Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized

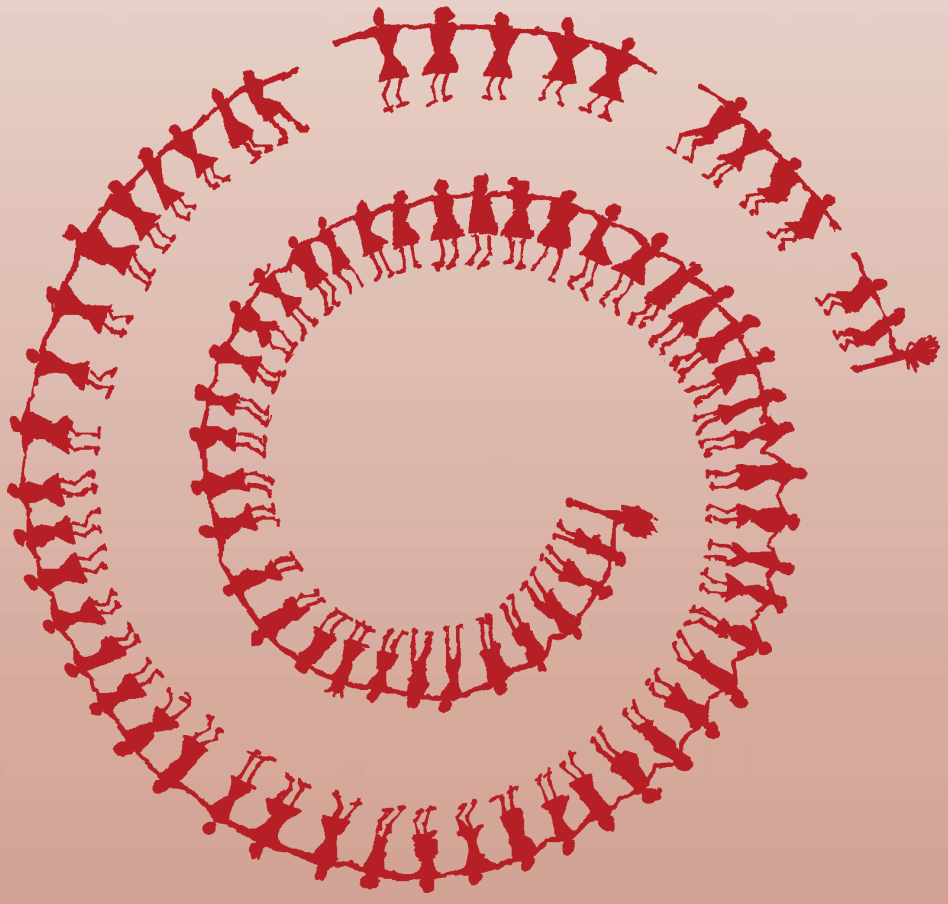
Report No. 73

89983

South Asia Human Development Sector

Strengthening Teacher Capacity in Bihar through ICT: Designing Innovative Solutions to Unique Challenges

June 2014



Discussion Paper Series

Report No. 73

South Asia Human Development Unit

Strengthening Teacher Capacity in Bihar through ICT: Designing Innovative Solutions to Unique Challenges

June 2014

Discussion Paper Series

Discussion Papers are published to communicate the results of the World Bank's work to the development community with the least possible delay. The typescript manuscript of this paper therefore has not been prepared in accordance with the procedures appropriate to formally edited texts. Some sources cited in the paper may be informal documents that are not readily available.

The findings, interpretations, and conclusions expressed herein do not necessarily reflect the views of the International Bank for Reconstruction and Development/The World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the Governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

TABLE OF CONTENTS

AUTHORS

Shabnam Sinha
Senior Education and Institution Development Specialist
World Bank

and

Neil Butcher
Consultant

ACKNOWLEDGEMENTS

This report is the result of several processes of engagement, with the Government of Bihar (GOB), drawing on the expertise of colleagues in the World Bank, and various teacher education and ICT experts. Their valuable inputs during missions, in preparing conferences/workshops and field research, and in helping to write and comment on many documents from which this report has drawn extensively are gratefully acknowledged.

The authors would like to thank all the representatives of the GOB for their many contributions to, and thoughtful reflections on, the emerging design of the teacher education systems and interventions in Bihar on which this report is based. We are particularly grateful for the important contributions: of Principal Secretary, Human Resource Development, Amarjeet Sinha; State Project Director, *Sarva Shiksha Abhiyan* (SSA) and Secretary, School and Elementary Education (SEEL), Rahul Singh; Managing Director, Bihar State Education Infrastructure Development Corporation (BSEIDC), Sanjiwan Sinha; Joint Director, Department of Primary Education, R. S. Singh; Directorate of Research and Training, Department of Education, A. K. Pandeya; Director, State Council of Education Research and Training (SCERT), Hassan Waris; and Director, Training, SCERT, A. Moin. We would also like to acknowledge all of these representatives of the GOB, staff of SCERT, DIET and PTEC Principals, BRC and CRC Coordinators, and school principals and teachers who participated in many different consultative processes that contributed ideas towards this document.

We would also like to recognize the contributions of many World Bank colleagues, who have participated in missions to Bihar, reviewed and commented extensively on documents, and provided excellent advice during the processes leading to this report. Although the contributors are too numerous to mention all by name, we would particularly like to mention: Toby Linden (Lead Education Specialist), Michael Trucano (Senior Education Specialist), and Sangeeta Dey (Consultant, World Bank). In particular, we would like to than Amit Dar (Sector Manager, Education South Asia) for his overall guidance and encouragement in undertaking this challenging task. We would also like to recognize the contributions of Tony Mays and Andrew Moore, consultants to the World Bank, who made significant contributions to the design of the program curriculum and the ICT infrastructure design respectively. We would like to recognize the logistical and administrative support of Tanusree Talukdar, without whom most of the missions to Bihar, workshops, and other field engagements would not have been possible.

ABBREVIATIONS AND ACRONYMS

ADSL	Asymmetric Digital Subscriber Lines
BITE	Block Institute of Teacher Education
BRC	Block Resource Centre
BSEIDC	Bihar State Education Infrastructure Development Corporation
CRC	Cluster Resource Centre
CTE	College of Teacher Education
D.El.Ed.	Diploma in Elementary Education
DIET	District Institute of Education & Training
GOB	Government of Bihar
ICT	Information and Communication Technology
IGNOU	Indira Gandhi National Open University
LMS	Learner Management System
MHRD	Ministry of Human Resource Development
NCTE	National Council of Teacher Education
ODL	Open and Distance Learning
OS	Operating System
PMA	Project Management Agency
PRI	Panchayati Raj Institution
PTEC	Primary Teacher Education Centres
RET	Renewable Energy Technology
RtE Act	Right to Education Act
SCERT	State Council Educational Research and Training
SEEL	School and Elementary Education
SIET	State Institute of Educational Technology
SMF	Social Management Framework
SSA	Sarva Shiksha Abhiyan
TE	Teacher Education
TEIDI	Teacher Education Institution Development Index
TEMIS	Teacher Education Management Information System
UPS	Uninterrupted Power Supply

CHAPTER 1: INTRODUCTION

Until recently, Bihar had a huge shortage of teachers and the student-teacher ratio was as low as 90:1. Most schools were single or two teacher schools, which, on average, used to open for fewer than 100 days per year. Realizing that Bihar can only progress through development of its human resources, education was accorded the highest priority in the State in the year 2005-6. Recruitment of teachers was decentralized to panchayati raj institutions, as a result of which 242,000 teachers were recruited. At that time, too few trained teachers were available; hence half of those recruited were untrained. These untrained teachers, numbering about 102,000, were trained through distance mode by the Indira Ghandi National Open University (IGNOU) in two-year training courses.

The most recent estimates put the number of unqualified teachers in the system, and not engaged in study with IGNOU, at 44,000. To meet the requirements of the *Right to Education*, however, Bihar is currently deploying more teachers. According to estimates, 150,000 of these will again be untrained. It is a major task to provide two-year training programmes to so many teachers in such a short period. Bihar has very few training institutions, the combined current training capability of which is not more than 5,000 new teachers per year.

To meet such diverse and pressing needs, it became important to explore alternative mechanisms of providing teacher education that are professionally managed, address the issue of distance between teachers and the taught, and generate enhanced and innovative delivery mechanisms. The Department of Education of the Government of Bihar launched Mission Gunwatta, which has as its goal that ‘every child in Bihar enrolled in Primary schools attains learning competencies of the class that he/she is in’. Amongst other objectives, Mission Gunwatta is intended to enable a dramatic improvement in learning outcomes for primary learners, to enable teacher educators to make a real difference to the classroom process, to support teachers in schools very effectively, and to support teacher training institutions, Block Resource Centres (BRCs), and Cluster Resource Centres (CRCs) vibrant and effective.

Mission Gunwatta includes a heavy emphasis on developing an effective teacher education system for the State, including: training and support for all levels; onsite support to teachers for transforming classroom processes; teams of excellent resource people at CRC level; training modules for all levels of functionaries, with well-defined roles; developing testing tools in training institutions; assessing performance of schools and teachers; and separate training for teachers of Classes I-II and teachers of Classes III-V. Thus, the programme focuses on revitalizing and re-designing teacher education by empowering institutions at the state, district, and sub-district levels to provide quality teacher education for improved teacher performance. This includes providing institutions with robust training infrastructure; sustainable processes for selection and capacity building of teachers and teacher educators; use of modern information

technology; efficient teacher management processes; strong monitoring and evaluation; and social audits of school and teacher performance.

Several achievements have been registered in this work. The State has obtained permission from the National Council on Teacher Education (NCTE) to start a Diploma in Elementary Education in 52 government institutions, as well as a Bachelor of Education in four government institutions. Teachers with adequate qualifications have been selected through a rigorous process to become teacher educators, and all are being put through a mandatory direct trainer skills training programme (with some also doing an advanced training programme for trainers). The State aims to develop at least 50 outstanding teacher training campuses with the best possible teacher educators, as well as developing infrastructure and resources teams at CRCs and BRCs to meet teacher development needs. Strong monitoring systems for assessing the progress of children, teachers, and schools have also been put in place.

Within this context, there are significant opportunities to harness Information and Communication Technology (ICT) and Open and Distance Learning (ODL) in teacher education, especially to deliver pre-service teacher education. Consequently, the Government of Bihar requested the World Bank to provide support in development of distance education curriculum, related syllabi, content, effective delivery mechanisms, appropriate student support systems, and assessment strategies to meet the needs of its untrained teachers. Many other states and countries are facing similar problems, and will need to prepare comprehensive time-bound plans for untrained teachers to acquire the prescribed qualifications (both academic and professional). Thus, experiences in Bihar might provide models for developing an ICT-based teacher education system that can be used as a useful reference point by others facing similar problems. This report outlines these experiences and shares lessons learned through the process to date.

CHAPTER 2: FINDING A SUITABLE MODEL FOR BIHAR

Design Commencement: Engaging the Stakeholders and the Experts

Development of suitable models for implementing large-scale teacher education programmes in a context like Bihar is challenging, for various reasons: it is culturally and geographically unique in many respects; the scale of the challenge and the context of implementation is very large; there are significant infrastructural constraints; and the experiences of harnessing ODL and ICT in developing country contexts are much less well documented than in the developed world. Consequently, the process of exploring suitable models to tackle these challenges in Bihar was initiated by an International Conference, held in Patna in June, 2012, on the Use of ICT in Teacher Education in Bihar. The conference, which brought together over 150 education experts from India and around the world, covered both policy and practice in teacher education, with particular emphasis on the use of ICT and ODL. Discussion reflected on both Indian and international experiences, while group discussion allowed participants to engage with each other to develop with implementable solutions.

Key messages from the Conference provided a strong conceptual platform for further planning and design. These included the following key observations:

1) Given the challenges facing the State of Bihar, there are many innovative educational strategies and approaches that have been deployed, both in India and around the world, that can be effectively harnessed to solve the problem of certifying teachers in the State. New ICT tools, in particular, offer innovative options for finding creative solutions to the State's challenges.
2) Design and selection of educational strategies and a suitable blend of learning methodologies in any teacher certification programme needs to take into account contextual realities in Bihar. Any use of technology identified must be designed to work successfully even in the most challenging rural environments in the State, and should accommodate the ICT proficiency levels of students and teacher educators alike.
3) Implementation of a teacher certification programme in Bihar needs to focus strongly on developing institutional capacity for ongoing teacher education in the State that can be sustained well beyond the life of the project.
4) Although ICT and ODL provide excellent strategies for solving the challenge of teacher education in the State, ODL has historically faced immense challenges when it has not included sufficient student support. Because of this, it is essential to ensure that effective use of face-to-face sessions and interaction is integrated into the design of the programme.
5) There is a wealth of existing expertise, content (particularly open educational resources or OER), and other valuable resources available, both within India and internationally. This should all be harnessed during any programme development process, both to accelerate the development process and to ensure that the subsequent programme builds on the best of what is available locally and globally.

Strong commitment was expressed by all key players represented in this inaugural Conference to ensure development and delivery of a high quality, innovative ICT-based teacher education programme in Bihar, which simultaneously focuses on building effective institutional capacity and an accompanying ICT infrastructure within the State for ongoing teacher professional development.

Exploring Suitable Options

Following this Conference, a series of engagements subsequently took place to explore suitable options for teacher education in Bihar. These included widespread consultation with key stakeholders in the State, field visits to teacher education sites and schools, and desktop research exercises. This phase culminated in an intensive three-day workshop on the use of ICT in Teacher Education in Bihar, which was organized by the World Bank in November, 2012. This workshop brought together representatives from the State Council of Educational Research and Training (SCERT), Primary Teachers Education College (PTECs), District Institutes for Education and Training (DIETs), Block Resource Centres (BRCs), and Cluster Resource Centres (CRCs)[1] to define a number of key elements of the proposed teacher education system. Together, these structures represent the key institutional infrastructure for delivery of teacher education in Bihar.

This workshop, and the various research and development exercises leading up to it, yielded further important insights regarding the design of a suitable model for teacher education in the State. The immediate priority identified in considering a suitable teacher education system was to begin by defining clear Teacher Standards. Here, it was proposed that the State should lead a process to create explicit Teaching Standards for Bihar that capture the key knowledge, skills and understanding required of practising teachers. Simultaneously, such a process should define key leadership roles for state/district institutions, as well as school principals, in driving school improvement and improving teaching quality. This would include a particular focus on the role of teacher educators and principals in coaching, mentoring, and challenging teachers to improve their practice. Linked to the Teaching Standards, it was identified as essential to introduce systematic approaches to performance management focused on improving teaching, based on the Teaching Standards. Having done this, the final step would be to align pre-service teacher education and Continuing Professional Development in Bihar with the Teaching Standards and an agreed performance management system.

Although developing Teaching Standards and a Performance Management System was identified as critical for effective teacher education, it was not as only constituting a starting point. The next priority is then to strengthen institutional capacity within the State to be able to deliver and

[1] In Bihar, education is organized as follows: the State is broken up into Districts. Each District is then divided into Blocks, which are further broken into Clusters. Thus, CRCs are typically the smallest support centres, closest to individual schools (although, due to geographical positioning and the reality that not all planned CRCs are yet functional, some schools are closer to BRCs than CRCs). The planned infrastructure will ensure that a CRC or BRC is within relatively easy walking distance of all schools in the State, thus facilitating ongoing professional development support for teachers.

support effective teacher education, both pre-service and in-service. In this regard, the following key points were noted during this phase of development:

1) It is critical to assess teacher performance on an ongoing basis (using the Teaching Standards and performance management system) and to incentivize good performance. Support and development will be needed to equip teacher educators and principals with the skills and techniques to monitor and evaluate teaching in order to identify strengths and weaknesses and then to lead and manage appropriate action to improve practice. This will include coaching, mentoring, and training on specific pedagogical techniques, as well as improving teachers' subject knowledge through training. Identification of suitable incentives is also critical.
2) Curriculum reform is essential: in this regard, ICT is a key enabler, but it is only one mechanism amongst many. Most important is to ensure that the design of programmes aligns to the Teaching Standards, is truly innovative in improving classroom practice, and leads to measurable improvements in quality and student attainment.
3) Strong emphasis is needed on institutional strengthening to deliver both pre-service teacher education and continuing professional development, with an explicit focus on improving pedagogy. Of particular importance is to strengthen academic/educational support capacity at both the DIET/PTEC and CRC/BRC levels, with heavy emphasis on developing capacity and infrastructure for BRCs and CRCs to be able to function effectively as local learning centres.

Key roles and responsibilities were identified for all players. These are summarized below:

1) SCERT was identified as the nodal agency for teacher education, responsible for coordinating and managing the activities of the expected 10,000 teacher educators operating at different levels across the State. Its responsibilities are to:
   a) Undertake ongoing needs assessment to determine priorities;
   b) Provide academic support across the system;
   c) Undertake continuous development of teacher training programme and materials, linked to National and Bihar Curriculum Frameworks;
   d) Develop capacity of local content developers across state to contribute content;
   e) Coordinate deployment of ICT infrastructure for teacher education, as well as ongoing monitoring of the extent and quality of its use;
   f) Prioritize and sequence annual TE targets, followed up by monitoring through Results Frameworks.
2) PTECs and DIETs were identified as the entities responsible for managing teacher education across the districts, with the following roles and responsibilities:
   a) Empowered as model ICT centres;
   b) Focus work according to district need, based on regular needs assessment;
   c) Manage monitoring and evaluation at district level;
   d) Develop model lesson plans and other materials (including subject-based materials for classroom teaching).

3) CRCs and BRCs will function as local learning centres, ideally within easy walking distance of every school in the State, that offer a full range of teacher education activities They will:
    a) Function as sites for local group discussions, tutorials, remote teaching sessions, and other contact sessions;
    b) Provide access to ICT for teachers to work through materials, participate in online activities, view video materials as a group, and so on;
    c) Focus on larger-scale, intensive face-to-face support activities where required (predominantly at BRCs) and provide day-to-day support and facilitation close to school sites (predominantly at CRCs);
    d) Work to develop a common leadership vision with school principals on teacher support; and
    e) Identify and share innovative best practices in schools.

During this period, a prototype ICT architecture was also designed. Several options were considered in this regard, including a highly ambitious plan to distribute individual devices (such as cheap laptops or 'netbooks') to each of the teacher trainees. This option was seen as educationally ideal but financially and logistically unfeasible (particularly as it would likely generate frustration amongst those teachers employed in Bihar who did not participate in the subsequent certification programmes and thus did not receive such a device).

Consequently, the subsequent ICT architecture focused on capacitating the institutions themselves, based on the following broad parameters:

1) All content and interactive facilities should be made accessible online from the centre via online, cloud-based applications and systems, managed by the SCERT.
2) PTECs, DIETs, BRCs, and CRCs should all be equipped with:
    a) Thin-client networks, with the capacity to store content and systems locally when Internet services are disrupted;
    b) Enough workstations to meet needs of teachers who access these facilities (fewest required at CRC level and most at PTEC/DIET level);
    c) Data projector/s to enable group engagement with materials, watching videos, lecture presentations, and remote teaching sessions;
    d) Alternative energy solutions (solar, bio-mass, generator, and so on) to ensure reliable energy supply where there is no electricity.
3) Every teacher educator should be provided a netbook-type device to facilitate mobile support, ongoing access to content and facilities, communication up and down hierarchy, peer support, and networking.
4) Options should be developed and made available to teachers to procure their own devices (at their own cost) through preferential (bulk) purchasing arrangements arranged by the State, in order to develop a culture of ownership and access to ICT amongst teachers.

These choices were based on the infrastructural realities of Bihar, taking into account constraints in electricity supply, connectivity coverage, availability of local technical expertise to support ICT installations, and the realities of often extreme climatic conditions in the State. Thin client networks were identified as a relatively low maintenance, low-power, and cheap alternative to traditional fat client networks. Success in having deployed thin client networks into schools in the State also indicated that this computing model would work well for teacher education in Bihar.

CHAPTER 3: THE DIPLOMA OF ELEMENTARY EDUCATION

With these basic parameters in place, it became possible to commence the detailed design of a suitable programme and systemic capacity to meet the teacher capacity needs of Bihar. The immediate priority was to design a Diploma of Elementary Education (Open and Distance Learning), D.El.Ed (ODL) that would allow for the large-scale upgrading of the knowledge and classroom competences of unqualified, in-service elementary school teachers.

Programme Design

Design of the curriculum for the D.El.Ed (ODL) was coordinated by the SCERT, with technical support provided by the World Bank. This design focused on implementation of an ICT-supported distance learning programme. The programme subsequently designed is based on the agreed Bihar Curriculum Framework, and comprises the following elements:

A. Core/Foundation/Fundamental/Theory [this component deals with questions of WHAT to teach and WHY].
B. Methods/Pedagogy [this component deals with HOW to teach taking into account the needs of different children, contexts and subjects].
C. Practical/ Internship [this component calls for reflexive practice. It involves field activities, co-curricular and extra-curricular activities that are classroom and school-based and require teacher- students to use theory to guide and interrogate practice and in turn to generalize theory from practice.].

The three components will be taught in an integrated way.

The D.El.Ed (ODL) will comprise 70% self- and classroom-based learning from printed materials especially designed for purpose and 30% contact-based support in the form of orientation workshops at the start of each semester, as well as contact sessions on Sundays. The contact sessions will happen in study centres (SCERT, DIETs, PTECs, BRCs, and CRCs), that have been equipped with ICT facilities. This will allow teacher students to develop knowledge and skills progressively to integrate appropriate technology into their teaching and learning interactions.

The two key components of the programme are high quality learning resources and a robust, pre-emptive support strategy geared towards maximizing improved classroom practice and student throughput. The programme will extend over two years, divided into four semesters. Mechanisms for change include print-based self-learning resources that are activity-based and model an approach to learning that sees knowledge as constructed and contested. This approach will be further reinforced during workshops and contact sessions so that the programme is seen to ‘practise what it preaches’. A variety of media will be used to support this process, for example, watching short videos of classroom practice at a contact session and discussing evidence of good practice and possibilities for improvement. This will also model a collaborative

learning approach and hopefully lead to the formation of a professional community of practice that continues even after students have graduated from the programme. In-course activities, formative and summative assessment, and the feedback thereon will be focused towards improved classroom practice and evidence of improved pupil attainment.

The main emphasis of the D.El.Ed (ODL) is on improving the quality of teaching practice. Numerous course activities and assessment opportunities focus on ensuring that pedagogical theory is transferred into effective classroom methods and techniques. A team of facilitators working from dedicated Study Centres will be employed to facilitate this growth though observation and mentorship. The D.El.Ed (ODL) is therefore not an online programme, but rather an ICT-supported programme. However, to ensure meaningful exposure to ICT, students will be required to engage with components of the curriculum using computers situated in Study Centres. Student access to computers, either at Study Centres or via their own digital devices, will be necessary for students to complete the course.

Student Assessment

The assessment strategy is integral to the design of the curriculum, and is intended to privilege requirements for and evidence of improved classroom practice. It is also designed to be manageable for students who are already in full-time employment as teachers. The following diagram illustrates the ways in which the assessment strategy in the programme needs to reinforce improved practice in an integrated way.

Figure 1 Towards an integrated assessment strategy

Given that increased learner engagement in the classroom is a desired outcome of the teacher development programme, this needs to be modelled in the distance learning programme through an activity-based approach that requires teacher-students to engage with, critique and problematize content and not simply memorize it. Given also that, for 60% of the time, teacher-students are working independently, the learning resources provided will offer sufficient feedback on the in-resource activities to enable meaningful self-assessment.

From a design perspective, it is important that the activities and feedback for self-assessment are varied and challenging enough to develop the knowledge and skills required for formal assignments and formative feedback thereon. Constructive formative feedback on assignments is needed to help students pace themselves and to confirm their self-assessment. It must be provided timeously so that students can learn from one assignment to improve the next. Overall, the assignments provided for formative assessment need to provide sufficient scaffolding for effective completion of time-bound and proctored summative assessment tasks. These summative assessment tasks need to require teacher-students to make explicit the theory that informs their practice and vice versa.

In the complex practice of teaching, students will draw on learning from several Papers and other programme elements simultaneously. Hence, there is a need to include in the programme design elements that focus explicitly on classroom practice. With this in mind, the programme assessment approach is as follows:

- Assessment involves a combination of assignments, presentations, case studies, projects, group work, group discussions, teaching practices, demonstration classes, simulation classes, critical lessons, final teaching, observations (by senior teachers in schools), and summative or theory final examinations, split 50 + 50 for applied theory and practicals.
- A group of students may also be attached to a teacher educator/counsellor for evaluations of some assignments, projects.
- Students complete 3 assignments for each of the eight core papers each year, counting for 40% of the final mark.
- Students also write an examination for each paper, counting for 60% of the final mark.
- For the two non-core courses each year, there are two assignments counting 40% and some form of summative assessment e.g. ICT practicum or lesson planning/observation counting 60%. [It is felt that a 20%/80% split would be better.]

Continuous assessment will be coordinated by Study Centre coordinators/facilitators.

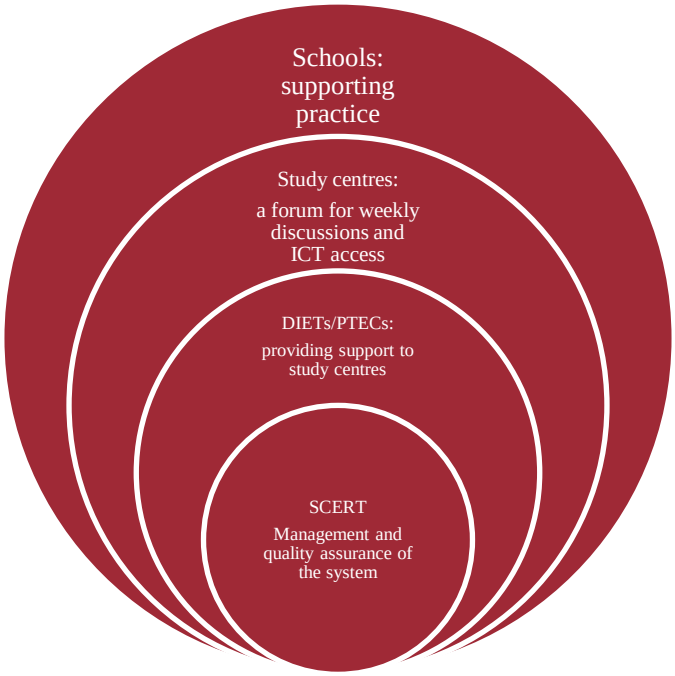
There will be two major terminal examinations. At the end of the first year SCERT will conduct an examination which will be held at the DIETs and PTECs and in the second year the Bihar School examination Board will conduct the final year examination. The Board is a statutory body with adequate regulatory powers for conducting these examinations.

Students must meet a 50% pass (aggregate for all subjects), with a minimum of 45% marks for each subject, in order to proceed; not more than two modules can be repeated concurrently. Feedback is an essential part of the teaching-learning process. For example, the experienced teacher, the school-based mentor and the teacher educator or counsellor will sit together to discuss the strengths and shortcomings of an observed lesson, against a supplied rubric, and outline actions for further improvement. Formative assessment will play a number of roles including, but not limited to, helping both students and teacher educators gauge progress as well as pace the learning process leading to summative assessment.

Student Support

Support will be provided at different levels:

Figure 2 Integrated student support model



First is the state level, represented by SCERT, which will comprise the following departments: Student Support, Academic, Administration, Training and Materials Supply. SCERT will:

- Ensure that the curriculum meets national and state requirements;
- Develop learning resources to support the curriculum;
- Create a content repository comprising OER (Indian and international), as well as collecting and digitizing available resources with Bihar SIET and other SIETs;
- Develop summative assessment instruments to support the curriculum for year 1;
- Liaise with Bihar State Examination Board for summative assessment in year 2;
- Monitor the quality of provision at study centres;

- Host and maintain an integrated ICT system;
- Track student progress, identify students at risk, and initiate supportive interventions if not already in process.

Study centres will provide support as follows:

- There will be weekly meetings at study centres for discussions on progress and challenges, including lessons planned and taught for the programme, and to download materials updates, upload assignments and/or contribute to ongoing discussions. Each session involves groups of 20-30 teachers. Discussions are led by qualified teacher educators.
- Students also attend a 40 hour orientation workshop each semester at designated study centres.
- The study centre teacher educator tracks student progress and escalates common problems up to nodal DIET/PTEC or to SCERT staff as appropriate.

Schools will also provide support of different kinds:

- School- and classroom-based practicals will be supported and assessed at school level.
- Practice teaching, demonstration classes, and school-based activities etc. will be conducted under the supervision of a mentor, a teacher educator or counsellor from the related study centre, and/or a senior teacher.
- The head of the school will work as mentor, and an experienced teacher will evaluate the lessons.
- Very small schools will need to be linked with larger schools for support.
- Handbooks/rubrics, training and support will be needed for school-based support staff.

Sunday discussions will be divided into four categories: reading materials discussion; assignment related discussion; day-to-day problems faced in the classroom; and ICT practice and integration. Attendance will be compulsory since the programme is offered at no cost to students. A minimum attendance requirement (possibly 80%) will be implemented.

A five-day workshop will take place at the start of each semester; preferably during school vacations. The workshops will aim to: model good practice, including simulated and micro teaching; consolidate practical competences such as timetable development, lesson planning, and action research competences; and provide an orientation to the practical and assessment activities of the semester.

Proposed ICT Architecture

ICT Architecture Overview

Rollout of ICT infrastructure will be synchronized with the enrolment of students into the programme, on a district-by-district basis. The ICT architecture has, at its centre, a hosting server maintained and supported by the SCERT. The server will host a Learner Management System (LMS) whose functions include registration of student enrolments, provision of a teaching and learning platform, storing and distributing digital programme resources, collecting student submissions, tracking student activity, and calculating student grades.

Students registered for the diploma will access the server from their allocated Study Centres. These Study Centres are designed to provide students with access to thin client work stations that connect to the SCERT server via the Internet, using either ADSL or 3G connectivity. In addition, though, all Study Centres will be synchronized regularly with the SCERT servers so that all content and systems are locally accessible when there is no Internet access. Thus, thin client network servers will need to be sufficiently large to facilitate local storage of all course content, while it is proposed that each thin client network comprise at least two servers to build hardware redundancy into the architecture. In addition, it will be necessary to ensure that all equipment is both dust- and heat-resistant.

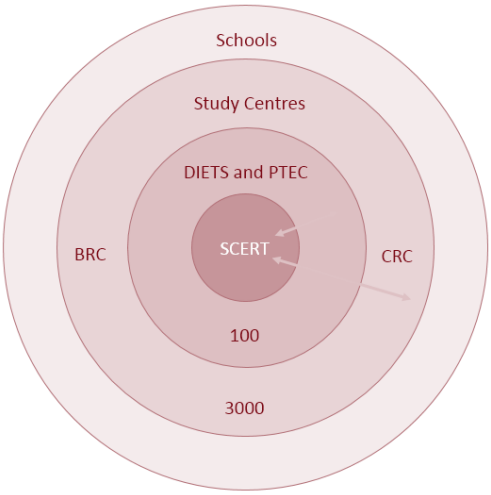
Study Centres will provide local Wi-Fi connectivity, allowing students to use their own devices if they have them (netbooks, tablets, smart phones, and so on) to connect directly with the local server and course LMS. Study Centres will be equipped with clean energy power solutions, either to provide a primary power source where there is no grid electricity or to compensate for intermittent or inadequate electricity supply via the grid. To facilitate this, all equipment procured across the entire system will need to be energy efficient as a key requirement.

Consequently, at Study Centres, students will be assured of computer access, connectivity, and power, as well as the mentoring services of the Study Centre coordinator. Students will interact with computer-based learning for a minimum of four hours per week, although the centre will be open to them throughout the week. Access to a Study Centre is thus crucial to the teacher education design model for Bihar. This means that they need to be close to teachers' schools. Consequently, the local CRC will typically be the most logical place to locate Study Centres, while BRCs can also serve as Study Centres when they are close to students' schools. Likewise, PTECs and DIETs will function as Study Centres.

There will also be training facilities at SCERT set up to operate in the same way as the other Study Centre nodes. These venues will be used to train coordinators who will operate and perform basic maintenance at the CRC, BRT, PTEC and DIET Study Centres. Thus, the ICT

architecture can be summarized as a series of concentric circles providing wide access to support across the state:

Figure 3 ICT Architecture from Centre to Periphery



The architecture summarized above supports two-way communication between the various study centres and the central SCERT server. Students will access materials from the central LMS, but will also submit assignments and their progress will be systematically tracked (including progress through activities, time spent on computers, assessment progress, and so on). They will also be able to communicate with each other, with mentors, and with central SCERT support structures. Once this communication infrastructure is in place, it can be used by the Government of Bihar for a wide range of educational communication requirements, while also supporting more general development of professional communities of practice across the state. Thus, this is a highly flexible, decentralized ICT architecture designed to accommodate the contextual realities of Bihar.

A key design issue was how best to integrate ICT into the programme in such a way that students are forced to engage with the technology, even though they will not have access to it on an individual basis in their respective classrooms. It was thus proposed that the self-assessment/reflection activity at the end of each unit or sub-unit of learning should be mandatory and completed on one of the Study Centre's computers during the first 15 minutes of the Sunday session. The self-reflective activity will include tasks where the student can capture their experiences and thoughts, but also include survey type questions designed to collect quantitative data. This has a number of benefits for SCERT, the mentor, and the student as it:

- Ensures that the student is forced to engage with the computers on a weekly basis and hence acquire soft skills in the process.
- Provides an opportunity for the students to see their growth as each week's reflection maps their learning journey.

- Allows the mentor to quickly identify issues within the week's work that many of the participants are struggling with and needs to be the focus for that day's discussions.
- Provides SCERT with a log of each individual who has logged in and completed their self-reflection activity, thus tracking absenteeism from those who have not completed the activity.
- Provides SCERT with data from across the state to perform diagnostic analysis of the effectiveness of each week's course activities. With this data, problems within course materials can be identified and revised.

SCERT Central Server and Learner Management System

SCERT, located in Patna, will be the coordinating agency for teacher education in State. As part of this responsibility, it will coordinate the rollout of the Study Centre model described above, as well as overseeing its deployment into CRCs, BRCs, DIETs, and PTECs. A central SCERT server, hosting key programmatic applications, will be central to teacher education, dispensing content, collecting data, monitoring progress, and facilitating communication. In addition, SCERT will act as a venue for the training of Study Centre coordinators so that they can confidently access, use, and maintain the ICT facilities being deployed across the State.

Given this, SCERT will be required to deploy and manage a suitable Server Cluster for all online ICT applications, which will disperse and collect data and communication across all Study Centre nodes (either at SCERT or in partnership with a suitable Internet Service Provider). This server cluster, made up of web and database servers, will need to serve a potential Sunday student audience of as many as 40,000 concurrent users. For every 10,000 concurrent connections, five web servers and two database servers are required to support traffic.[2] Beside weekend traffic spikes, the central systems need to be operational 24 hours a day to encourage students to access course materials using their own devices. To mitigate against the risk of hard disk failure, a swappable system, such as RAID, will need to be incorporated into the server design to minimize down time and loss of data.

The central servers will be collecting data about student progress and storing student course submissions, as well as managing all communication across the State. A scheduled back-up will thus be required either continuously or at least on a 24 hour basis in order to protect data. A back-up solution is thus required for the server cluster. In addition, the servers and communication infrastructure should be deployed on an isolated network segment front-ended by a shared firewall. This will prevent denial-of-service attacks, as well as providing additional security from hacker attempts. The servers should also run anti-virus software to monitor files uploaded and shared by students.

The servers should be proactively monitored to identify actual and, to the best of ability, potential faults and errors, with a view to fixing errors or producing a proposed plan of action to mitigate potential problems. The hosting environment will need to be provided with backbone-

[2] See discussion on the Moodle Community website for an example: https://moodle.org/mod/forum/discuss.php?d=111847

class Internet connectivity, ensuring maximum resilience and performance from the Indian and international Internet. Finally, as the electricity powering the server comes from numerous sources, it will be necessary to have a voltage spike protector to ensure that any supply of voltage above safe levels is diverted to ground.

The follow software will be required on the SCERT server cluster:

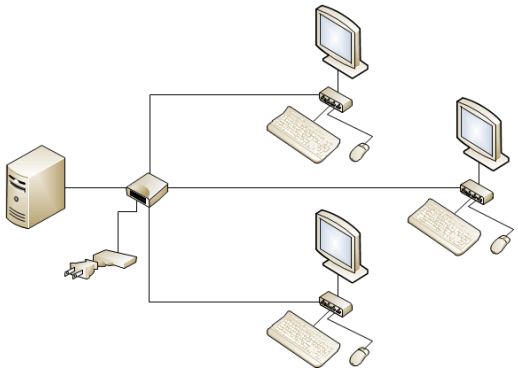
- Operating System (OS) - The server cluster will run an open source operating system. Popular systems include Ubuntu, Centos, Fedora and Suse.[3] These systems are cost effective and have a good international support base which can be used to overcome installation and maintenance issues.
- Learner Management System (LMS) – An open source option for the LMS is also advised for similar reasons as stated for the OS. Popular and well supported open source LMS options include Moodle and Sakai. A new open source alternative that is gaining support, which offers cloud hosting as an additional service, is the Canvas platform.
- Video-streaming server – SCERT has inherited a collection of video resources developed by the State Institute of Educational Technology (SIET). There are potentially hundreds of curriculum based videos that could be converted into a digital format and distributed using the new server cluster. An alternative to this might be to partner with YouTube for delivery of video content.
- Link to Teacher Education Management Information System (TEMIS), for management and administration purposes.
- Other specialized software as defined by the requirements of individual teacher education programmes.

ICT Infrastructure Across the System

As has been noted, thin client networks are envisaged as the preferred device solution across the system. Thin-client networks link individual work stations to a host computer. The works stations are in effect intelligent clusters of monitors, keyboards and mice that use the processing power of the host computer to perform tasks. Some thin-client networks can support up to 100 workstations from one host.[4] A typical thin client set up is illustrated in the diagram below.[5]

[3] See Wikipedia for a more comprehensive list at http://en.wikipedia.org/wiki/Linux_distributions#Popular_distributions
[4] This statistic refers to the NComputing education solution: http://www.ncomputing.com/solutions/education
[5] This diagram shows a small MS Multipoint Server thin client set up: Available online at http://technet.microsoft.com/en-us/library/jj916390.aspx

Figure 4 Thin-client Network Setup



Thin client networks used in the training centres at SCERT, DIETs, PTECs, BRCs, and CRCs will all share the same architecture, but will vary in size according to specific needs.

The following peripherals will also be needed to support the thin client networks at each Study Centre.

- Printer/Scanner/Copier – A printing device will be added to each network to allow for small runs of paper-based documents for classroom use. Due to energy constraints, it is important that energy-efficient appliances are procured. Printer consumables, ink and paper will also be required. However, printing at micro level is expensive, so only small print jobs of essential documents will be printed at the Study Centres. Large anticipated paper runs will be coordinated through the State printer. In order to digitize paper-based materials, such as student assignments that are to be submitted directly to the SCERT server, a scanning device will be included in the Study Centre installation. In order to serve both print and scan functions a single Printer/Scanner/Copier combination device will be installed in the Study Centre at BRC and CRC level, while dedicated devices for each function might be required at the DIET, PTEC, and SCERT level.
- Monitor / Projector – In order to allow the students and mentors to refer to digital resources, a ceiling- or wall-mounted LCD monitor will be mounted and connected to the thin client network. Any smaller and the usefulness of the equipment is nullified as text becomes almost impossible to read. For Study Centres that host 20 or more students, a data projector will be required in place of a wall monitor.
- Uninterrupted Power Supply (UPS) – To ensure a timely shut down of the server during times when there is a disruption in the power supply, or to stop the server 'going down' when there is a temporary lull before the alternate power source cuts in it, is also important to have a UPS connected to the thin client network to provide short term temporary power in the event of power loss. In addition, this facility should modulate power flow to protect the equipment against unforeseen power surges.
- Netbook – all teacher educators across the system will be supplied with a Netbook, with 3G capability, to ensure that they have full-time access to the courseware, facilitation notes,

resources, and communication tools needed to provide ongoing support to teacher trainees. They will be able to use the centre connectivity to access the SCERT server.

Study Centres will need to be connected to the SCERT server via the Internet. To create this Internet link, two options can be deployed based on availability of infrastructure in the area:

- Asymmetric Digital Subscriber Lines (ADSL) can be deployed in those areas where the telecommunications infrastructure exists. ADSL solutions use existing copper telephone wires. The ADSL technology 'splits' the wires so that both voice signals and data can use the line concurrently. ADSL is usually a last-mile solution and runs from telephone exchanges in a radius of 4-8km.
- Alternatively 3G (3rd Generation) networks can be used. They use a different infrastructure based on mobile technology and are available usually where cellular telephone penetration exists. Dongles (USB modems) are usually associated with this method of connecting to the Internet.

The Study Centre, will also provide local connectivity for students using a Wi-Fi network. Students can access the course materials on their own digital devices where they have they them, whether these be netbooks, laptops, tablets or smart phones.

Building Structure Requirements

All of the above ICT infrastructure needs to be hosted in flexible tutorial facilities, which can be used for both tutorial sessions and self-study. These buildings will all require the following:

- Security – Windows, entrances, walls, and all apertures (such as air conditioning and power ducts) will need to be designed to prevent theft of equipment. The computer room will be a 'lock-up & go' facility where it is quick and easy to secure. Steel doors, window shutters, burglar guards are standard.
- Natural Elements – The design will ensure that the facility is raised off the ground, especially where there is a local risk of flooding. Piles or a concrete slab can be constructed to achieve this. An accompanying set of stairs might be necessary in some instances and this option needs to exist for those sites where this is needed. Each building will also be equipped with suitable firefighting equipment.
- Limited Space – In those schools, especially in urban or peri-urban locations, where space is limited, the study centre computer facility can be assembled on the roofs of existing ground floor buildings. Many of these buildings were built to bear the weight of a second floor, but never received funding to do so. However, this should be verified at each site before construction commences.

At all levels, SCERT to CRC, power supply is imperative to ensure the ICT infrastructure is operational. Where possible, Study Centres will use power from the national electricity grid. The reality, however, is that electricity supply is often disrupted, even in urban areas. Also, for many

schools, there is no electricity from the grid. Consequently alternative power solutions are required.

The anticipated power demands of a typical 20 Thin Client Study Centre using energy efficient appliances include:

Table 1 ICT Equipment Power Requirements

	Energy Efficient Appliances	**Typical Consumption**
1	Host Computer	0.2 KW
20	Thin Client work stations with monitors running[6]	2.1 KW
1	Window air conditioner[7]	1.4 KW
2	Energy saver light bulbs[8] (18 watt)	0.036 KW
1	Energy efficient Printer / Scanner / Copier[9]	0.040 KW active, 0.006 KW standby
1	Digital display[10]	0.160 KW active, 0.001 KW standby
1	ADSL Router	0.006 KW

The Study centres will therefore require access to clean energy solutions:

Bihar faces acute energy shortages, with annual energy deficit in Bihar ranging from 13% to 21% in the six-year period from 2008 to 2013. During the same period, the peak deficit in Bihar has been in the range of 14% to 34%. Many people also still do not have access to the grid supply, while around 83% of the households are not electrified (most of which are in remote or far-flung areas). As part of the enabling infrastructure, there is a need to provide a reliable and a cost-effective alternate energy source for energizing the ICT equipment under the project. Bihar is blessed with significant renewable energy sources which can be exploited to alleviate the situation. Given this situation, the ICT architecture considered various potential solutions:

- Solar – Atop the study centre, solar panels can collect power from the sun. This energy can be stored in an inverter when not required or when demand is less than supply. A typical solar power system deployed for schools can produce 5 KW of power, although this may not be sufficient to run the facility reliably.[11] Power requirements to run an energy-efficient, thin-client network of 20 terminals and host computer is estimated to be 2.1 KW (but more

[6] Drawn from Wyse Technologies.(ND). Desktop Energy consumption: A comparison of Thin Clients and PCs. Available at www.athena.dk/files/UserDir/Documents/**energy**_study.pdf *p.*
[7] http://michaelbluejay.com/electricity/cooling.html
[8] Based on the Philips 'Genie' bulb: http://www.philips.co.za/consumerfiles/pageitems/master/categorypages/energysavers/assets/pdf/Switch%20Guide%20(version%20for%20consumer,%20May%202009).pdf
[9] These figures based on the Energy Star rated HP OfficeJet 7710 All-in-one Printer at http://h10025.www1.hp.com/ewfrf/wc/document?docname=c00839084&tmp_track_link=ot_faqs/top_issues/en_us/c00839084/loc:1&cc=us&dlc=en&lc=en&product=3330793#N2057
[10] Based on the NEC 55" Large screen display: http://www.necdisplay.com/p/large--screen-displays/e553
[11] See installation at BRCM Public School, Kolkata for an example http://www.vikramsolar.com/projects/commercial/105-brcm-public-school

detailed analysis is required to verify this). Additional power demands will come from an air conditioner, lighting, printer, scanner, and display unit.

- Wind – Bihar is not characterized by high wind power density, with less than 200 W/m^2 being reported in one study.[12] Ideally, a minimum of 200 W/Sq.m is recommended.[13] However, this is worth investigating further. A number of options are worth exploring, such as small wind turbines designed for residential use, between 2-7m in diameter. These weigh as little as 16kg and are generally very quiet. Ideally, they need to be 9m higher than anything within a range of 150m. These small scale turbines can generate 300-10,000 watts in the right wind conditions.[14] A larger, more substantial installation like the qr5 turbine can be installed on a 15m tower or 6m roof mast. The turbine itself is 5.5m tall and 3.1m in diameter, and is reported to generate between 6.5 and 8.5 KW in a wind of 16m/sec.[15] All power generated using wind would be stored in the Study Centre's inverter and battery bank.
- Inverter and Battery Bank– an invertor converts low voltage DC power generated by solar panels or wind turbines to 120 volts AC that can be used to either run study centre appliances directly or charge a bank of batteries connected to a utility grid. The advantage of having batteries is that, when power is not being used by the centre but is still being generated by the solar or wind systems, it is stored for later use.

In this context, after conducting a thorough analysis of available renewable energy technologies in Bihar and their suitability with the proposed ICT load requirement, solar energy has been considered as the most viable option. Based on the analysis, solar PV technology was found to have greater acceptability and technology adaption for the requirements of teacher training infrastructure spread across the state.

The proposed technical design proposes a solar grid hybrid with storage and manual switchover facility for DG set option. It also considers and mitigates certain critical issues unique to the local conditions in the state, including the threat of theft and vandalism, as well as lack of training and knowledge about Solar PV for the field education department staff. Training needs are proposed to be met through involvement of the project developer in the annual maintenance contract (AMC).

A quantitative assessment of daily energy requirement of ICT loads in the given conditions indicates a daily energy requirement for various categories of institutions ranging from 5.3 kWh for a BRC/CRC, 23.8 kWh for a DIET/ PTTEC, and 32.6 kWh for SCERT. A total solar PV capacity of 607 kW is estimated for the pilot phase, which will cover SCERT and 150 additional sites. The capacity for the entire program, covering 1,201 teachers training institutes, will be around 2,600 kW.

[12] See Wind Resources Map on the Indian Wind Power website at http://www.indianwindpower.com/wind-map.php
[13] See Gross Wind Power Potential report: http://www.indianwindpower.com/pdf/Gross%20Potential%20Wind%20Energy.pdf
[14] See Wikipedia http://en.wikipedia.org/wiki/Small_wind_turbine
[15] See Quiet Revolution http://www.quietrevolution.com/qr5/qr5-turbine.htm

Human Resource Requirements

Clearly a system of this scale requires a wide range of human resources to function effectively. Although detailed analysis of these requirements was beyond the scope of the design work, several key role-players were identified. First is programme managers, who will be responsible for:

- Ensuring that their programmes comply with the criteria for programme accreditation as set out by SCERT.
- Ensuring that their programmes comply with quality standards effective in India and where applicable, outside India. This includes ensuring that their programmes are aligned to the quality criteria set out by the Distance Education Council and, where applicable, to criteria set by Professional Bodies/Departments of Education as employers.
- Ensuring that all conditions of programme delivery are in place (effective communication with students, student support, determination of workloads, timely submission of study material, checking of tutorial letters, and so on).
- Tabling any teaching-related matters (for example, calendar changes) related to their programmes at SCERT programme review meetings.
- Managing and processing RPL applications in their programmes.
- Coordinating and facilitating Programme Reviews (both national and internal reviews).
- Convening Programme Committee meetings (including academics, students, and other stakeholders).
- Leading and managing a team for development and delivery of the programme in accordance to SCERT curriculum review processes.
- Developing and maintaining sound working relationships between centralized and decentralized support departments, so that there is an evolving coherence between the programme and various other programmes and learning pathways that may evolve in future.
- Being responsible for quality assurance of the programme so that the programme not only meets the requirements of the SCERT and/or Professional Bodies, but is delivered in ways that are continually self-improving.
- Advising the relevant Director about all matters pertaining to the programme.
- Ensuring that all documentation submitted to the relevant Director for processing and authorization by staff members of the programme have been properly checked for completeness and correctness.
- Providing intellectual leadership for the programme. This entails tracking both internal and external policy environments and ensuring the programme is responsive to such imperatives.
- Advising the relevant Director about professional development needs of members of the programme, both full-time and part-time.
- Managing and processing applications for exemptions.

Next are the school-based mentor teachers, whose roles include:

- Introducing the student teacher to the school community and explaining his or her reason for being there (making him or her feel at home) if she/he is new, or formalizing a mentoring relationship where a collegial relationship already exists
- Helping teacher students to try new approaches but within an understanding of established school activities and practices (recognizing that some established ways of doing things may need to be questioned and communicating and helping to resolve any tensions between required programme activities and established school practices with the school principal and teacher educators of the local study centre).
- Providing teacher students with information about the school, and its policies, regulations and resources and how these relate to the requirements of the programme.
- Demonstrating various teaching techniques and strategies.
- Providing a space for the teacher student to work and keep materials.
- Encouraging teacher students to evaluate their own progress using a reflective process.
- Providing teacher students with feedback and advice on a regular basis.
- Undertaking assessment of classroom practice using a provided rubric and engaging in critical constructive discussion thereon.

In addition to their study centres-based activities, teacher-educators will at times also act as teaching practice supervisors. Given that the overall purpose of the programme is to improve classroom practice and pupil achievement, it is important that current practice is assessed at the start of the programme and at regular intervals during the programme. Most of this monitoring and support will be provided by the school-based mentor, but teacher educators, acting as teaching practice supervisors, are responsible to build relationships with the schools in their cluster as well as with district officials wherever possible, and to recruit, train and support school-based mentor teachers. They also assess the practice of teacher-students at key milestones – start of programme, end of first year and end of final semester. It is important that teacher educators keep themselves up to date with current developments in the curriculum and the profession.

The following are some of the roles performed during their subsequent school visits:

- Allocate adequate time to visit a teacher-student at a school.
- Allocate sufficient time to visit all students allocated to him/her.
- Observe and assess the lesson presented by the student.
- Meet with the mentor teacher and if possible with the principal to discuss the student's presentation and determine whether the student needs further assistance.
- Meet with the student after the lesson presentation and collect the student's self-reflective feedback.
- Provide own observation and feedback.

- If the teacher educator is of the opinion that the student's performance is poor/unacceptable/below the expected standard, he/she spells out the challenges/concerns and implications and suggests strategies to address them with both the teacher-student and her/his mentor.
- Gather information about the student's learning needs.
- Gather information about the mentor teacher's and/or principal's perceptions and recommendations on the SCERT programme and system.
- Complete the relevant student assessment evaluation form and enter review data onto the SCERT LMS no later than a week after a school visit.

As the process unfolds in Bihar, different training and support needs will manifest themselves. However, there are already several clear areas in which further capacity-building or continuing professional development support will be needed. Amongst others, these include:

- Training/support for Heads of Schools and Senior teachers as school-based mentors and assessors.
- Training/support for study centre-based teacher educators.
- Training/support for DIET/PTEC trainers and assessors.
- Training and support should cover:
  - Orientation to the programme design including the assessment and support strategy;
  - Orientation to the supporting ICT system for all of those who need to use it.
- Orientation briefs for Department of Education officials and other contracted and affected stakeholders etc.
- ICT systems support from SCERT.

Teacher educators at all levels are likely to be more experienced in contact-based provision and may be tempted to lecture on the content of the programme. This would undermine the proposed design of the learning resources that students should engage with the content. Guidelines are therefore needed for teacher educators on how to facilitate discussion, consolidate learning and model good teaching practice in their engagements with student study groups. An additional requirement for teacher educators working from a Study Centre will be an orientation to the ICT used to support the teaching and learning processes. They will need to be familiar with the LMS in order to teach and support students new to the platform. Some of the course administration will also be done using the LMS. Teacher Educators will also be the Study Centre coordinators and so some minor maintenance tasks will be necessary (such as replacing ink cartridges or running a virus checker).

Those responsible for training the teacher educator study centre coordinators will be drawn from the DIETS and PTECs. Consequently, trainers need to be well versed in the programme's pedagogy, mentoring techniques, LMS operation, and minor technical support. They too will need to be trained. The DIETS and PTECs can draw on different personnel to specialize in certain areas, but the programme of training they develop needs to appreciate that these diverse

skills need to be acquired by one person. This is especially true of the CRC Study Centre coordinators.

Personnel at the DIET and PTEC level, and, in some instances, the BRC level, will also have the task of coordinating and administrating the programme for their district. Consequently, these personnel need to be trained to diagnose district data collected by the LMS, as well as data collected during the multiday orientation and semester workshops hosted by the DIETs and PTECs. These personnel will also be responsible for the deployment of the assessment and support strategies at the district level and will need to be trained on methods of assessment that elicit the skills the programme design encourages as well as strategies to engage clusters and blocks that are struggling with the new way of teaching and learning.

At the SCERT level, personnel will also need training to effectively support the programme. All facets of the programme need to be championed at this highest level. Personnel need to be intimate with the new pedagogy, the course materials, ICT integration and the technical specifications of the Study Centres. One of their responsibilities will be to devise and run a programme of capacity development for all stakeholders of the Diploma. In addition they will be responsible for analysing the success and failures of the programme at a state level.

CHAPTER 4: CONCLUSION-EMERGING LESSONS

As can be seen from the narrative above, the process of developing capacity to support teacher education in Bihar has been a comprehensive and wide-ranging exercise. While the process is ongoing (and in many ways still embryonic), extensive knowledge has been generated that is potentially applicable in many developing country contexts. Beyond the experiences documented above, there are a few key emerging lessons that are worth documenting:

1) *Effective design of teacher education systems cannot be conceptualized as a once-off intervention*. Rather, it is a series on ongoing, iterative processes that continually needs to adjust to changing circumstances. In the case of Bihar, these processes are still unfolding as implementation continues.
2) Assuming that teacher education systems focus primarily on the public sector, *the design and development process must ultimately be led by the relevant government agencies*, with technical support from others as needed. Well-intentioned efforts to undertake design on behalf of such agencies, for example by NGOs or donor-funded activities, are generally always unsuccessful in the long run, as the requisite government ownership is too weak to ensure implementation and sustainability. Success in Bihar has been largely a function of the fact that government has led the process from the outset.
3) Although it is tempting to design state-of-the-art ICT architectures, the prospect of their failure is very high. Thus, *educationally effective design of ICT architectures needs to take contextual realities and logistical constraints into account to be relevant and useful*. Importantly, in developing country contexts and particularly in large-scale implementation where resources are scarce, there is little merit in experimenting with untested technologies, particularly as there is now enough evidence of successful technological models that can be harnessed to avoid this type of experimentation.
4) Although ICT is an important piece of the puzzle, *the real challenge in designing teacher capacity development systems is to ensure that they are built on a sound pedagogical platform*. The design of the Diploma Programme provides exactly this kind of platform, developed over an extended period through ongoing consultation and engagement.
5) Given the previous recommendation, *implementation of effective pedagogy is only as effective as the people engaged to deliver it*. As is clear from the description of capacity development needs, there is still much work to be done in capacitating teacher educators in the State to do this well, although it is promising that there has already been extensive work to build this capacity.

Consequently, although the journey in Bihar is, in many ways, just beginning, it has already yielded many lessons and innovative models that are potentially in many other contexts.

SELECTED BIBLIOGRAPHY

- Government of India – Ministry of Human Resource and Development. (2011). *Overview of Teacher Education Policy in India.* Retrieved from http://mhrd.gov.in/print/1665.
- Government of India – Ministry of Human Resource and Development (Department of School Education and Literacy). (ND). *About Teacher Education*. Retrieved from http://www.teindia.nic.in/About.aspx.
- Government of India – Ministry of Human Resource and Development (Department of School Education and Literacy). (ND). *Policy Context*. Retrieved from http://www.teindia.nic.in/policycontext.aspx.
- Government of India – Ministry of Human Resource and Development (Department of School Education and Literacy). (ND). *Reforms in Teacher Education in India*. Retrieved from http://www.teindia.nic.in/reforming_TE.aspx.
- Mays, T. 2011a. Programme modelling: a Nadeosa investigation into the cost and human resource implications for different models of ODL provision. Johannesburg: Nadeosa and Saide.
- Mays, T. 2011b. Developing practice: teaching teachers today for tomorrow. US-China Education Review, December 2011.
- National Council of Educational Research and Training. (2009). *Comprehensive Evaluation of Centrally Sponsored Scheme on Restructuring and Reorganization of Teacher Education.* Retrieved from http://www.teindia.nic.in/js/TE_Scheme_review_NCERT_Review.pdf
- National Council for Teacher Education. (ND). *Evaluation of the Diploma in Primary Education Programme through Distance Education.* Retrieved from http://www.teindia.nic.in/js/Report_on_IGNOU_%20DPE_Prog%20by_NCTE_experts.pdf
- National Council of Educational Research and Training. (2012). *Impact of In-service Teacher Training on Classroom Transaction.* Retrieved from http://www.teindia.nic.in/js/Impact_of_TT_Aug2012.pdf.
- National Council of Educational Research and Training. *Fifty Years of Teacher Education in India (Post Independence Developments).* Retrieved from http://www.teindia.nic.in/js/50Years_TE_Devp.pdf.
- Government of India – Ministry of Human Resource and Development. (1997). *National Council for Teacher Education Rules.* Retrieved from http://www.teindia.nic.in/Files/RTE-Act-2009/NCTE_rules.pdf.
- Ministry of Law Justice and Company Affairs. (1993). *National Council for Teacher Education Act-1993.* Retrieved from http://www.teindia.nic.in/Files/TE-Vikram/NCTE_ACT-1993.pdf.
- University of South Africa (Unisa). 2013. Supporting teaching practice: a manual for mentors and supervisors. Pretoria: Unisa.