including MediaWiki) while developing the pedagogic competencies required for the revision of resources. This was seen as too complex a requirement by the teachers. They reported that imagining resources in an online format required pedagogic competencies as well as technological familiarity, which was a challenge. Though some COA teachers had a basic familiarity with ICT, some of the digital methods adopted in the programme were found to be challenging, such as editing content on the Wiki page or embedding resources in different formats (e.g. concept map, videos, images) directly on the Wiki page. Some COA teachers wanted simpler technological alternatives, such as sharing OER on the PLC mailing lists. The challenge in this context was the need to be able to imagine a hyper-linked flow of content, which was quite different from the hierarchical flow of content teachers were used to accessing in textbooks.

Limited time to gain technical proficiency

In the focus group discussions, COA teachers mentioned that the process of learning how to use ICT was complex and layered. Even if basic digital literacy was acquired, becoming proficient required devoting significant time to practice, which was seldom available. Some teachers brought with them a legacy understanding of ICT as a set of proprietary tools to be used for very specific purposes, and it took time to move to a perspective of ICT as a set of processes that could alter content and pedagogical approaches. While discussions on the mailing lists about using public applications suggested that FOSS was accepted by teachers, proprietary applications and proprietary document formats were still being used, though this was no longer the default situation.

Influence of COA processes on techno-pedagogical factors

Influence of COA processes on OER adoption

COA and Comparable group teachers were asked about their resource creation, sharing and adaptation practices in the structured questionnaire. COA teachers reported a higher percentage of material creation (88%, as opposed to 59% for the Comparable group) and material sharing (97%, as opposed to 65% for the Comparable group) (Table 13). While the

28 The term "2G" refers to second-generation internet. See https://en.wikipedia.org/wiki/2G.

COA teachers were chosen based on their participation in the STF programme and were already resource persons for the Education Department, this high percentage of resource creation and sharing is positively related with their participation in the COA programme.

Table 13: OER creation and sharing practices

Group	Creating learning materials	Percentage	Sharing learning materials	Percentage
Comparable	62	59.05	68	64.76
COA	59	88.06	65	97.01

Responses to the structured questionnaire indicate that COA teachers also had far greater engagement with resource adaptation than the Comparable group of teachers. Table 14 illustrates the types and frequency of OER adaptation practices of COA teachers in relation to the Comparable group of teachers.

Table 14: Types of adaptation undertaken with learning materials

Type of learning material adaptation	Comparable	Percentage	COA	Percentage
Use with own examples	70	66.67	66	98.50
Reduce or add content	65	61.90	61	91.04
Mix two or more materials	52	49.52	58	86.57
Change format (document layout)	55	52.38	52	77.61
Change sequence	58	55.24	52	77.61
Translate into another language	45	42.86	50	74.63
Use for a purpose different from original purpose	43	40.95	39	58.21

Note: The percentages in this table are all individually computed on a base of the total number of teachers in the respective groups. They do not therefore add up to 100% across the rows.

The COA teachers reported higher percentages of resource adaptation habits across different levels of OER reuse. This suggests that the COA processes had an impact on the teachers' OER adoption habits.

The level of learning-materials adaptation activity indicates an ability to engage in resource adaptation processes. COA teachers not only showed higher rates of content adaptation (e.g. including their own examples, reducing or adding content and changing the sequence of material), but also higher levels of use of sophisticated adaptation methods, such as use of materials for a different purpose from what was originally intended, and remixing two or more materials. The Comparable group teachers also adapted learning materials to meet their needs using similar practices, but undertook these less frequently than the COA group.

As indicated in Tables 13 and 14, the percentage of teachers adapting resources is greater than the percentage creating content. Teachers seemed to find it harder to create their own resource than to adapt an existing one. In the focus group discussions, some COA teachers shared their experiences in accessing and creating OER and how this helped

in improving their own conceptual understanding. Such sharing encouraged other COA teachers in their OER adaptation activity.

Influence of KOER platform design on OER creation

The KOER platform was established as part of the COA programme and designed in consultation with the COA teachers in terms of form, structure and content in order to facilitate the OER creation process. The choice of the MediaWiki platform was an important pedagogic decision as it offered affordances for bottom-up OER creation. MediaWiki allows the editor to easily add text, image, audio and video content. Content can be uploaded within the MediaWiki platform or linked to other websites. Images, audio segments and videos already hosted on other platforms can also be embedded in the MediaWiki platform, meaning that they appear as if they are hosted within the MediaWiki itself. These advantages of the platform in terms of allowing remixing of different kinds of OER were raised and discussed by the COA teachers.

The COA OER development process was conceptualised in a modular way with topics (e.g. "light" or "circles") for resource creation being allocated to teams of teachers. Each topic was developed as a resource page, the template for which was developed in consultation with the teachers and refined over the course of the programme to allow for individual resource units to be shared by different teachers. The resource template had sections for content, as well as for activities and assessment, thus allowing for an integrated approach to technology, content and pedagogy. The COA teachers suggested that an online form be developed to ease the content submission process to the KOER platform.

The MediaWiki platform enabled teachers to contribute (create), edit (revise) and combine (remix) resource units[29] on any page. A web page created by a COA teacher on the KOER platform is in itself a resource to which other OER can be linked or embedded. COA teachers created the web pages required for their topics and created resource units in the form of text materials, images, audio clips, videos resources, concept maps and Geogebra simulations.[30] These resources were often created by the COA teachers using FOSS tools.

An analysis of the KOER pages pertaining to the resource topics (forming chapters in the grades 8–10 mathematics and science textbooks[31]) on the KOER platform is summarised in Table 15, which lists the resource units and states which resources have web pages, concept maps, links from the internet, audio-visual resources, lesson plans and animations. The data indicate that teachers remixed a variety of text, image and audio-visual resources for each topic on the KOER resource topic pages.

29 Resource units consist of text, images, audio and video resources, or any combinations of these.
30 See, for example, the pages on circles: http://karnatakaeducation.org.in/KOER/en/index.php/Circles.
31 Social science content was not included in this analysis.

Table 15: Overview of KOER content created by type of resource

Subject (language)	Web pages created	Concept maps	Links from the internet	Audio/ video/ image files	Text materials (lesson plans)	Animations	TOTAL
Mathematics (English)	39	24	22	18	23	8	134
Science (English)	56	21	25	23	16	4	145
Mathematics (Kannada)	42	9	7	6	5	2	71
Science (Kannada)	51	21	14	44	15	1	146
TOTAL	188	75	68	91	59	15	496

Of the 496 resources created, 146 (29.4%) were science materials in Kannada and 145 (29.2%) in English; 134 (27%) were mathematics materials in English and 71 (14.3%) in Kannada. The type of materials varied, with the most predominant being web pages (188); audio, videos and images (91); concept maps (75); links from the internet (68); lesson plans (59) and animations (15).

During the focus group discussions, teachers reviewed the KOER resource repository, both in terms of content created and adoption processes. The suggestions that emerged from these discussions include changes to the form and content of KOER, the need to build awareness of the platform and the need for coordinated district-level contributions.

The teachers suggested specific changes in terms of the form and content of the repository to make it more accessible to teachers. They felt that it would be useful to categorise resources in terms of intended use (e.g. videos of experiment demonstrations) to allow for easier user navigation. Teachers also felt that the KOER platform should make existing curricular resources created by the Education Department (textbook supplements, teacher handbooks for assessments, etc.) more accessible.

The teachers indicated that there was a need to build awareness amongst teachers and members of the state Education Department about the KOER platform. Using the STF PLC mailing list, sharing with communities through mobile services (e.g. WhatsApp), and sharing through articles and newsletters from the Education Department were suggested as possible methods of popularising the KOER platform.

For sustained OER creation, COA teachers suggested a decentralised model, comprising district-level resource groups which could regularly contribute to KOER, facilitated by DIETs in each district. They also suggested increasing the core group of resource creators through the decentralised district-level groups. The teachers further emphasised that in order to allow teachers to continue this OER process in a sustainable way, it was important for the Education Department to make resource creation a formal responsibility of teachers and to incorporate a mechanism for reviewing the quality of resources.

PLC as a site for OER adoption

COA teachers envisaged the mailing list as a way to pool resources which could be organised and uploaded to the KOER platform. The teachers felt that the PLC provided the context for resource creation by articulating resource needs and providing a forum for sharing the resources created. COA teachers saw the PLC as a significant contributing factor in their thinking on resource creation. In addition to sustaining OER creation, the teachers felt that adopting the resources shared on the mailing lists would encourage critical thinking in teachers and enhance TPD.

An analysis of the mails on the PLC provided information on the kinds of mails, subject matter of discussion and different file formats of resources shared. Table 16 provides an analysis of the mails sent on the mathematics and science PLC list in August 2014, February 2015 and August 2015.

Table 16: Number of emails addressing COA processes

COA processes	Number of emails	Percentage
Sharing resources – accessed	56	34.43
Sharing resources – created	102	62.58
Sharing resources – revised	3	1.84
Sharing resources – remixed	2	1.23
Total – resources shared	163	100.00

The number of emails containing resources created by teachers (102) is higher than the number of resources accessed elsewhere (56). This suggests that teachers are open to sharing the resources they have created. The lower number of resources accessed elsewhere could, however, also be due to limitations in internet search habits amongst teachers and a paucity of resources in the Kannada language. Since the PLC mailing list was an open forum for teachers, it was used for sharing resources as well as for discussion on various topics of interest. Most of the "other" 296 emails focused on discussions about different topics.

Impact of COA processes on TPD

Development of curricular resources is seen as an important aspect of TPD (NCTFE, 2010). This study attempted to examine whether OER adoption could provide teachers in India with additional learning materials to counter the prevailing textbook culture. Data collected from the structured questionnaire show that 63 of the 67 (94.03%) COA teachers reported using additional learning materials (other than the government-issued textbook and teacher guides), compared to 79 of the 105 (75.24%) teachers in the Comparable group.

The questionnaire also collected data on the frequency of use of additional learning materials to ascertain if the COA teachers used learning materials other than the textbook more frequently than the Comparable group (Table 17).

Table 17: Frequency of use of additional materials

Frequency of teachers' use of additional materials	Comparable	Percentage	COA	Percentage
1. Often	21	20.00	22	32.84
2. Occasionally	58	55.24	41	61.19
3. Hardly	1	0.95	1	1.49
4. Not at all	2	1.90	0	0.00
5. No response	23	21.90	3	4.48
Total	105	100.00	67	100.00

The COA teachers reported more frequent use of learning materials (32.84%) than the teachers in the Comparable group (20%).

The use of ancillary materials in addition to those traditionally prescribed by schools is an indicator of teachers' engagement with their profession and self-development. A higher percentage of additional resource use among COA teachers, many of whom are district- and state-level resource persons, suggests that engagement with curricular resources is related to TPD, considering their trajectory of development from a teacher to a resource person and trainer. Furthermore, during the focus group discussions, COA teachers questioned the dominant role that textbooks historically played in their teaching and felt that engaging with a variety of resources helped them in their own learning. Teachers could make the connection between COA processes and TPD aspects and were able to articulate their own trajectories of development as well as their aspirations.

In the focus group discussions, COA teachers expressed that resources supplementing the textbook can help to increase teachers' subject knowledge as well as student interest in a subject. They spoke of the development of new skills in terms of reading, writing, reviewing, providing feedback, considering multiple perspectives, building research capabilities, interacting with other teachers, and supporting and training fellow teachers. They articulated advantages for using resources to make teaching and learning more effective in terms of time, quality of transaction, general conceptual clarity and more engaging learning experiences. Resources in general also played a role in increasing the creativity of teachers by stimulating thinking about various options and possibilities in teaching.

The COA teachers spoke about their identity as teachers and resource creators, their capabilities as resource persons for training other teachers, self-awareness of professional development needs, possibilities for creativity and self-expression, and an increased sense of agency as they interacted with school administration and gained greater confidence.

Impact of ICT on TPD

With digital methods being centrally involved in OER adoption, it was important to investigate how enhancing ICT abilities could impact TPD. The questionnaires administered to the COA and Comparable groups captured information on the number of teachers who used ICT for their learning and teaching (Figure 3).

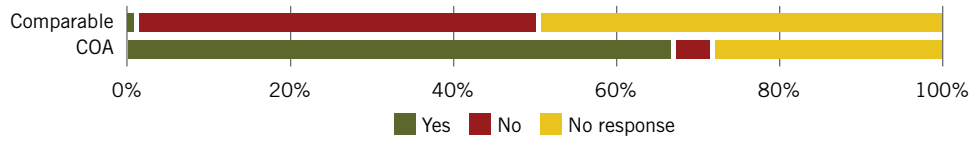

Figure 3: Use of computers and the internet to fulfil teacher professional development needs

COA teachers reported more frequent use of computers to support their development (67.16%) than teachers in the Comparable group (0.95%). Only 4.48% of COA teachers said that they did not use computers for their own development, compared to almost half of the teachers in the Comparable group (49.52%), indicating a strong relationship between the use of computers and teachers' perceptions of their need for professional development.

A starker distinction is apparent between the COA teachers use of ICT for teaching compared to teachers in the Comparable group (Figure 4).

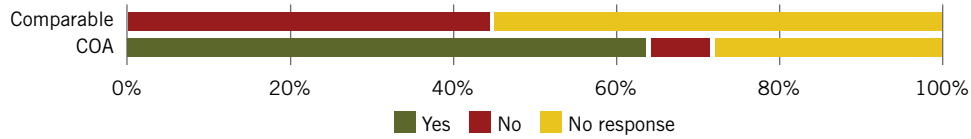

Figure 4: Use of computers by teachers for preparation and teaching

No teachers in the Comparable group used ICT for teaching, compared to 64.18% of COA teachers. The teachers in the Comparable group either explicitly indicated that they did not use computers for teaching (44.76%) or did not respond to the question (55.24%). By contrast, only 7.46% of COA teachers indicated that they did not use computers for teaching and 28.36% did not respond to the question. This suggests that there is a high level of computer use among the COA teachers in preparing for their classes and in teaching. The increased use of ICT in teaching has the potential to impact TPD by enriching teaching practices.

Impact of COA processes on teacher practice

The study did not focus on changes in teacher practice due to the COA processes, since an overall two-year period was felt to be too short to expect changes in practice. However, anecdotal evidence recounted in the focus group discussions suggests that some teachers are modifying their teaching practices, using the resources accessed and created by them or created and shared by their peers.

A few history teachers uploaded videos of students enacting different scenes from historical events, which were picked up by others on the mailing list. Many mathematics teachers shared Geogebra files which they had created and used in their classrooms for teaching different topics. One teacher reported that she had developed formative assessments based on the students using Geogebra to construct materials. Another teacher recorded a lesson using a screen-cast application of a resource on the internet for use in her classroom, where there was no internet connectivity.

Impact of COA processes on teacher networking

The research process examined how conversations around OER adoption can become an effective method of teacher development by increasing networking to counter teacher isolation. Data from the structured questionnaire provided insight into the extent of professional interaction among teachers across different contexts and helped to establish a sense of the extent to which ICT-enabled COA processes could encourage networking and peer learning.

Findings show that the number of interactions between COA and other teachers at all levels (school, taluka, district and state) was much higher than those for the Comparable group teachers (Figure 5).

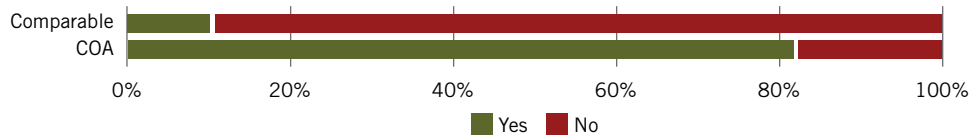

Figure 5: Extent of interaction between COA and Comparable group teachers with teachers from different districts

Just over 89% of COA teachers were in active contact with peers at block and district levels, as well as beyond their districts. In the Comparable group, just over 17% had contact of this kind with fellow teachers; the majority (82.09%) did not.

Along with exploring networking with other teachers, the study sought to ascertain if the COA teachers collaborated with other teachers to create resources. Two questions were asked: one on collaborating to create resources, and one on willingness to accept revision and modification of their resources by other teachers. In response to collaboration, 50 of the 67 (74.63%) COA teachers confirmed that they worked with others to create resources, whereas only 6 of the 105 (5.71%) Comparable group of teachers did so. These findings suggest that the COA processes supported teacher collaboration for OER creation.

A more telling finding is apparent in the teachers' responses to their willingness to accept revision and modification of the resources they created (Table 18).

Table 18: Teachers' willingness to accept revision of created materials

Response	Comparable	Percentage	COA	Percentage
Yes	8	7.62	54	80.59
No	15	14.28	6	8.96
No response	82	78.09	7	10.45
Total	105	100.00	67	100.00

Nearly 81% of COA teachers reported that they welcomed the idea of other teachers making changes to their resources; a marked difference from the only 7.62% of teachers in the Comparable group. Most telling is in fact the lack of response (78.09%) to the question of revision or a negative response (14.28%) by the Comparable group. By contrast, only seven (10.45%) of the COA teachers did not respond and only six (8.96%) said they would not

be willing to have their materials modified. There seems, therefore, to be an association between the COA programme and the teachers' willingness to collaborate on OER adoption.

Techno-pedagogical challenges

Sustainability of KOER platform publishing

The publishing of resources on the KOER English and Kannada websites by teachers largely took place under the auspices of the COA workshops and was not being done on an ongoing basis by COA teachers working in their school settings or homes outside of the workshops, as was originally envisaged. Most of the edits on the wiki portal also took place on the workshop days. Teachers experienced the publishing process on the KOER platform as conceptually and technologically complex. They explained that they were unable to populate the MediaWiki website and sought more seamless methods to populate it from the mailing lists and mobile phone channels. Infrastructural challenges imposed by poor connectivity also made KOER publishing a challenging process.

Quality of OER

One of the indicators of an effective OER model is the quality of resources produced. Analysis of the materials produced and shared suggests that the materials appear to be "fit for purpose", which is typically recognised as one dimension of quality. For instance, the most commonly sought, created and shared resources on the mailing lists were question papers; question-paper pages were also the most viewed pages on the KOER platform. During the focus group discussions, COA teachers mentioned that question papers were required by all teachers in order to provide practice for their students in preparation for exams.

Some COA teachers did, however, openly express their dissatisfaction with OER that only sought to meet the basic needs of teachers, such as question papers for summative assessments. They felt that such materials reinforced existing teaching practices without a critical pedagogy approach. This sentiment expresses the view held by many teachers that the introduction of technology does not automatically lead to better pedagogical or content practices, enhanced teacher capacities or even the desire to innovate.

This dissonance can be useful in encouraging teachers to reflect upon the kind of OER that would support the progressive pedagogies required by national curricular policy, such as approaches based on constructivist learning theory.

During the focus group discussions, teachers expressed the need for credible, authentic, high-quality materials, even while acknowledging exemplars of high-quality resources amongst their group as well as in the PLC. This could be a useful point of departure to address two aspects: their sense of agency as developers of curricular materials, and their articulated need for their own development, which could facilitate the development of quality materials.

The large volume of materials shared on mailing lists and the KOER platform means that only a very small sample has been formally checked for quality assurance purposes. One of the expectations of the Education Department was that teachers would peer review the resources uploaded to the KOER platform, and use MediaWiki functionality to continually edit and revise the content. Such continuous peer editing and revision of resources is

a higher-order skill not yet seen in the KOER context. Acknowledging that more formal structures are required for review processes, DSERT is considering setting up state and district resource groups of teachers and teacher educators to play the role of peer reviewing and revising OER.

Influence of COA processes on sociocultural factors

The influence of the COA processes on sociocultural factors was analysed in terms of the following: understanding of copyright and open licensing (legal aspects), and the contextual relevance of resources.

Understanding copyright and open licensing

In the public education system, textbooks and other curricular resources are largely produced by the Education Department and made available at no cost to teachers and students.

As part of the COA programme, the COA teachers were introduced to the idea of open licensing and Creative Commons, including training on how to identify openly licensed content for reuse. This was a new concept for many teachers, and their awareness of copyright issues was ascertained in the structured questionnaire (Figure 6).

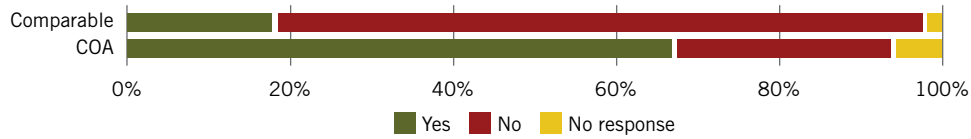

Figure 6: Teacher levels of copyright awareness

COA teachers reported higher awareness of copyright (67.16%) compared to the Comparable group (18.10%). However, even amongst COA teachers, more than one-third (32.84%) reported being unaware of copyright, despite the attention paid to copyright and open licensing during the COA workshops. It is perhaps not surprising that 80% of the Comparable group were not aware of copyright or open licensing, but it is concerning that while nearly 75% of COA teachers reported creating resources collaboratively, nearly one-third did not appear to be aware of the licensing framework that would support this collaborative OER development process.

One reason for this could be that the teachers are used to educational resources being "free" in the public education system. During the focus group discussions, it emerged that teachers found the default copyright approach counter-intuitive, especially in the context of online digital resources, since these were usually easy to download and reuse, and were mostly gratis. Full copyright stipulations on online content seemed easier for them to understand if related to paid-for content. Teachers did, however, appreciate the importance of open licensing and, as previously discussed, instinctively argued for OER for the public education system.

This brings us to an important observation about the understanding of resources in the context of the Indian education system. Throughout the study, the research team observed

that both the COA and the STF PLC teachers prepared learning resources. The resources were shared on the PLC mailing lists, often with an explicit request for reuse or feedback, or even a request for the material to be shared via the KOER platform. While they did articulate objectives of reuse, revision and remixing, the teachers did not explicitly license the resources. It appeared that teachers treated the resources created by them and shared on mailing lists as self-evidently open. This sentiment is reported by Sharma (2016, p.57) in his case study on the STF-KOER programme:

> Public education in India is totally managed through state funds. State functionaries rarely engage with issues of copyright. Traditionally, publications of any kind including textbooks are funded by the state, rarely sold, even then at grossly subsidized costs and almost always covers the entire population. Educational resources are *de facto* treated as open, with states encouraged to freely share, adapt and reproduce materials developed by each other.

Sharma goes on to state that resources are traditionally also produced involving a large number of people drawn from different specialisations within the education system. Outsourcing is only for printing or logistics. In the absence of private participation, the need for an explicit statement and enforcement of legal rights (i.e. copyright) has never been recognised.

In the Research on Open Educational Resources for Development (ROER4D) "Research Concepts" document[32] it is suggested that the term "creation" in the context of OER be referred to as the production of digital teaching and learning resources that are intended from the outset to be shared openly and under some form of licence that allows reuse – teaching and learning resources that are "born open". In the case of COA teachers, the first condition ("that [they] are intended from the outset to be shared openly") is satisfied, but the second condition ("under some type of licence that allows reuse") is not; even though these specially created resources were clearly intended to be "born open". These resources have either been created from scratch, or revised from other resources shared by other teachers.

In the context of this study, resources accessed on the internet, many of which have the traditional "All rights reserved" copyright provision, have been called "explicit non-OER" and those accessed on the internet which are openly licensed have been classified as "explicit OER". "Implicit OER" was used to refer to those materials which were subject to full copyright, but were still being shared within the PLC with the intention of being shared openly.

An analysis of 163 resources shared on the STF PLC by both the COA and PLC teachers reveals that the majority (88.34%) have been sent with the implicit intent of making them OER, while only 9.82% were explicitly allocated an open licence (Table 19).

This practice presented a disjunct between legal practice (where the default copyright provision is "All rights reserved") and social practice (where any resource available online is seen as being free to download/reuse/share in the absence of an explicit copyright clause, and any resource created and shared is intended to be reused, without specifying any copyright clause) and is an issue that requires further work – not only from a research perspective, but also in terms of policy advocacy.

32 goo.gl/57tYfx

Table 19: Email analysis: Implicit and explicit intentions to share OER

Implicit and/or explicit intentions to share OER	Number	Percentage
Explicit non-OER	3	1.84
Implicit non-OER	0	0.00
Implicit OER	144	88.34
Explicit OER	16	9.82
Total	163	100.00

Contextual relevance of resources

OER to respond to teachers' and learners' contexts

Traditionally, material preparation and provision has been the almost exclusive responsibility of DSERT and it has been a challenge to make these materials relevant to diverse learning contexts and needs across the state.

COA teachers articulated their dynamic learning and resource needs relating to content knowledge, teaching practices and assessment techniques. This was particularly acute as their textbooks had been revised and the Continuous and Comprehensive Evaluation (CCE) had been recently introduced as an assessment method. Although immersed in a textbook culture where the only resource accessible and considered necessary is the textbook, they expressed the opinion that the new textbooks were not adequate, and that they required additional resources for subject enrichment and teaching.

Teachers also outlined the difficulties associated with enabling student learning in the face of a changing culture of learning (e.g. lower student responsiveness to teachers, reduced attention span of students) and changes in parents' expectations (e.g. many parents desire that their children should speak English fluently, though there is little or no input from home to support this – a feature in rural as well as urban government schools).

Acknowledging the changing context of their work, COA teachers were keen to create resources that could be more easily grasped by their students. High school students often had many gaps in their learning skill-sets and the recently revised textbooks were not considered to be easily understandable. To this end, a group of COA teachers came together to create foundational materials for mathematics learning and to address the learning levels of the students entering high school at Grade 8. Focusing on strengthening the science lab as a method of teaching and learning, the COA group of teachers created (from scratch) 25 Kannada video resources for demonstration of various science concepts, which formed the core resource material for a state-wide training programme. The materials in English were published on the English KOER platform and those in Kannada were published on the Kannada KOER platform.

Department officials (during the key informant interviews) appreciated the concept of teachers creating resources for themselves, since this helped them to address their local needs. They also mentioned that digital technologies could enable other teachers to have access to the "good-quality" content created by "expert" teachers, and that this was more desirable than the notion of all teachers creating OER. According to them, all teachers may

not be able to, or be interested in, creating OER. They also expressed the view that easy availability of OER might encourage teachers to become lazy and not invest in making materials themselves.

Content analysis indicates that the KOER English and Kannada repositories were populated with materials that responded to these requirements through the provision of classroom activities for CCE, examination question papers, formative assessment activities and grade computation sheets. Question papers in mathematics, science and social sciences had some of the highest page views on the KOER platform.

OER creation in the local language

An important issue that arose in the focus group discussions was the relative unavailability of OER in local languages. Kannada is the state language of Karnataka, spoken by most of its six million inhabitants, and also the medium of instruction in 65% of the high schools in the state (State Project Director, 2012).

While Kannada Wikipedia was an important OER for teachers to access, the resources in Kannada Wikipedia represent a mere 0.34% of the wiki pages in English Wikipedia (Table 20), which can be seen as a proxy for the relative shortage of OER in the Kannada language. In this context, teacher creation of local-language OER becomes more important. The percentage of Kannada resources on the KOER platform as a percentage of English resources is 68%. This suggests that teachers see the COA process as being conducive to creating OER in local languages.

While Wikipedia is also a collaborative OER platform, it is interesting to see the difference in the percentage of local-language content between KOER and Wikipedia. The KOER Kannada to English content ratio is 200 times that of Wikipedia. One reason for this substantial difference could be that the COA teachers populating KOER are a coherently defined community of practising teachers creating OER to respond to their immediate professional needs. Teachers also feel a sense of ownership over the KOER platform, which has the "for the teachers, of the teachers and by the teachers" tag line.

Table 20: Breakdown of English and Kannada KOER content resources by language

Analytics category	Kannada KOER	English KOER	Ratio of Kannada to English
Web pages	3 000+	4 400+	68.18 : 100
Resource files uploaded	1 500+	2 500+	60.00 : 100
	Kannada Wikipedia	**English Wikipedia**	
Number of articles	16 500+	4.9 million+	0.34 : 100

Notes:
1. Data as at 30 September 2015.
2. KOER statistics were generated by using the "Special pages" (reports) feature of MediaWiki. The special pages can be viewed by clicking on the "Special pages" link on the KOER home page (in English[33] and in Kannada[34]). The Wikipedia data on articles in English and Kannada languages were generated from the Wikipedia "List of Wikipedia".

33 http://karnatakaeducation.org.in/KOER/en/index.php/Special:Statistics
34 goo.gl/tdmBm5

While the availability of local-language resources has been positively influenced by the COA processes, there are still more English OER pages than Kannada pages. One reason for this could be that technical writing is easier in the language in which teachers have studied. In Karnataka, mathematics and science teachers need to have a graduate degree in science (a Bachelor's of Science, or BSc.), which is offered in the English medium in universities across Karnataka. This may be the reason why these teachers prefer to create OER in English. Because of their bilingual competence in reading and writing English and Kannada, these teachers are able to access a wider linguistic range of OER for reuse.

Similarly, social science teachers, whose graduate degree in Humanities (Bachelor's of Arts, or BA) was usually offered in Kannada, preferred to create OER in Kannada. Consequently, OER access and reuse by the social science teachers was limited, as many were not as comfortable reading or writing in English. This pattern is also borne out in the anlaysis of the mailing-list interactions and suggests that there is a relationship between subject taught, language of interaction and language of resources created.

COA teachers mentioned that they required resources to be available in the different languages students used, and mentioned that teachers need to be able to transact in multiple languages, since in many schools students come from different linguistic backgrounds where more than one language may be spoken at home. One of the COA teachers who taught in an Urdu-medium high school translated some mathematics resources shared by other COA teachers into the Urdu language (Arabic script) and shared these on the mailing list. After Kannada and English, Urdu is the third most popular medium of instruction in government high schools across the state. This suggests that an OER adoption model embedded within the public education system has the potential to influence OER creation in local languages, making it possible for the OER model to be scaled and replicated in other states.

Critical reflections from the research

Changes to the research approach

While writing the proposal, the ITfC research team envisioned a participatory action research (PAR) methodological approach. However, it became clear that most of the COA teachers were not familiar with research methods and were trying to cope with the techno-social and techno-pedagogical challenges of OER adoption. There was therefore not adequate time and capacity in the research process to train the COA teachers on research methods. Hence, the approach was modified from PAR to action research, where the teachers participated in the COA and research processes but were not part of the research design or data analysis.

A second challenge for the research team was to define the role of the COA group of teachers and the larger PLC group of teachers in the action research. Initially, the team tried to understand the work of the PLC teachers, which included the COA teachers. Based on feedback from the ROER4D Principal Investigator as well as in an internal review workshop conducted at ITfC with one of the research advisors, it became clear that the research needed to focus on the processes of the COA group of teachers, for whom the OER adoption agenda was of central importance.

Insights from the research process

The emergence of the STF PLC as a space for OER sharing and adoption was a welcome but almost surprising outcome. While there was no benchmark for virtual interaction amongst teachers in a public education system in a developing country such as India, the poor availability of ICT infrastructure, the low competency levels of teachers in terms of adopting digital processes, and the complexity of a large public schooling system had kept expectations quite low. The high volume of emails on the PLC and the response of the COA teachers in terms of accessing these resources and publishing on the KOER platform was a gratifying outcome for the research team.

Moreover, the extent to which the COA teachers were receptive to the idea of collaborative OER adoption was a pleasing outcome. Participation in the workshops was not mandatory and many teachers had to negotiate with their school principals to be allowed to attend. Teachers would proactively share their preferences of dates for holding the workshops with the research team, indicating their willingness to attend. Besides their participation, they actively recommended additional members for inclusion in the process. In the context of a strongly hierarchical Indian education system, such active participation and inclusivity was also a pleasant surprise for the research team.

Public software

There have been several efforts to promote the use of FOSS in education. However, this has been a difficult journey as popular proprietary software is still dominant in schools. The research team explained the concept of FOSS as "public" software, suggesting that it was "owned" by all and hence open to use by all. While FOSS users needed to attribute its ownership to the creators, for all practical purposes, since they could freely use, reuse and share it, it could be seen as a "publicly owned" resource.

In the workshops, the COA teachers related the "public" term to their belonging to a "public" education system, open to all students without barriers. The schools in which they worked were "public schools", to which any child could gain access without any constraint. They appreciated that if software needed to be accessible to all in the digital society, it had to be available as a "public resource", just as universal access to education or healthcare was necessary.

Throughout the research process, the research team emphasised the fact that FOSS and OER are aligned in terms of their philosophies. FOSS offers the freedom to use, copy, modify and redistribute, similar to "5Rs" activity in the OER context.

Embedding OER adoption in the Indian public education system

While the large size of the public education system has traditionally been seen as a limitation or a weakness by the teachers, the size of the public education system in Karnataka (Table 2) helped to create a sufficient volume of interaction in the PLC.

It is possible that the networking of teachers using digital technologies can help to view the size of the system as a strength, as the large number of teachers participating in the network could be a benefit in terms of the volume of OER created and shared. Even if only a

very small percentage of teachers from the public education system participate in absolute numbers, it is likely to be large enough to provide a base for OER creation and adoption.

Conclusion

In the large public education system in India, as elsewhere, teachers have traditionally been very isolated. Schools tend to be geographically dispersed and there is often only one subject teacher per subject in each school. Teachers rarely have an opportunity to meet with other teachers teaching the same subject. Traditional teacher development processes do not therefore tend to offer much scope for interaction and peer learning (Rothberg, 1985). This research project has demonstrated that virtual networks can offer opportunities for teachers to connect with one another for peer sharing and learning. Such a PLC can also be a space for OER access and adoption, which can counter the "minor technician" role usually expected of a teacher by the education bureaucracy. A collaborative OER adoption model embedded within a PLC can provide the context for the community to come together and support a systemic model of OER adoption within a public education system. A FOSS environment can also encourage teachers to freely explore and connect digital means and ends.

Teachers in this study found the creation, revision, remixing and redistribution of resources on mailing lists and the KOER platform both interesting and useful. This has made a positive impact on their digital habits and has affected the techno-social habits of certain teachers in Karnataka. It has also supported their professional development, as evidenced by their reflections on the learning that has taken place through community interaction. The nature of these discussions has enabled teachers to see the value of an online community for accessing and sharing educational resources.

Policy recommendations

The following policy recommendations have arisen from the research process:

Implement the PLC approach to TPD in in-service teacher education

The PLC model of TPD, as implemented in the STF programme, provides opportunities for self-learning, peer learning and continuous learning, which are key requirements of the National Curricular Framework for Teacher Education, 2010. Since this model utilises available resources and budgets of the education system, implementing a similar programme in other states in India would be possible. State and district-level ICT infrastructure will, however, need to be developed and maintained in order to facilitate teacher training.

Implement the COA model for OER adoption

Bringing teachers together in collaborative OER creation and sharing processes can foster the creation of contextually relevant OER, including those in Indic languages. This can provide resources that complement and supplement the textbook, currently the primary curricular resource of the teacher in the Indian education system and in many other developing countries. However, continuous peer editing and revision of resources will

require that more formal structures and processes be established to ensure the quality of processes and outputs.

Copyright regulations should position open licensing as the default

One important step in promoting OER adoption would be to have a policy in which the default copyright treatment for any work would be open licensing. This would mean that legal permissions would be articulated upfront for newly created materials, which would facilitate legal reuse, revision, remixing and redistribution. Anyone who intends to prevent sharing or modification must stipulate it by explicitly stating "All rights reserved". This is a recommendation for policy, but the fact that most countries have "All rights reserved" as the default copyright expression means that this would require long-term effort at a global level.

Implement a FOSS-based ICT programme in school education

The "National Policy on ICT in School Education" (Department of School Education and Literacy, 2012) recommends the use of FOSS. India is one of a very few countries in the world that has a policy on adopting open standards (Ministry of Communications and Information Technology, 2010) for digital files in public institutions (which means that proprietary document formats are not to be used). Given the numerous advantages of the FOSS environment over a proprietary environment, these policies need to be fully implemented. Usually the apprehensions about mandating FOSS relate to perceived difficulties in implementation, and not to the concept itself. The experience in implementing FOSS in Karnataka as part of the STF programme, and earlier in Kerala (Kasinathan, 2009a), suggests that it is possible to implement a FOSS-based ICT programme in school education. Since software applications are the means by which OER can be adopted, mandating FOSS would support OER adoption by greater alignment at the philosophical and implementation levels.[35]

Possible next steps for research

A model for bottom-up collaboration in which teachers create, reuse, revise, remix and redistribute OER has been evidenced in this study. There are, however, a number of important areas that require further investigation.

1. Firstly, there is a need to study the influence of the PLC on the COA. While the COA teacher interactions with the PLC have been studied and discussed, a study of the interactions amongst the PLC teachers would be useful in terms of providing a better understanding of the COA model studied, since the COA effectiveness is partly due to it being embedded within the PLC.
2. Secondly, the actual use of the materials by teachers needs to be studied, as insight into which materials are deemed useful can help to better understand OER use with respect to TPD and student learning. This would support the further maturation and evolution of the collaborative model of OER adoption.

35 See http://roer4d.org/1570 for a blog by ITfC ROER4D research team member, making this argument.

3. Thirdly, scaling up the STF and PLC programmes to other states in India would help it mature as a mainstream model for OER adoption in India, which other public education systems in the Global South could explore.

Apart from these steps, it is necessary to create an awareness amongst teachers who share resources with the intention that they will be reused, revised, remixed and redistributed by others to explicitly use open licensing. This will enable the teachers who are reusing these materials as OER to operate comfortably within the boundaries of copyright law.

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