Implementations in Countries Outside India

Department of School Education & Literacy
Ministry of Human Resource Development, Government of India

Report Prepared with inputs from Choice Solutions (USA) and EY (China & Singapore)

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1. Introduction

Solution scan of the education solutions implemented in China and Singapore was carried out to identify any additional relevant products / solutions and implementation models that can be considered for implementation in Government and Government-Aided Schools in India. The ecosystem covering the themes with respect to governance mechanisms and standards that has been setup for implementing ICT in School Education in the USA was also studied to identify any relevant educational data and content standards that may be applicable for Indian context.

1.1. Methodology

NISG has tasked the Choice Solutions team with preparing the report of Implementation in School Education in the United States. Choice Solutions has implemented Student Longitudinal Data Systems (SLDS) in multiple states in the USA and the report is prepared based on the in-depth experience of Choice Solutions in implementing such solutions in the USA.

In addition to United States, NISG has tasked EY for case studies of two additional countries. The criteria for selection of countries for which secondary literature review was:

a. One that sets benchmark – something India should aspire for and
b. the other which is facing similar challenges as India in increasing the outreach of ICT in schools.

Using these two criteria the following two countries were selected for conducting secondary research in addition to United States,

c. China – is expanding the use of ICT in schools in remote areas.
d. Singapore – quite advanced in making use of ICT in education.

The following framework was used to collect information from China and Singapore.. Since it was only a desk review, the available information in public domain was used to prepare two case studies for China and Singapore.

Table: Framework used for review of ICT in Education in China and Singapore

Area of Review	Specific Areas of Inquiry
Broader Environmental Context	Education System Responsiveness Economic and Socio Cultural Context
Policy and Regulatory Environment	Policy Development (whether ICT in education policy is integrated in national ICT policy) Implementation of the policy Inter-Ministerial Collaboration
Use of ICT in schools	School Management Services – related to profile of students/teachers, student/teacher performance; how information is shared with parents, community and administrators MIS services – mechanism for aggregation of data Learning support services – assessment as a tool for improving classroom transaction; different technologies being used in classrooms; examples of self learning tools Governance services – use of ICT in conducting examinations and trainings; record keeping to support decision making
Management and Financing	Integration of educators and technocrats Resources from Government – Donor and Private Sector Strategies for sustainability
Technology Infrastructure and Connectivity	Support from Telecommunications Connectivity Options Choice of mode of deployment of technologies Emerging technologies
Monitoring and Evaluation	Evaluation methodologies Programmeme Evaluation

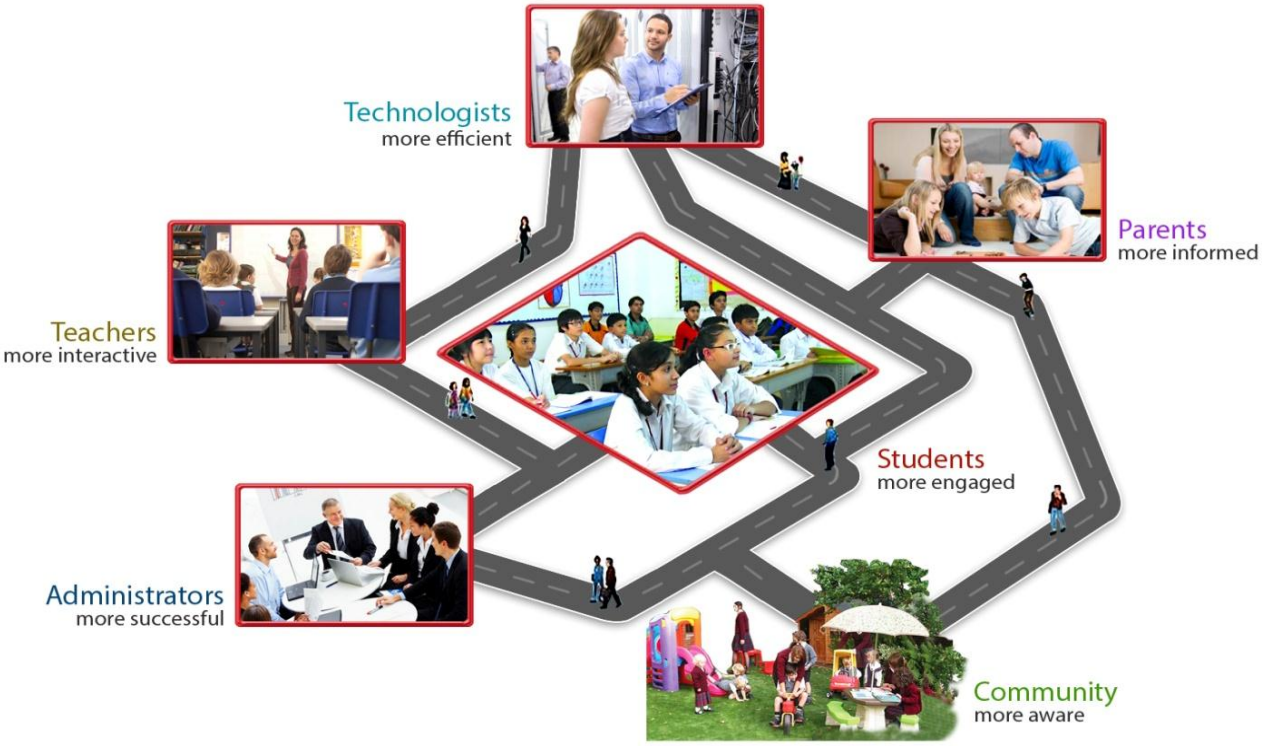
2. Case Study: USA

NISG has tasked the Choice Solutions team with preparing the report of Implementation in School Education in the United States. Based on the in-depth experience of Choice Solutions in implementing such solutions in the USA, the report has been created. Choice Solutions has implemented Student Longitudinal Data Systems (SLDS) in multiple states in the USA. An SLDS Implementation includes the consideration of administration, governance, policy and IT application implementation. This section, which covers these topics, is prepared based on the knowledge of such implementations in the US education market place. Several components of these implementation details need to be customized to the India education space prior to implementing the solutions.

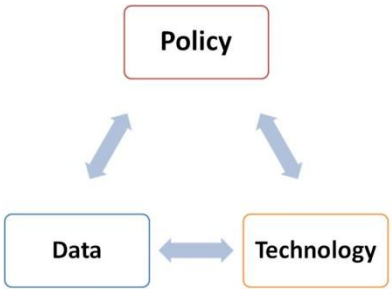
Creating an enterprise education ecosystem with an emphasis on effective data and content usage is a noble and compelling goal for any education entity. The challenge associated with addressing this goal is founded in the ability to create a policy- and standards-driven platform to support the needs of all constituents. In implementing this vision in India, it is important to look at how other education administrative agencies have worked to mature their processes and systems to support this goal. In this paper the best ways to instantiate this practice are outlined, drawn from the implementation experience and research.

2.1. Overview

The future of education industry is expected to be completely automated where all the key stakeholders could interact with each other and help enhance the learning experience of the student, improve the teacher-student interaction, create advanced learning management solutions, involve parents in managing student's learning process, provide informed decision making support for the administrators/legislators and finally helping the community with learned and qualified citizens.



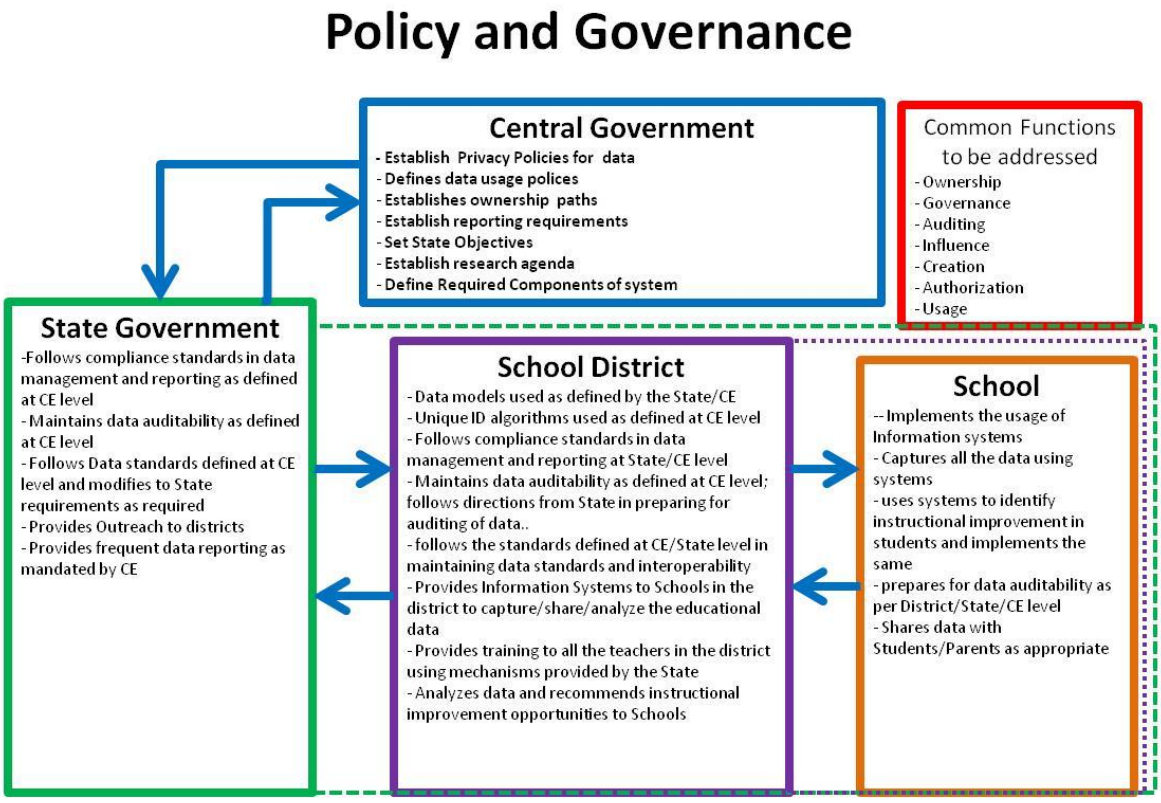
Implementation of ICT for education involves not only the ICT components but also the education policy, data and content management, data, content and IT governance, education standards, identity management, and security management of data and content. As we can see form the following diagram, Policy/Data and Technology are all tightly coupled within the education ICT space.

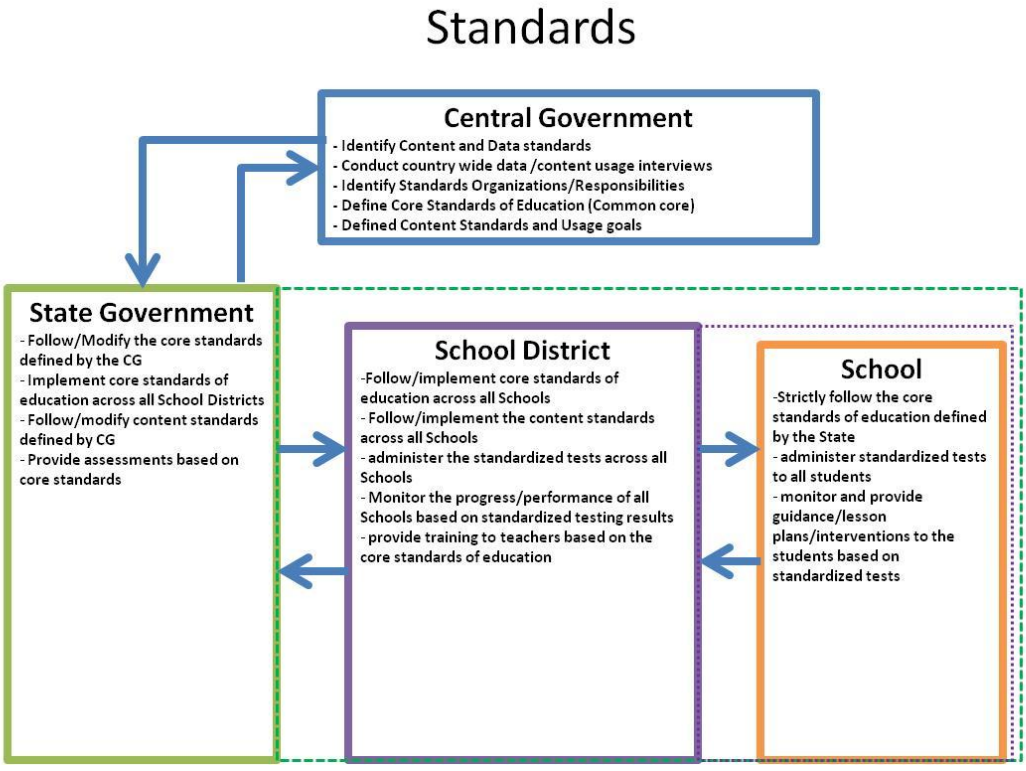


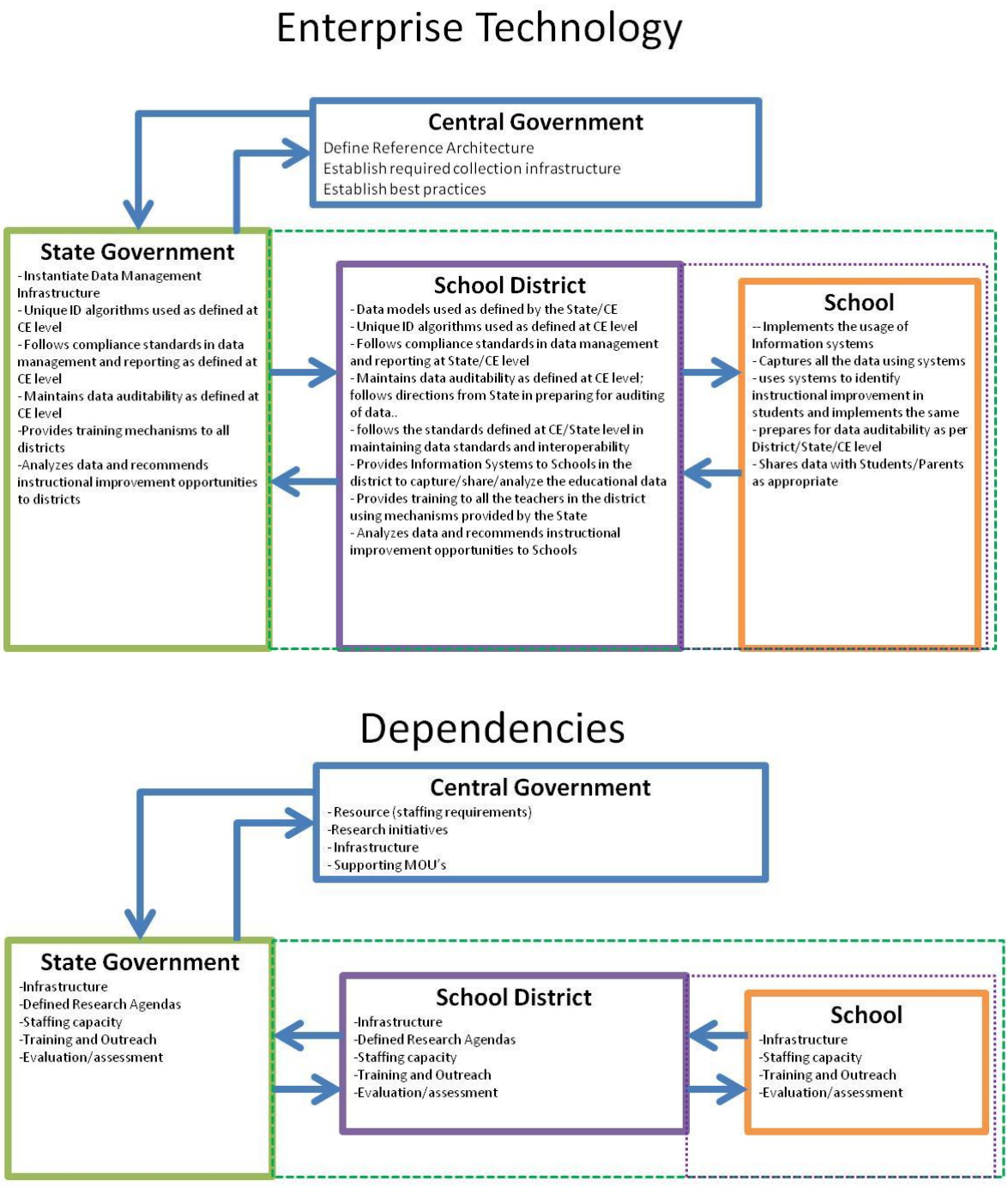
The education space is the responsibility of following government agencies:

a. Central Government Educational Agencies (CGEA)
b. State Government Educational Agencies (SGEA)
c. District Government Education Agencies (DGEA)
d. School Administration

The following diagrams provide an overview of the educational framework that is driven by the above mentioned agencies under Policy Governance, standards, Enterprise Technologies and other dependencies.







Creating a list of dependencies and assumptions based on current state of technological and pedagogical maturity

This section brings attention to all of the above-mentioned components with a focus on how these have been implemented and legislated for in the US educational

environment. Additionally, it also looks to document major standards which have been applied to those discrete components.

The components are defined under four major strands for clarity:

a. Policy and Standards
b. ICT Architecture
c. Security
d. Implementation

These four strands will cover the entire ecosystem of ICT implementation in school education.

Under each Strand/ICT Component for every level of Organization (CGEA, SGEA, DGEA and School Admin), the following are the functional responsibility areas:

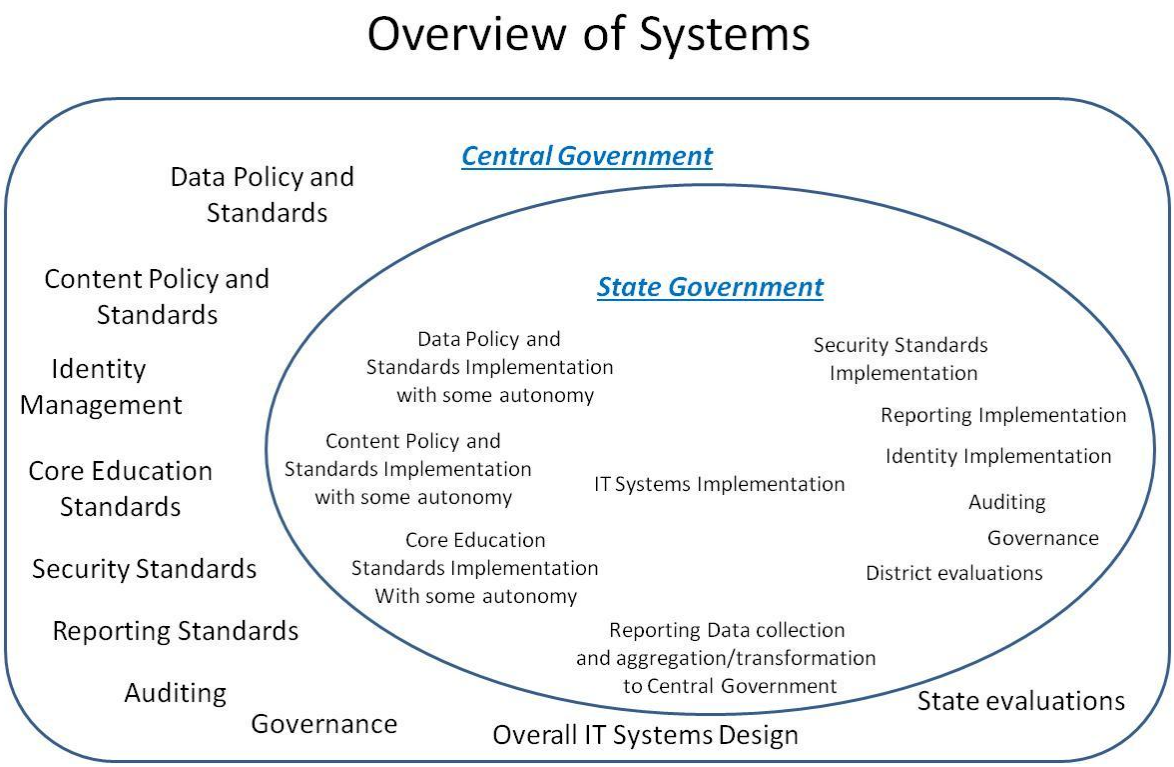
Ownership, Governance, Creation, Authentication, Influence and Usage

The following matrix identifies the responsibilities of each Organization within these functional components under each Strand:

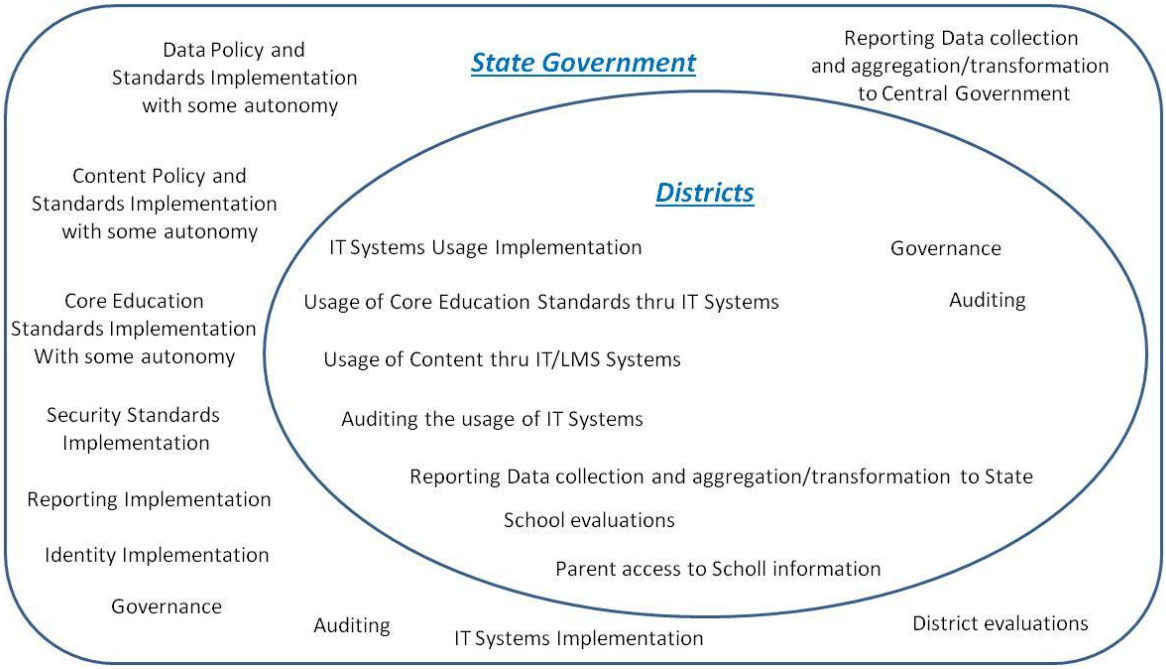
Functional Responsibilities Matrix						
Policy and Standards (Data, Content, Identity, Standards and ICT)						
Organization	**Ownership**	**Governance**	**Creation**	**Authentication**	**Influence**	**Usage**
CGEA	Yes	Yes	Yes	Yes	Yes	Yes
SGEA	Yes	Yes	Yes	Yes	Yes	Yes
DGEA	No	No	No	No	Yes	Yes
School Admin	No	No	No	No	Yes	Yes
ICT Architecture (Data, Content, Identity, Standards and ICT)						
Organization	**Ownership**	**Governance**	**Creation**	**Authentication**	**Influence**	**Usage**
CGEA	Yes	Yes	Yes	No	Yes	Yes
SGEA	Yes	Yes	Yes	Yes	Yes	Yes
DGEA	No	No	No	No	Yes	Yes
School Admin	No	No	No	No	Yes	Yes
Security (Data, Content, Identity, Standards and ICT)						
Organization	**Ownership**	**Governance**	**Creation**	**Authentication**	**Influence**	**Usage**
CGEA	Yes	Yes	Yes	Yes	Yes	Yes
SGEA	Yes	Yes	Yes	Yes	Yes	Yes
DGEA	Yes	Yes	Yes	Yes	Yes	Yes

School Admin	Yes	Yes	Yes	Yes	Yes	Yes
Implementation (Data, Content, Identity, Standards and ICT)						
Organization	**Ownership**	**Governance**	**Creation**	**Authentication**	**Influence**	**Usage**
CGEA	Yes	Yes	NA	NA	Yes	Yes
SGEA	Yes	Yes	NA	NA	Yes	Yes
DGEA	Yes	Yes	NA	NA	Yes	Yes
School Admin	Yes	Yes	NA	NA	Yes	Yes

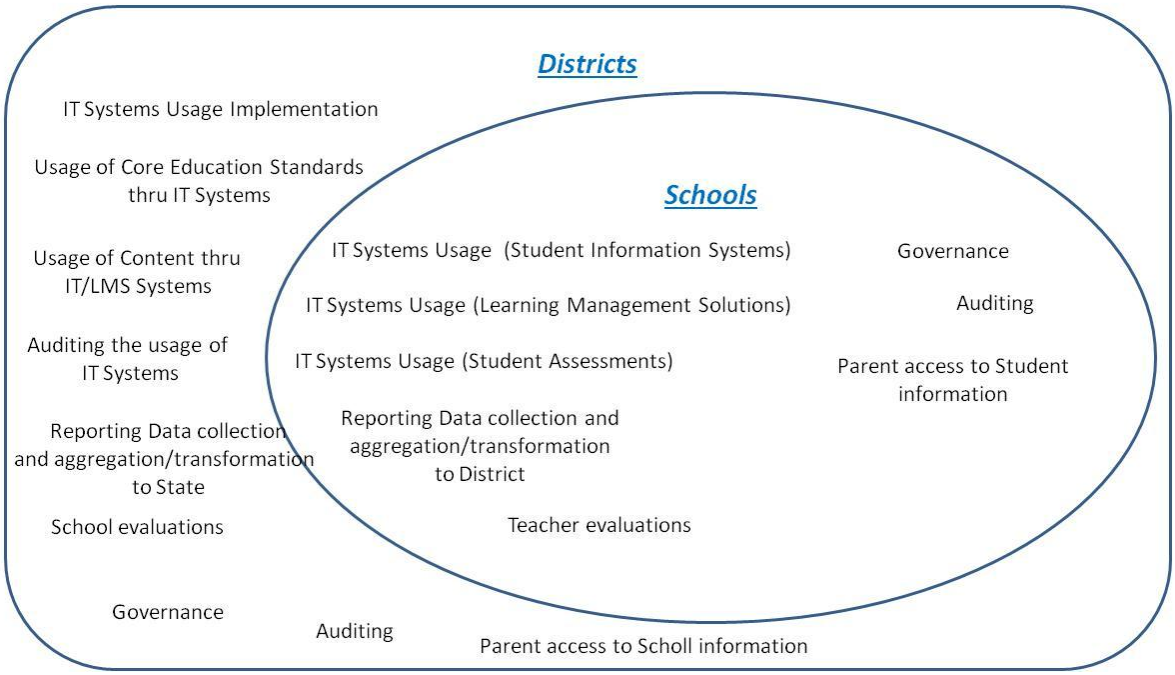
The following diagrams show the oversight of Data Governance, Standards, Security and ICT systems between four government agencies when the systems are implemented.



Overview of Systems



Overview of Systems



2.2. Policy and Standards

2.2.1. Policy

The driving forces behind educational reform in the US over the past two decades have been policies at both the local and national level. The legislative decisions and subsequent funding have greatly changed the landscape of educational data and learning management systems in the US.

As outlined above the Elementary and Secondary Education Act (ESEA) and subsequent No Childe Left Behind Act (NCLB) *(www.ed.gov/nclb)* were some of the initial drives behind the data driven and accountability systems in the US. This work has been followed up by competitive and non-competitive grant driven initiatives including State Longitudinal Data System Grants (SLDS), Investing in Innovation (i3) Grants (www.ed.gov/programs/innovation), Race to the Top (RttT) Grants, Title 1 Grants (www.ed.gov/programs/**titlei**parta/) provide the funding incentives to help drive wholesale change within state departments of education as it relates to how they store and manage data.

a. I3 Grants
   i. The Investing in Innovation Fund, established under section 14007 of the American Recovery and Reinvestment Act of 2009 (ARRA), provides funding to support (1) local educational agencies (LEAs), and (2) nonprofit organizations in partnership with (a) one or more LEAs or (b) a consortium of schools. The purpose of this program is to provide competitive grants to applicants with a record of improving student achievement and attainment in order to expand the implementation of, and investment in, innovative practices that are demonstrated to have an impact on improving student achievement or student growth, closing achievement gaps, decreasing dropout rates, increasing high school graduation rates, or increasing college enrollment and completion rates.

   ii. These grants will (1) allow eligible entities to expand and develop innovative practices that can serve as models of best practices, (2) allow eligible entities to work in partnership with the private sector and the philanthropic community, and (3) identify and document best practices that can be shared and taken to scale based on demonstrated success.

b. SLDS Grants

i. Better decisions require better information. This principle lies at the heart of the Statewide Longitudinal Data Systems (SLDS) Grant Program. Through grants and a growing range of services and resources, the program has helped propel the successful design, development, implementation, and expansion of K12 and P-20W (early learning through the workforce) longitudinal data systems. These systems are intended to enhance the ability of States to efficiently and accurately manage, analyze, and use education data, including individual student records. The SLDSs should help states, districts, schools, educators, and other stakeholders to make data-informed decisions to improve student learning and outcomes; as well as to facilitate research to increase student achievement and close achievement gaps.

c. RttT Grants

i. Through Race to the Top, we are asking States to advance reforms around four specific areas:
   - Adopting standards and assessments that prepare students to succeed in college and the workplace and to compete in the global economy;
   - Building data systems that measure student growth and success, and inform teachers and principals about how they can improve instruction;
   - Recruiting, developing, rewarding, and retaining effective teachers and principals, especially where they are needed most; and
   - Turning around our lowest-achieving schools.

ii. Awards in Race to the Top will go to States that are leading the way with ambitious yet achievable plans for implementing coherent, compelling, and comprehensive education reform. Race to the Top winners will help trail-blaze effective reforms and provide examples for States and local school districts throughout the country to follow as they too are hard at work on reforms that can transform our schools for decades to come.

d. Title 1 Grants

i. Title I, Part A (Title I) of the Elementary and Secondary Education Act, as amended (ESEA) provides financial assistance to local educational agencies (LEAs) and schools with high numbers or high percentages of children from low-income families to help ensure that all children meet challenging state academic standards. Federal funds are currently allocated through four statutory formulas that are based primarily on census poverty estimates and the cost of education in each state.

Basic Grants provide funds to LEAs in which the number of children counted in the formula is at least 10 and exceeds 2 percent of an LEA's school-age population. Concentration Grants flow to LEAs where the number of formula children exceeds 6,500 or 15 percent of the total school-age population.

- Targeted Grants are based on the same data used for Basic and Concentration Grants except that the data are weighted so that LEAs with higher numbers or higher percentages of children from low-income families receive more funds. Targeted Grants flow to LEAs where the number of schoolchildren counted in the formula (without application of the formula weights) is at least 10 and at least 5 percent of the LEA's school-age population.
- Education Finance Incentive Grants (EFIG) distribute funds to states based on factors that measure:
    - a state's effort to provide financial support for education compared to its relative wealth as measured by its per capita income; and
    - the degree to which education expenditures among LEAs within the state are equalized.

2.2.2. Policy Impacts

Policy decisions in the US are largely driven by funding and control. By providing both a carrot and a stick, the federal departments of education or state departments of education can significantly influence or impact the way education administration utilize funds to drive desired outcomes. These initiatives, especially the grant driven initiatives provide the ability for organizations to decide on which policies have benefit for them and are generally not mandates, but incentive driven.

Additionally, these policy mandates have changed the way certain state departments of education have looked at servicing their constituent districts. Traditionally, state departments of education have focused on compliance; but now, with increased funding, there are opportunities for states to begin to offer additional data and learning services toward their districts. This shift is to both support underfunded districts as well as provide a best practices framework to support the overall goals of the state.

Examples include:

a. Ohio and Massachusetts have partnered to provide a statewide instructional improvement infrastructure for all districts who enroll in program
b. NY state is implementing a statewide content and education portal for all state constituents
c. Wyoming has released a statewide assessment management analytic tool

2.2.3. Standards

Standards and policies are seen as core plumbing issues required to address effective, efficient and sustainable systems which will allow for comparability, compatibility, and maintainability. Without data standards and content standards the ability to manage data long term is nearly nonexistent.

2.2.4. Data Standards

Through last 10+ years in work with education, the positive impact of standards is clearly visible on education. The challenge that standards present is that they need to be comprehensive and managed to support changes over time. Although standards are important for effective education data management, they are only one component of the overall ecosystem that a federal, state, and local education organization needs. To support this need, organizations need to establish entities to establish and help enforce those standards to support required adoption.

Education data is pervasive and creating standards allow that data to be effectively collected, coalesced, and compared to provide meaningful insight for all stakeholders.

As defined, data is “Factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation < the data is plentiful and easily available” (H. A. Gleason, Jr.). However, that definition does not answer the questions that need to be answered within your education ecosystem. The goal to establishing data standards is to ensure that the data and information available within the system can be used to help improve future outcomes.

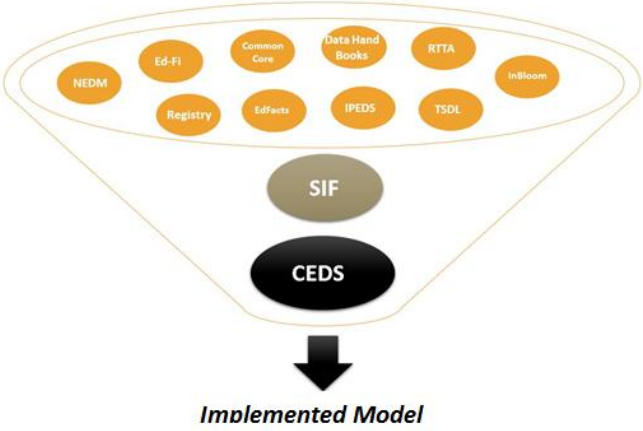
Establishing data standards has a dramatic impact on the following areas:

a. Data Usage
b. Data Collection
c. Data Management
d. Data Analysis

In the US, the primary factor driving data standards has been federal-based education reform policies dating back to the 1980s. These policies force vertical reporting from the local and state level up to the federal government. Through this vertical reporting, the federal government began to mandate the types as well as format in which data must be reported.

In 2001, with the passing of the No Child Left Behind (NCLB) Act, the US federal government introduced a wide range of compliance initiatives on which state and district entities would have to report in order to receive requisite funding. Initially, there were limited standards or policies on how to effectively collect and transmit that data, which essentially became a heavy labor burden on the state and district entities.

Understanding these challenges, many governmental and non-governmental organizations have been established to help guide those efforts and create more transparency and increase effectiveness in the data management requirements.



Implemented Model

Some of the most notable organizations and initiatives are as follows:

a. **The Institute of Educational Sciences (IES)**: Provides rigorous and relevant evidence on which to ground education practice and policy and share this information broadly. By identifying what works, what doesn't, and why, IES aims to improve educational outcomes for all students, particularly those at risk of failure. They are the research arm of the U.S. Department of Education, and by law their activities must be free of partisan political influence.
b. **National Center for Educational Statistics (NCES):** The data research arm of IES and the primary federal entity for collecting and analyzing data related to education in the U.S. and other nations. NCES is located within the U.S. Department of Education and the Institute of Education Sciences.

i. **NCES Data Handbook:** Provides guidance on consistency in data definitions and maintenance for education data, so that such data can be accurately aggregated and analyzed.

ii. **National Education Data Model (NEDM):** A conceptual but detailed representation of the education information domain. The Education Data Model strives to be a shared understanding among all education stakeholders as to what information needs to be collected and managed at the local level in order to enable effective instruction of students and superior leadership of schools.

iii. **Common Education Data Standards (CEDS):** A national collaborative effort to develop voluntary, common data standards for a key set of education data elements to streamline the exchange, comparison, and understanding of data within and across P-20W institutions and sectors.

c. **Data Quality Campaign (DQC):** A nonprofit, nonpartisan, national advocacy organization committed to realizing the vision of an education system in which all stakeholders—from parents to policymakers—are empowered with high-quality data from the early childhood, K–12, postsecondary, and workforce systems to make decisions that ensure every student graduates high school prepared for success in college and the workplace. To achieve this vision, DQC supports state policymakers and other key leaders to promote the development and effective use of statewide longitudinal data systems.

d. **School Interoperability Framework (SIF) Association:** A unique, non-profit collaboration composed of over 3,200 schools, districts, local authorities, states, US and International Ministries of Education, software vendors and consultants who collectively work to define the rules and regulations for educational software data interoperability.

e. **Postsecondary Electronic Standards Council (PESC):** A data interoperability standard designed to aid in data and systems operability for post-secondary institutions and vendors.

Our previous work shows us just how crucial of a component data will be for the educational ICT needs. We feel there needs to be a strong focus on data standards are defined, instantiated and managed at different organizational levels. While the Central Government Education Agency (CGEA) defines the overarching data definitions and data models for capturing educational data across all States/Districts/Schools, responsibilities of capturing/maintaining/securing the same will be spread across State Government Education Agency (SGEA), District Government Education Agency (DGEA) and School administrative staff.

2.2.4.1. Data Usage

Over the last 20 years in the United States, many agencies have worked to establish effective and efficient data usage processes. These organizations have driven that work both through compliance reporting as well as a focus on data-driven decision making in the classroom. For ICT to effectively set a data structure and model, it is essential to understand what data is actually available, and not only what is desired for future considerations. These data standards represent a maturing of the data usage and packaged services models in the United States.

a. **Existing Data**: Part of the process of developing or adopting an existing educational data model for use with the Indian market will be the auditing of data usage. This includes establishing a minimal viable data model as well as analyzing best practices for future consideration.
b. **Future Data:** Establishing a vision and usage pattern for data-driven education requires structures to both store and report on that data. Understanding the data usage patterns within international markets, as well as reference implementations, will help guide the future data usage patterns in India.

Since these models have been developed, there have also been several reference implementations put in place at both local and national levels that have looked to take the logical design, and instantiated physical models to support their needs.

2.2.4.2. Data Collection

As mentioned, the primary data collection mechanisms in the US have been initially focused on compliance data. That data has been designed primarily to support the NCLB and EDFacts reporting requirements.

EDFacts is a U. S. Department of Education (ED) initiative designed to collect and place state-reported K through 12 education performance data at the center of policy, management and budget decisions for all K-12 educational programs. The vehicle used to collect this data is through the Education Data Exchange Network (EDEN). EDEN is a centralized portal through which states submit their educational data to the U.S. Department of Education. Critical directory data are submitted in the beginning of year, as well as data on schools, services, staffing, students, and educational outcomes in order to meet the data requirements of annual and final grant reporting, specific program mandates, and the Government Performance and Results Act.

EDFacts centralizes performance data supplied by K through 12 state education agencies (SEAs) with other data assets within the Department, such as financial grant information, to encourage improved analysis and use of data. Data is generally submitted at the state, district and, in some instances at school levels. EDFacts does not collect individual student or staff-level information and all information provided to EDFacts is aggregated, often by categories such as grade level.

EDFacts is a U. S. Department of Education initiative to put performance data at the center of policy, management and budget decisions for all K-12 educational programs. EDFacts centralizes performance data supplied by K-12 state education agencies (SEAs) with other data assets, such as financial grant information, within the Department to enable better analysis and use in policy development, planning and management. The purpose of EDFacts is to:

a. Place the use of robust, timely performance data at the core of decision and policymaking in education.
b. Reduce state and district data burden and streamline data practices.
c. Improve state data capabilities by providing resources and technical assistance.
d. Provide data for planning, policy, and management at the federal, state, and local levels.

2.2.4.3. Data Analysis

Significant changes have been made in the types of data collected and in turn the types of reports being generated on this data. Often, the need for data is no longer just to cover compliance mandates; but, to provide true organizational insights and a decision making platform for key stakeholders. Data reporting and analysis are determined heavily by the type and sensitivity of the data, as well as who the viewing audience will be.

The following are examples of state based reporting for compliance and public consumption:

- http://svapp15586.ksde.org/k12/k12.aspx Kansas Department of Education
- http://dw.education.maine.gov/DirectoryManager/Web/Maine_report/MaineLanding.aspx Maine Department of Education
- http://fusion.edu.wyoming.gov/ART/WEB/art_report/ARTHome.aspx Wyoming Department of Education

These resources have a wide variety of reporting styles and applications as well as the ability to provide secure role based access for more granular data for education.

These solutions also have the ability to use granular data for local administrators, which in turn provides them with a decision support capabilities based on the data.

2.2.4.4. Data Governance

Effective data governance is one of the most central aspects of an education data system. Agencies sharing data need to have a say in how that data is used, and they need to have a stake in the overall project. Beyond software expertise, the Choice Solutions team is uniquely positioned to aid India in their data governance challenges. For example, our Vice President of Client Implementation Services holds the CGEIT (Certified in the Governance of Information Technology) credential from ISACA and has many years of experience with data governance in both the private and public sectors, including education data.

Governance refers to the oversight of people, policies, procedures and processes that affect the integration, availability, usability, quality, and security of the data assets of an organization. The traditional three pillars of data governance are compliance, business integration, and business transformation. The Choice team has worked with other agencies in multiple states to implement these pillars.

Historically, risks in creating governance programs include imprecise definitions, multiple governance frameworks and nebulous requirements. We are convinced that long term education data system project success requires ubiquitous authoritative data governance program. That is why our implementation strategy includes providing expertise and allocating project time to the initiation of the data governance program's deployment by defining and documenting the existence of key high level components, including:

a. strong leadership
b. data quality management
c. controlled analysis and reporting
d. security and confidentiality
e. resource management
f. policy relevant strategic data use and accessibility
g. communications and public relations plan

Once these components are recognized, the development of robust data governance policies and procedures will serve to insure the integrity and security of these data managed by each source institution. It makes possible the aforementioned data sharing requirements. It also balances the transactional requirements of conducting educational operations and compliance report generation with the evolving requirement to coalesce multiple sourced data into researchable data extractions for

policy relevant analysis. When the program is designed, deployed, operated, and sustained, the benefits of the program will include:

a. the effective creation and application of policies and processes designed to extract the maximum value from data owned, stewarded and/or managed within the education data systems organization while managing acceptable risks
b. providing a forum where all appropriate stakeholders are given a voice
c. designing and implementing a conflict resolution methodology
d. designing and implementing the decision making processes associated with data collection and usage, determining how accountability and data quality are assured
e. creating formalized processes and artifacts for data access requests, memoranda of understanding (MOUs), intergovernmental agreements (IGAs) and addition of future data sources
f. clearly defining the roles of appropriate stakeholders while defining their associated responsibilities, involvement and interdependencies
g. setting the governance board's and stakeholders' rules of engagement
h. defining data ownership, data stewardship, data management and data quality responsibilities
i. setting procedures and best practices related to data collection and provisioning
j. setting procedures and best practices related to data usage and consumption
k. setting data usage requirements
l. determining the threat environment
m. determining the organizational hierarchy, culture, data and work flows
n. establish stakeholder collaborative/communication processes and systems, including frequencies and methods of sharing
o. training goals and guidelines
p. documentation and artifact standards
q. process development and the enterprise information lifecycle management (collection, retention, update, process, delete/archive, transfer and access)
r. oversight of the security framework (risk assessment, security assessment/IT controls, security metrics, security incident management, security awareness training program)
s. reduction of solution/management TCO and enhancement of sustainability metrics
t. strong intersection with data management constructs including:
    i. Data Quality (standards, validations, consensus of rules, 'operational DG')
    ii. Data Integration

iii. Metadata Management (data definitions and context "semantics rather than physical data")
iv. Master Data Management (consensus driven data definition)
v. Data Warehousing (data model accurately represents information related to the agency's goals and mission for analysis purposes and Decision Support)
vi. Data Administration
vii. Enterprise Data Architecture (sometimes Data Governance policies dictate changes to data models so they comply with physical or semantic standards and are more conducive to integration and quality operations) provide transparency into all aspects of governance and data warehousing structures

Fundamentally, when implementing a successful governance program, the initial step is recognizing that a governance program is an operational framework that includes organizational structures that define data policies and procedures and their implementation strategies, and has a keen eye on measurable outcomes that ensure managed availability of quality data. Through this data informed usage, the ability to create quality enlightening information that can be transformed into actionable insight is now a true reality. By definition, informed data usage involves systematically collecting, analyzing, and interpreting the varied types of data that guide informed decision making processes at all levels of the early childhood, economic, education (e.g., higher education including community colleges and career tech), student/learner information including assessments, and so on, educator information, (financial, and so on), welfare, health care, unemployment and workforce pipelines.

Governance programs that simply refer to the term "data quality" without defining it are lacking the details necessary to author an exceptional governance program. Within the governance framework, the ultimate objective of providing quality data results from implementing a governance program that ensures the completeness, accuracy, consistency, validity, integrity, security, timeliness, accessibility of the system-managed data.

Each of these data attributes must be addressed in a systematic and rigorous fashion to ensure data quality. Achieving this level of data quality necessarily imposes a set of technical and organizational requirements that must be governed.

When implementing a governance program, there are two recommended organizational bodies that work in concert to achieve the desired results: the Data Governance Board and the Data Management/Technical Team.

The Data Governance Board has authority in enterprise data issues, leaving the source institutions to continue to govern their education data systems source data locally. When creating the Board, a charter is created that authorizes the formation of the education data systems Governance Board which defines targets that include:

a. Better decision-making anchored in the integration of available data assets into a single version of reality
b. Creating a forum for a common voice to create policy
c. Reduced operational friction between the business units through adoption of an enterprise view of all data assets
d. A commitment to the needs and a clarification of the responsibilities of all data stakeholders whether they are data providers, data consumers, or both
e. A culture that motivates all levels of management and staff to seek out and adopt common approaches to data issues
f. Generate and implement standardized, repeatable, and auditable data processes
g. Reduced costs and increased effectiveness in the data arena through the coordinated efforts of all business units and stakeholders
h. Transparency of all data related business rules and the processes that execute them
i. Standardized data definitions across the multiple information and data domains, with input from internal and external SMEs
j. Transition of business units from narrow-use data silo operations to broad-use enterprise data systems, and the evolution of their role as “data owners” to stewards and suppliers of quality data to the enterprise
k. Establishment of direction and measurement of Data Quality initiatives, including the definition of responsibilities and accountabilities of business units, their Data Stewards and their data quality officers
l. Creation of personally identifiable information (PII) and small cell size aggregation acceptable use policies
m. Creation of roles and their decision rights and accountabilities to:
    i. establish safeguards and controls for data privacy compliance, and
    ii. control access management to meet usage standards
n. Centralized technology architecture to mitigate data integration challenges between cross-functional business units in order to meet the data and information needs of all education stakeholders
o. Maintenance of the operational integrity of education data systems solution through the enforcement of Change Management standards and rules for all data processes that support this and other longitudinal data system components

p. Data Stakeholders (consortium internal, consortium external, data consumer or data provider) have a forum to present data needs and perspectives
q. Define rights and accountabilities to establish safeguards and controls for Data Security, Confidentiality and Privacy compliance
r. Define rights and accountabilities to control Access Management in order to meet data usage standards
s. Centralized technology architecture to mitigate data integration challenges from any internal or external data sources
t. All data stakeholders (internal, external, consumer, provider) have a forum to present data needs and perspectives
u. Operational integrity of downstream data delivery mechanisms preserved by enforcement of change and configuration management standards/controls

The Governance Board's membership generally includes a broad spectrum of vested stakeholders including, but not limited to: agency/institutional executives, policymakers and staff, program managers, data stewards, local education leaders, and technical leadership. One of the most important "enterprise-level" outcomes of implementing Choice's governance strategies is the inclusion and representation of the various source Data Stewards and Data Quality Governors. These serve as a group of individual Subject Matter Experts (SMEs) from each of the functional source data organizations.

The Data Management Team is the functional/operational extension of the Data Governance Board; its prime responsibilities include implementing the directives of the governance board and overseeing that data standards and other guidelines are met by all of the source data institutions. This will be coordinated as a focused working group under the direction of a data management lead for the purpose of realizing the data governance goals cited by the Governance Board. It is anticipated that the Governance Board, Data Management Team and Data Stewards will meet at a predetermined frequency, with periodicity, agendas and attendance documented and adjusted as need dictates.

Completing these additional supportive governance programs in all three of these disciplines assists in:

a. completing business risk analysis and risk assessment
b. generation of ongoing sustainable operational policies, procedures, and controls
c. selecting mitigating controls
d. implementation and management of these controls
e. testing of controls
f. logging, auditing and reporting

2.2.4.5. Data Management

To establish an effective data management and linking strategy the system requires several key elements components as outlined by the work done by the Data Quality Commission (DQC):

a. Statewide Student Identifier
b. Student-Level Enrollment Data
c. Student-Level Test Data
d. Information on Untested Students
e. Statewide Teacher Identifier with a Teacher-Student Match
f. Student-Level Course Completion (Transcript) Data
g. Student-Level SAT, ACT, and Advanced Placement Exam Data
h. Student-Level Graduation and Dropout Data
i. Ability to Match Student-Level P-12 and Higher Education Data
j. A State Data Audit System

Of these requirements, an effective identifier is one of the most essential components. This unique identifier allows for effective longitudinal tracking across entities and organization as well as the ability to link those individuals to programs and activities.

2.2.4.6. Unique ID/Golden Record/Master Person Index (MPI)

It is important to not only load the data but to also link the data in order to create a Master Person Index or identify the "Golden Record". One of the cornerstones in constructing, maintaining, and sustaining an education Longitudinal Data System is a strong Master Data Management (MDM) plan; one that is founded upon an extensibility of the master index entity/master person unique identifier. In realizing an institution's objectives related to a seamless integration of the varied authoritative data sources (sources) that support a successful implementation, a common vocabulary must be defined and utilized. This necessitates inclusion of a master indexing strategy that empowers the sources to generate and/or update indexing unique identifiers based upon the dynamic human/service relationships their data are describing.

Once an effective directory and MPI is implemented, the system's dataflow would naturally be centralized and gated in a manner that, no matter the source, verifies a record's associated identity through weighted matching algorithms or by direct index matching. A well-orchestrated deployment of a MPI and Directory will result in a person's or entity's master index, the fundamental unit of system, record and

outcome's system accountability, to be exposed, available, credible and consistent amongst all of the system's dependent data repositories.

2.2.4.7. Data - Role of Central Government Educational Agencies (CGEA)

Ownership

The CGEA owns the responsibilities for the definition of all required data elements and the educational data models. Any modifications to the data models should be managed by the CGEA only. CGEA mandates the usage of the common data models across all states in the country.

Governance

The CGEA keeps the governance authority over the data definitions and data models being used by the State Education Agencies (SEAs), Districts Education Agencies (DEAs or LEAs), and schools. Governance mechanisms are implemented through certain outcomes, from the reporting of data back to the CGEA. This governance will also manifest itself in the vertical data reporting from the states to the CGEA. Under the governance principles, the CGEA should create evaluations and measures for monitoring the status of education across all levels (SEA, DEA/LEA, school).

The primary principles for the governance of data in the US was set forth in 1985 with the work of the National Center for Education Statistics (NCES), who funded a series of projects with the Council of Chief State School Officers (CCSSO) focusing on improving education data.

The first of these projects, the Education Data Improvement Project, was a three-year project looking at improving the comprehensiveness, comparability, and timeliness of data collected, analyzed, and reported by NCES. The beginning of this project coincided with the Department of Education's extensive redesign of the national elementary/secondary education statistical data system. The major focus of this project was the NCES Common Core of Data, a unified collection of data about schools, local education agencies, and state education agencies.

These initial efforts in data quality were followed up in 2001 by The No Child Left Behind Act (NCLB), which focused on more effective collection and reporting on data with a focus on compliance and accountability of all US states. This focus on data accountability made the need for quality data of much greater significance which help to drive various data quality and comparability initiatives. This also helped to set a variety of outcome-oriented goals associated with the data. Since that time several other national initiatives have also focused on the quantity and quality associated with US education data.

The CGEA creates the data standards and the logical data model(s). CGEA also maintains updates to the standards and models.

Authentication

Any and all data definitions and data models being used by states/districts must be authenticated by CGEA through a certified process. All states are expected to be certified after they implement the CGEA-published data models.

The USDE authorizes the data models and definitions used by all states. USDE sets certain audits and frequent reporting back from States to make sure all authenticated usage of data models/definitions is being followed by the states. To drive data accountability, the US has tied certain types of funding to data collections and frequently audits the collections to ensure the accuracy and completeness of those collections.

a. Vertical reporting is based on various collections, either annual or bi-annual
    i. Typically data audits are done on an annual basis
    ii. Additional audits can be triggered by anomalies in data (for example, significant changes in the enrollment number)

Influence

The CGEA influences the implementation and usage of data standards and data models across all States and Districts. By establishing a defined data standard that is required to submit data, reporting entities are guided to align to this data standard. By publishing a logical data model, entities are allowed to align any existing data structures to the needs of the vertical reports. Audits should also help to guide the data which is being collected and also recognize opportunities to optimize collections and usage.

Usage

The CGEA uses the data models to create databases at the central level. The CGEA uses these databases for aggregated data collections from all states. All CGEA reporting will be based out of these databases for decision support in managing education across the country.

There are two main usage scenarios with which this data is used and will influence future data collection requirements:

a. Research: To provide data to inform future planning sessions
b. Quantify: To find the information about the organizations that are being supported; for example, enrollment, per student expenditures, graduation rates, and so on

2.2.5. Content Standards

Content standards, used both in the US educational system as well as internationally, are key paths for the future of content interoperability, alignment and usage in the converging worlds of Open Education Resources (OER) and commercial resources. Over the last dozen years, we have seen significant advancements within the standards space and will allow for the level of alignment and self-discovery of educational resources for educators and learners. The following are some key education content standards that will help to support the future usage and management of education content:

a. Learning Registry

Learning Registry (LR) is a joint effort of the U.S. Departments of Education and Defense that also is supported by numerous federal agencies, non-profit organizations, international organizations, and private companies. This new approach to capturing, sharing, and analyzing learning resources data provides a structured index—not a repository—of digital educational content from various free and paid sources. It can present a visual map of available content directly in a browser or from within other tools. That makes things easier for teachers to find, in one place, related content and lesson plans by subject, grade level or other criteria. As an index, it can be replicated in real-time across the web in copies called “nodes.” One key point: the Learning Registry recognizes LRMI (Learning Resource Metadata Initiative) tags. It also applies other kinds of tags to content, reflecting how the content is used and how it might be rated by teachers.

This effort has been driven by a call for increased openness, sharing and use of digital learning resources as described in both the National Education Technology Plan and National Broadband Plan. The specifications have been developed to support learning organizations from across all education sectors.

Key advantages for the Learning Registry to share:

i. metadata that describe learning resources
ii. ratings, reviews, comments, and other annotation data
iii. alignments to educational standards
iv. usage information such as favoriting, foldering, remixing, embedding, and other social metadata / paradata
v. resource updates, relationships between resources, and other assertions

b. LRMI (Learning Resource Metadata Initiative):

The Learning Resource Metadata Initiative (LRMI) is working to make it easier to publish, discover, and deliver quality educational resources on the web. LRMI is spearheaded by the Association of Educational Publishers and Creative Commons. It provides a taxonomy to consistently tag digital learning content so it can be easily found in web search by teachers. LRMI's version 1.0 spec has been submitted to Schema.org, and, when approved, it will be used by Google, Bing and Yahoo in delivering search results.

c. Shared Learning Collaborative:

Inspired by the vision of the Council of Chief State School Officers (CCSSO) and nine participating states, the Shared Learning Collaborative (SLC) is an alliance of states, districts, educators, foundations, and content and tool providers who are passionate about using technology to improve education. The SLC aims to accelerate the progress of U.S. public schools toward personalized learning by creating a set of shared technology services that will help existing and future instructional technology investments in states, districts and schools work better together.

d. IMS Global Learning Consortium:

The IMS Global Learning Consortium (IMS GLC) is a global, nonprofit, member organization that strives to enable the growth and impact of learning technology in the education and corporate learning sectors worldwide. IMS GLC members provide leadership in shaping and growing the learning industry through community development of interoperability and adoption practice standards and recognition of the return on investment from learning and educational technology.

The mission of the IMS Global Learning Consortium is to advance technology that can affordably scale and improve educational participation and attainment. To ensure that the "Learning Impact" of technology-enabled innovation is achieved around the world, IMS's influential community of educational institutions, suppliers, and government organizations develops open interoperability standards, supports adoption with technical services, and encourages adoption through programs that highlight effective practices.

IMS Global is supported by over 190 organizations – the world's leaders in educational and learning technology, including leading learning technology product suppliers and publishers, leading institutions of learning and training, and leading government and professional consortia. The breakdown of members is 58% leading corporations, 24% leading institutions of learning or school

districts, and 18% consortia and/or government organizations. Currently, 47% of member organizations are headquartered outside the United States.

e. Learning Tools Interoperability (LTI):

The principal concept of LTI is to establish a standard way of integrating rich learning applications (often remotely hosted and provided through third-party services) with platforms like learning management systems, portals, or other educational environments. In LTI, these learning applications are called Tools (delivered by Tool Providers); the LMS (learning management systems), or platforms, are called Tool Consumers.

The basic use case behind the development of the LTI specification is to allow the seamless connection of web-based, externally hosted applications and content, or Tools (from simple communication applications like chat, to domain-specific learning environments for complex subjects like math or science) to platforms that present them to users. In other words, if you have an interactive assessment application or virtual chemistry lab, it can be securely connected to an educational platform in a standard way without having to develop and maintain custom integrations for each platform.

f. Common Cartridge:

The Common Cartridge defines a new package interchange format for learning content, able to run on any compliant LMS platform. It is a set of open standards, freely available and without royalty, developed by a global industry consortium with over 80 voting members. These standards, if followed by content developers and learning platforms, enable strict interoperability between content and systems. They also support great flexibility in the type of digital content supported (content can actually be applications) and where such content is located (content and applications in a Common Cartridge can be distributed).

g. Open Education Resources (OER):

Schools have been moving away from content that is structured linearly and captured in all-inclusive books with predetermined progressions. Digital instructional content, too, is shifting away from approaches that simply break comprehensive digital textbooks into smaller parts. Newer forms of instructional content often begin with a scattered landscape of digital chunks that are then assembled to support full courses.

Encouraging the acceleration of such chunky digital content, in large part, is the Open Educational Resources (OER) movement. Though definitions vary, OER is

essentially digital instructional content that's designed to be mixed, modified and shared. In other words, a teacher can pick and choose learning elements he or she needs for a lesson from a variety of sources, make changes, use those lessons in class, and theoretically distribute either the individual pieces or the completed combination to other educators for their use.

h. Granular Identifiers and Metadata for the Common Core State Standards (GIM-CCSS)

The Partnership for the Assessment of Readiness for College and Careers (PARCC), the Smarter Balanced Assessment Consortium (Smarter Balanced) and the State Educational Technology Directors Association (SETDA) – working in partnership with the Council of Chief State School Officers (CCSSO) – have launched a collaborative, state-centric project ("Granular Identifiers and Metadata for the Common Core State Standards" or GIM-CCSS) to facilitate the long-term technical implementation of the Common Core State Standards (CCSS) in a digital format that meets assessment needs, while preserving the conceptual and structural integrity of the standards.

i. Curriki:

Curriki is an online community for creating and sharing curricula and teaching best practices. This represents an example of Open Education Resources (OER), in which there are thousands currently available both funded and unfunded. Additional examples include Khan Academy, Thinkfinity, International Federation of Library Associations and the Digital Library of India.

i. **Provides High Quality Free Resources** – Curriki contains over 46,000 free K-12 lessons, units, assessments, and multimedia learning resources across all subject areas.
ii. **Empowers Educators –** Curriki's free platform enables educators to build their own curriculum by assembling Curriki resources, as well as their own, into collections.
iii. **Helps Eliminate the Education Divide –** Curriki originated from the idea that technology can play a crucial role in breaking down the barriers of the Education Divide – the gap between those who have access to high-quality education and those who do not. Curriki helps bridge this divide by providing free and open resources to teachers who need them most. The Curriki community is composed of millions of users and hundreds of collaborative networking groups.
iv. **Leads the Open Education Resource Movement –** Curriki is a leading organization behind the OER movement—a movement based around the

idea that educational resources should be freely available for educators and students to use, mix, modify, and share.

v. **Engages in Dynamic Partnerships with a Global Reach –** Curriki is working with partners around the world to develop multilingual educational content that supports local education initiatives and goals.

2.2.6. Core Education Standards

2.2.6.1. Common Core

The Common Core State Standards provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. By having students fully prepared for the future, communities will be best positioned to compete successfully in the global economy.

The Common Core State Standards Initiative is a state-led effort that established a single set of clear educational standards for kindergarten through 12th grade in English language arts and mathematics that states voluntarily adopt. The standards are designed to ensure that students graduating from high school are prepared to enter credit bearing entry courses in two or four year college programs or enter the workforce. The standards are clear and concise to ensure that parents, teachers, and students have a clear understanding of the expectations in reading, writing, speaking and listening, language and mathematics in school.

The nation's governors and education commissioners, through their representative organizations the National Governors Association (NGA) and the Council of Chief State School Officers (CCSSO) led the development of the Common Core State Standards and continue to lead the initiative. Teachers, parents, school administrators and experts from across the country together with state leaders provided input into the development of the standards.

The standards clearly communicate what is expected of students at each grade level. This will allow our teachers to be better equipped to know exactly what they need to help students learn and establish individualized benchmarks for them. The Common Core State Standards focus on core conceptual understandings and procedures starting in the early grades, thus enabling teachers to take the time needed to teach core concepts and procedures well—and to give students the opportunity to master them.

With students, parents, and teachers all on the same page and working together for shared goals, we can ensure that students make progress each year and graduate from school prepared to succeed in college and in a modern workforce.

High standards that are consistent across states provide teachers, parents, and students with a set of clear expectations that are aligned to the expectations in college and careers. The standards promote equity by ensuring all students, no matter where they live, are well prepared with the skills and knowledge necessary to collaborate and compete with their peers in the United States and abroad. Unlike previous state standards, which were unique to every state in the country, the Common Core State Standards enable collaboration between states on a range of tools and policies, including:

a. the development of textbooks, digital media, and other teaching materials aligned to the standards
b. and the development and implementation of common comprehensive assessment systems to measure student performance annually that will replace existing state testing systems
c. changes needed to help support educators and schools in teaching to the new standards

Granularity Initiatives

One of the challenges of broad-based standards initiatives is that there is often a need to provide additional granularity or versioning for different populations or users of these standards. Allowing education entities/regions to personalize/customize a broader-based standards initiative with their own local influence will support more effective adoption of these standards.

Example of States' Granularity Efforts with Common Core

Basic education in Washington state is defined by the Legislature (RCW 28A.150.2). As required by state law, OSPI develops the state's learning standards (RCW 28A.150.210) and oversees the assessment of the learning standards (RCW 28A.655.070) for state and federal accountability purposes. A national effort is underway to develop Common Core State Learning Standards in English Language Arts and Mathematics for grades K-12. We call our learning standards Essential Academic Learning Requirements (EALRs), which define what all students should know and be able to do at each grade level.

This example of granularity on a standard allows the state to align to the overall educational standards while giving it flexibility to define how to best use that framework to address their unique student populations. Granularity is effective way of allowing for high-level standards to be issued or mandated without taking away

too much local control/accountability. As there are multiple standards, often granularity can be applied to each of those standards and subsequent assessments to support overall needs of local education initiatives.

2.2.6.2. Additional Standards

Outlined below are some additional targeted national standards that have been implemented in the United States.

Next Generation Science Standards (NGSS)

Another state-based initiative, this time for the development of national Next Generation Science Standards, is led by Achieve—in collaboration with the National Research Council, the National Science Teachers Association, and the American Association for the Advancement of Science. The standards are based on a July 2011 framework developed by the National Academy of Science's National Research Council.

National Standards for Arts Education

The National Standards for Arts Education were last released in 1994. Currently, the National Coalition for Core Arts Standards, a partnership of organizations and states, is developing revised grade-level standards for dance, media arts, music, theatre and visual arts.

National Standards for Foreign Language Learning

The American Council on the Teaching of Foreign Languages (ACTFL) led an 11-member task force to produce the first content standards for foreign language learning in 1996. The resulting document, Edition Standards for Foreign Language Learning in the 21st Century, is now in its third edition. Currently, ACTFL is currently working to explicitly link its language learning standards with the Common Core State Standards.

Career and Technical Education (CTE)

Many of those working in the field of Career and Technical Education (CTE) have grappled with the need for a uniformly global set of information—a national-level database or a standardized set of definitions and measures—to meet CTE's multiple needs, including accountability and evaluation, career guidance, and program improvement.

The Common Career Technical Core (CCTC) is a state-led initiative to establish a set of rigorous, high-quality standards for CTE that states can adopt voluntarily. The standards have been informed by state and industry standards and developed by a

diverse group of teachers, business and industry experts, administrators and researchers.

2.2.7. Assessments Standards

Having established national education standards it is important to also address the needs of assessing on those standards. We understand there are already various assessments in place and we are only looking to recommend how we address assessment interoperability within a technical framework.

There are several nationwide assessment initiatives in the US that are being utilized to benchmark the current state of academic performance across the US.

Smarter Balanced

The Smarter Balanced Assessment Consortium (Smarter Balanced) is a state-led consortium working to develop next-generation assessments that accurately measure student progress toward college- and career-readiness. Smarter Balanced is one of two multistate consortia awarded funding from the U.S. Department of Education in 2010 to develop an assessment system aligned to the Common Core State Standards (CCSS) by the 2014-15 school year.

The work of Smarter Balanced is guided by the belief that a high-quality assessment system can provide information and tools for teachers and schools to improve instruction and help students succeed – regardless of disability, language or subgroup. Smarter Balanced involves experienced educators, researchers, state and local policymakers and community groups working together in a transparent and consensus-driven process.

PARCC

The Partnership for Assessment of Readiness for College and Careers (PARCC) is a consortium of 22 states plus the U.S. Virgin Islands working together to develop a common set of K-12 assessments in English and math anchored in what it takes to be ready for college and careers. These new K-12 assessments will build a pathway to college and career readiness by the end of high school, mark students' progress toward this goal from 3rd grade up, and provide teachers with timely information to inform instruction and provide student support. The PARCC assessments will be ready for states to administer during the 2014-15 school year.

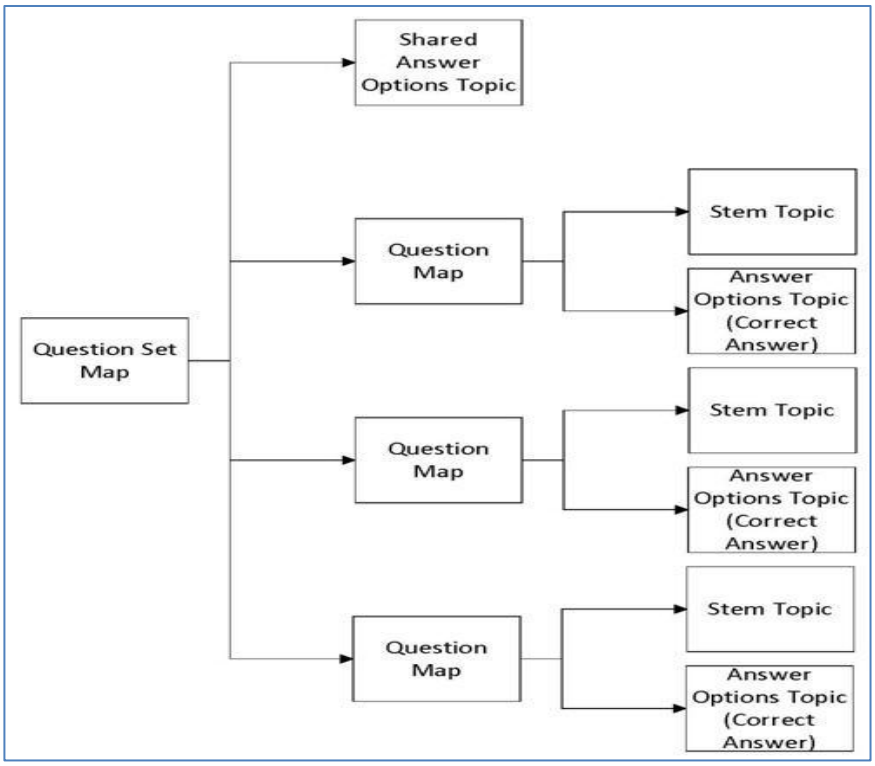
PARCC received an $186 million grant through the U.S. Department of Education's Race to the Top assessment competition to support the development and design of the next-generation assessment system.

NAEP

The National Assessment of Educational Progress (NAEP) is the largest nationally representative and continuing assessment of what America's students know and can do in various subject areas. Assessments are conducted periodically in mathematics, reading, science, writing, the arts, civics, economics, geography, U.S. history, and beginning in 2014, in Technology and Engineering Literacy (TEL).

Since NAEP assessments are administered uniformly using the same sets of test booklets across the nation, NAEP results serve as a common metric for all states and selected urban districts. The assessment stays essentially the same from year to year, with only carefully documented changes. This permits NAEP to provide a clear picture of student academic progress over time.

Granularity in assessment creates these specialized maps and topics to chunk our assessment content at a much more granular level. Essentially, we based our model, not on building blocks, but on minute grains of sand. Doing so has afforded us much greater flexibility in supporting new and existing structures whose definition is owned by other organizations (as seen in the figure below).



A More Granular Assessment Model

Of course, more granularities can—and, in this case, does—lead to greater complexity in content management and content authoring. It should be noted that

this is just one strategy for supporting flexibility. For many organizations, the costs of managing and authoring a highly granular architecture may outweigh the benefits of using a highly flexible model.

Additionally, there has been significant work on assessment specification and interoperability. Some of the guiding reference implementations and standards we have utilized in our work are as follows.

2.2.7.1. Question and Test Interoperability Specification (QTI)

The IMS Question & Test Interoperability (QTI) specification enables the exchange of item, test and results data between authoring tools, item banks, test constructional tools, learning systems and assessment delivery systems. QTI has developed and deployed a conformance certification program and an online validation tool.

2.2.7.2. Assessment Interoperability Framework (AIF)

The Assessment Interoperability Framework (AIF) focuses on interoperability of content and data so that solutions providers can exchange content and data effectively and connect system components together seamlessly. AIF are specific educational technology and assessment standards that can be used by any assessment implementation provider supporting Race to The Top Assessment (RTTA).

AIF includes:

a. A high-level interoperability architecture for an Assessment Platform and how the Assessment Platform integrates with the broader education systems enterprise
b. Identification of cross-standard interoperability alignments or transformations necessary for data and content to flow through the assessment platform and to other consuming or providing systems

2.2.8. Other Standards and Policy Resources

The following site has several other links in the education standards/policy organizations:

a. http://www2.ed.gov/policy/elsec/guid/states/index.html
b. Here is the NCLB link to wikipedia which provided all required info regarding NCLB policy/standards/measures/funding etc: http://en.wikipedia.org/wiki/No_Child_Left_Behind_Act

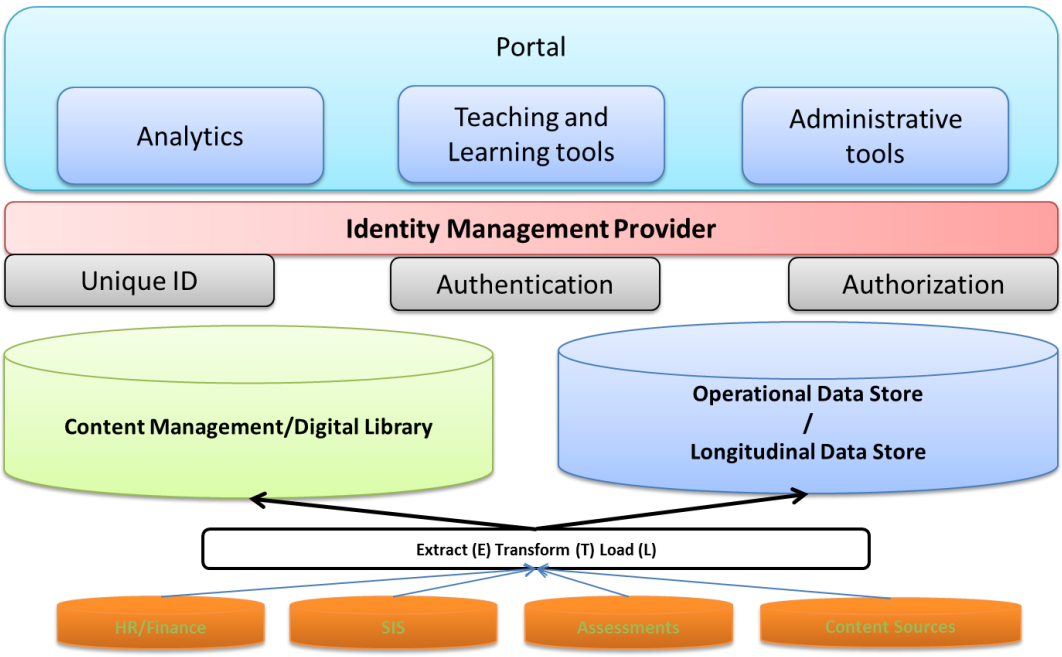
c. Attached accountability workbook can be used as another reference. This one is from VA.
d. VA's NCLB report card: http://web.archive.org/web/20080211145310/http://www.doe.virginia.gov/VDOE/src/vps-accountability.shtml
e. The following URL provides the gist of NCLB in a short paragraph: http://www.fairtest.org/what-nclb and http://www.openbadges.org/
f. Learning Registry: http://www.youtube.com/watch?v=Ong_jvDNpR8
g. LRMI: Peek under the hood of Personalized Learning: http://www.youtube.com/watch?v=14h253iQRZs
h. U.S. Department of Education Datapalooza Playlist: http://www.youtube.com/OfficeOfEdTech
i. U.S. Department of Education's Office of Educational Technology: Personal Learning: Profile http://www.youtu.be/O46JZB_a8Pk

2.3. ICT Architecture

Advancements in information technology have facilitated a dramatic evolution in the way education is delivered and results are measured. What has emerged is an electronic education ecosystem populated with a variety of systems, tools, applications, digital content and infrastructure that is ostensibly aimed at improving the way teachers teach and students learn. In order to establish such an infrastructure that supports not only today's needs but also the future vision, you must focus on the system's ability to scale and overall system extensibility.

We feel the technology to support this vision has reached a level of maturity where the goal of educational institutions is to leverage their electronic assets to enable teachers to deliver personalized learning, at scale, based on the specific needs of each student. Achievement of this goal requires the unified integration of student level data and analytics with accessible digital content, and this can only be delivered with enterprise ICT architecture.

Through implementations throughout the world, we have seen that the building blocks are in place that can ultimately enable the realization of this strategic vision. Unfortunately, most institutions find it difficult to execute against such a vision. We believe shortcomings in existing enterprise infrastructures make it difficult to aggregate, manage, and deliver education data and digital content. Said another way, education institutions are failing to fully leverage existing investments in information systems in a way that can make teachers more effective and students more successful. India has a unique and game changing opportunity to set the future technology and architectural direction to take advantage of this paradigm.



We have worked to develop a unified enterprise architecture and data management system recommendation designed to unlock the true value of existing electronic assets and digital content. This proposed architecture outlines the minimum required investment. The full investment that a future integration would require is more extensive.

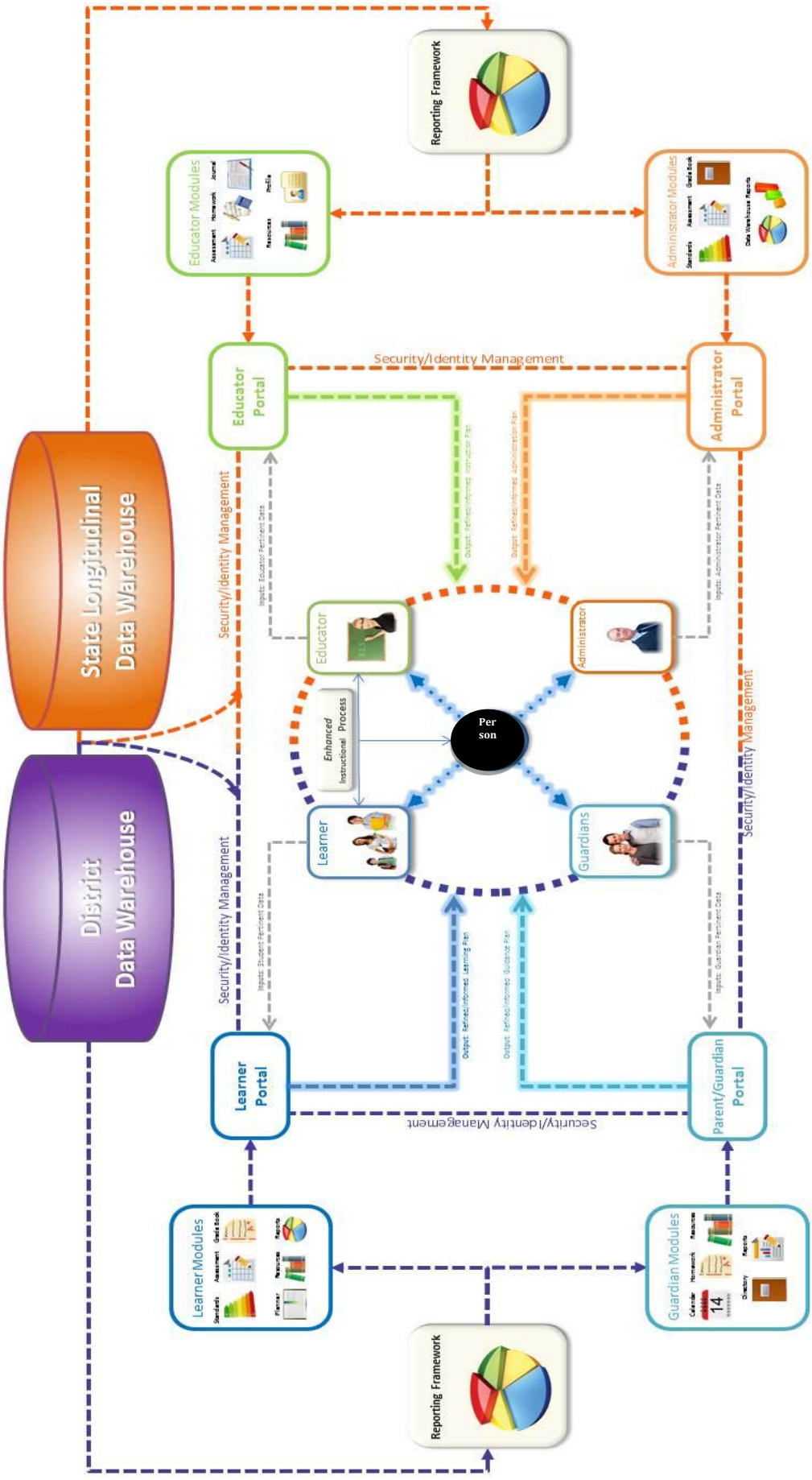
We feel our understanding and approach to designing/implementing an education data system architecture addresses the shortcomings of existing data management practices/systems. We will focus on a KEY tactical issue plaguing all education institutions: how to get educators access to the data, applications, services, and content they need in an easy, sustainable, and quick manner.

2.3.1. Overview

Helping educators apply content to the classroom requires a new type of data system to integrate and support—rather than replace—existing curricular, assessment and management software.

Such a system will:

a. Unify access to all the content in a school—content stored locally and/or in multiple places by multiple providers
b. Provide a cohesive user experience
c. Unlock for educators the value (of content, people, and technology resources) already available to them


Reporting Framework
Educator Modules
Administrator Modules
Security/Identity Management
Educator Portal
Administrator Portal
State Longitudinal Data Warehouse
District Data Warehouse
Security/Identity Management
Educator
Administrator
Enhanced Instructional Process
Person
Learner
Guardians
Learner Portal
Parent/Guardian Portal
Security/Identity Management
Learner Modules
Guardian Modules
Reporting Framework

2.3.2. Enterprise Architecture for Education

2.3.2.1. Complex Integration Needs

Many applications need to share data, and the relationships between the sources and their data can get very complex.

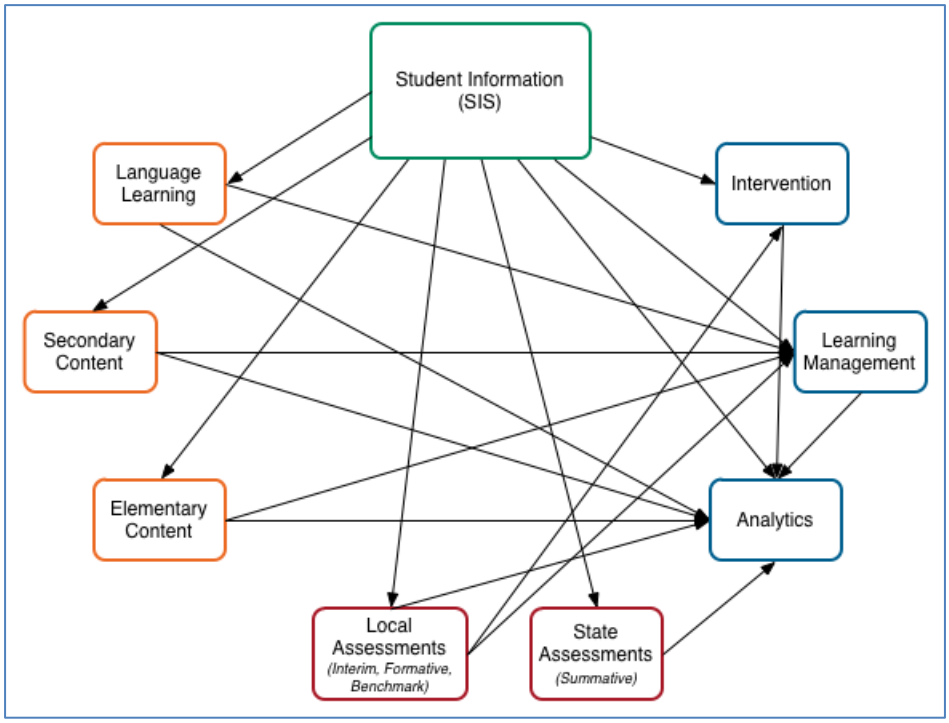


Figure: Integration Complexity

We have been researching, and building, enterprise architectures for education for over a decade. As experts in enterprise class education data management we have, a unique understanding of the untapped capabilities of today's technologies. One way to visualize the possibilities is an Education Data Broker structure (we call ours the edFusion EduBus™).

Essentially, an Education Data Broker makes all content, data, and access to applications in a school discoverable in a united, cohesive manner. It puts everything an educator or student needs in one place and one time.

2.3.2.2. Education Data Broker Technical Overview

The Education Data Broker unites the two fields of data integration (sharing data and identity between applications) and presentation integration (showing the integrated data to users). It wraps those two integrations in common but crucial technologies

such as single sign on, directory management, automated provisioning, role-based access control and authentication. The following is a very high level architecture diagram of Education Data Broker (EduBus).

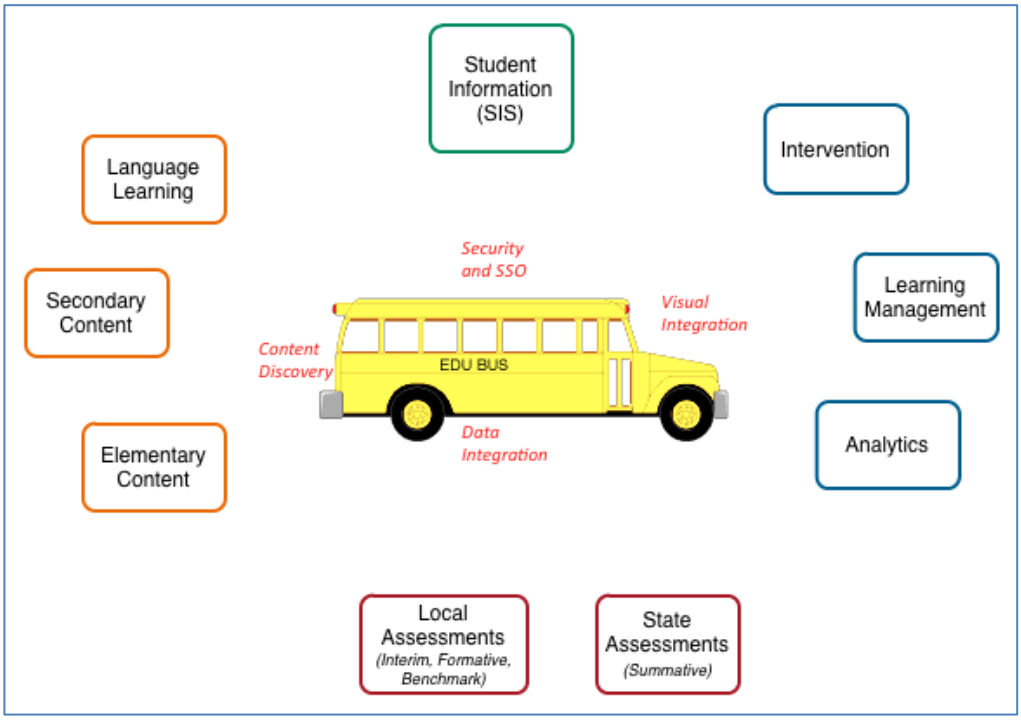


Figure: Education Data Broker (EduBus): A True Integration Platform

Fundamentally, an Education Data Broker structure solves the problem caused by lack of unified integration of student level data and associated analytics with accessible digital content.

2.3.2.3. Application/Service Integration

Existing applications and resources are, and should be viewed as, a central part of any enterprise education system. Our recommended view is not to replace existing applications and systems but to find effective ways to append and integrate those systems without impacting the existing usage. When thinking about integrations, it is important to often look at how various methods of applications can be used, such as single sign-on to reduce the barriers to entry.

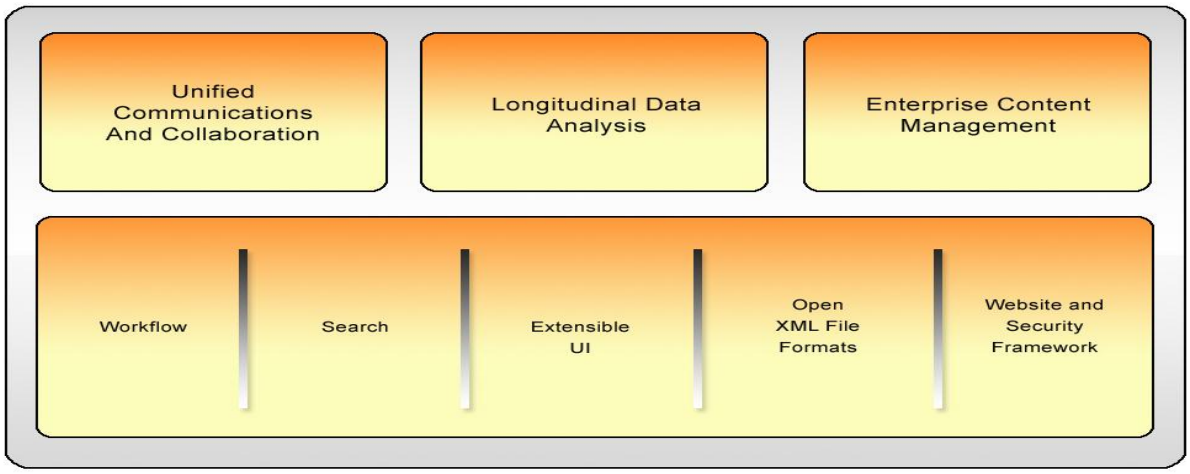
An effective enterprise solution for education starts with single-sign-on and application integration. Individual applications use a variety of security methods and technologies (such as SAML, LDAP and so on). Therefore, the application integration tools must be flexible enough to not only apply all relevant current standards but to be applied to new methods as applications implement them.

An enterprise solution should include at least three and possibly five levels or depths of presentation integration:

a. Inclusion as a link
b. Level 1 plus single-sign-on and appropriate role-based re-direction to target application, service, or web view
c. Level 2 plus user and entity provisioning so rosters are available and context is maintained
d. Level 3 plus coordinated navigation and resource usage to minimize back-and-forth requirements by the educator or student as they do their work
e. Level 4 plus seamless integration of visual preferences and style so the user does not even perceive they are in different environments

Level 4 and 5 require work on both the source and target systems while 1 through 3 are possible with almost no changes to the source and target applications so long as an Education Data Broker is present.

2.3.2.4. Content to Data Integration



Data (and metadata) can be imported from every separate application into a search database or search registry. User searches in a single portal page can then return results (including direct links) back for every relevant application along with any metadata or paradata that the content resource supports. The search portal can then also apply personalization and configurations dictated by the user once and apply it to all the searches. As shown in the example, unified search gives the user a holistic view of the available materials.

The Education Data Broker (in this example, EduBus) solves the search problem by searching all available data and returning a unified, comprehensive set of results.

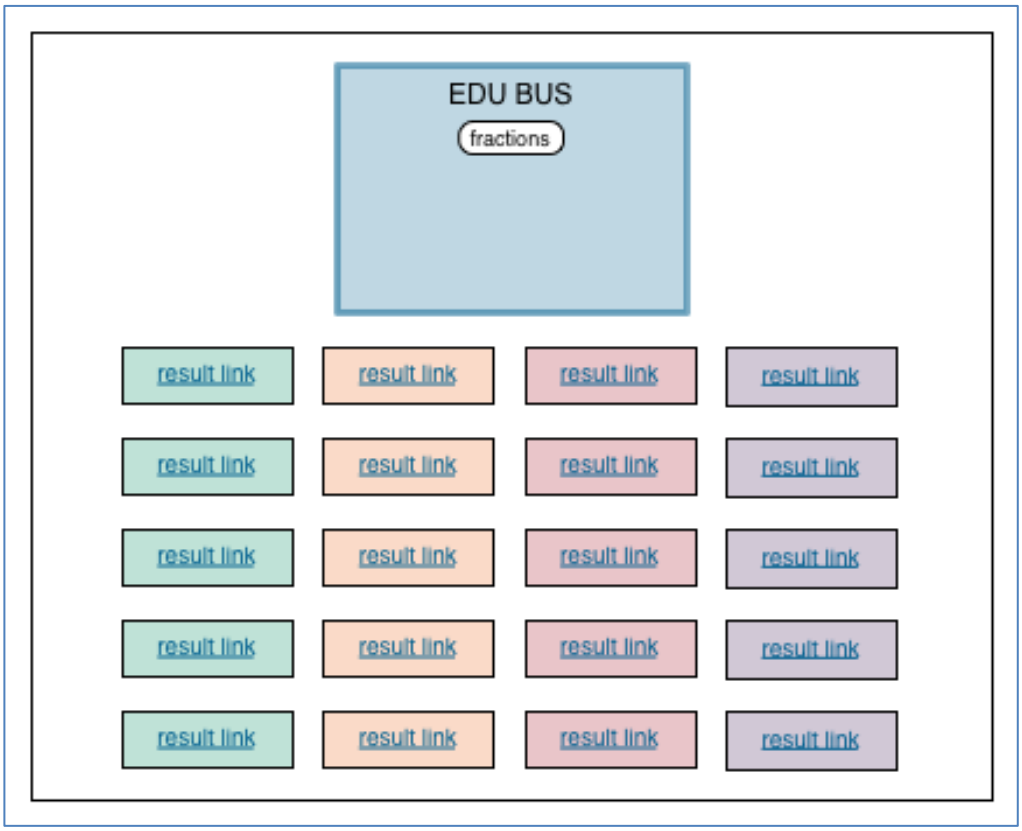


Figure: Unified, Comprehensive Search Results

2.3.2.5. Challenge: No Provisioning

Not only must the educator log in to each application every time, but getting that educator's rosters, student demographics, and history into each application can be a nightmare of varying import formats and methods. While the Student Information System (SIS) is the repository of such information often other applications utilize that same data which requires multiple data inputs. The result, the student lists quickly become "out of sync" among all the applications.

Solution: Automated Provisioning with Validation

There are many entities in an education enterprise and most systems need the information about these entities in order to serve the educator.

Such entities include:

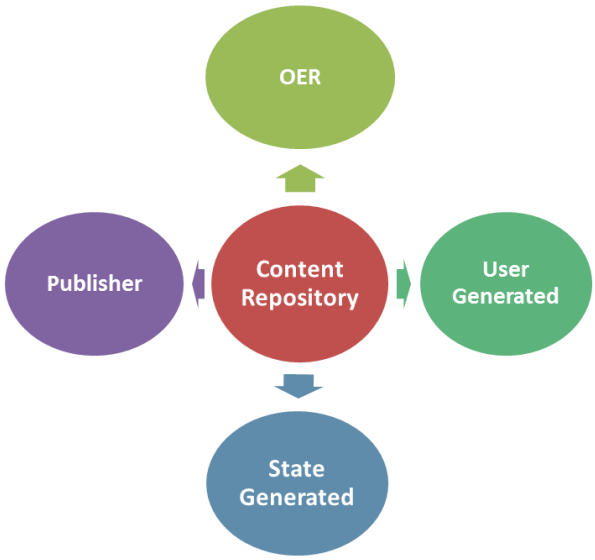
a. People like students, parents, educators and the relationships between them and between them and organizations
b. Organizations like districts, schools, programs, classrooms, and even families

c. Assessments ranging from local formative and benchmark tests to district end-of year tests to the state summative tests to more non-traditional assessments like videos of dance recitals
d. Curriculum and instructional structures like units, courses, lessons, and activities

A solid data integration schema involves ETL (Extract, Transform, and Load) definitions for a variety of data collection and integration mechanisms. These include file-based imports, database connections, SIF-based connections and Web Services-based communications. Automating these connections—to whatever degree possible—is the key to ensuring that this enterprise architecture remains synchronized with the various applications, services, and content providers that make it up.

2.3.2.6. Content Delivery

The challenges facing most education institutions is not just focused on the acquisition of content, but the effective delivery and management of the content over time, especially when content localization is required.



When looking at the variety of potential sources of content being served to your constituents, it is important to consider the overall digital rights management (DRM) and copyright considerations of the content to be served to your users. Often, even though these are free or open educational resources (OER), there are still copyright owners of the content, which means that these items cannot be sold or repurposed without express written consent of the original publisher. Some of the current initiatives allow for localization of content as long as the resulting content is made

available to the community at large. When using OER content, it will be crucial to understand the ownership implications before significant investments are made.

2.3.2.7. Open Textbook Initiatives

Currently, there are dozens of OER content organization initiatives which are working to align the world of resources into specific subject areas. These initiatives are exemplified by the following:

a. CreativeCommons.org:

Creative Commons (CC) is a nonprofit organization that enables the sharing and use of creativity and knowledge through free legal tools. Creative Commons copyright licenses provide a simple, standardized way to give the public permission to share and use your creative work on conditions of your choice. CC licenses let you easily change your copyright terms from the default of "all rights reserved" to "some rights reserved.

b. Connexions:

Connexions is a dynamic digital educational ecosystem consisting of an educational content repository and a content management system optimized for the delivery of educational content. Connexions is one of the most popular open education sites in the world. Its more than 17,000 learning objects or modules in its repository and over 1000 collections (textbooks, journal articles, and so on) are used by over 2 million people per month. Its content services the educational needs of learners of all ages, in nearly every discipline, from math and science to history and English to psychology and sociology. Connexions delivers content for free over the Internet for schools, educators, students, and parents to access at any time. Materials are easily downloadable to almost any mobile device for use anywhere, anytime. Schools can also order low cost hard copy sets of the materials such as textbooks.

c. CK-12:

CK-12 provides open-source content and technology tools to help teachers provide learning opportunities for students globally. Free access to high-quality, customizable educational content in multiple modalities suited to multiple student learning styles and levels, will allow teachers, students and others to innovate and experiment with new models of learning. CK-12 helps students and teachers alike by enabling rapid customization and experimentation of teaching and learning styles

2.3.2.8. Ranking/Jurying of Content

When developing any effective content management solution that will be able to aggregate such a large amount of content from various sources, there need to be mechanisms for validating the efficacy and quality of that content. Without investments in psychometric analysis of resources, there are other ways to help crowd source the validity of instructional resources. One of the most effective ways to address this need is to have mechanisms for ranking or jurying that content so that the best resources are readily available to users. This can be as simple as usage metrics or a ranking scale for each resource.

2.3.2.9. Content Discovery

One of the most significant challenges is content bridging based on data to those who need that data. Even when an educator identifies an outcome in an application (for example, a useful insight from a formative or benchmark assessment, or a weakness against a learning standard), identifying the appropriate instructional resources can be time consuming. The educator has to switch to one or more systems (such as a learning management system or a curriculum vendor's courseware catalog) and then search again to find the relevant material.

Automatic Bridging Based on Standards

The enterprise data management system can, and should, go beyond merely finding content based on criteria; it should use objective data such as the Common Core standards as a link. For example, consider an assessment that tests mastery of specific learning objectives. When the educator is looking at assessment results, the system should present web links to the relevant curricular and other materials that address those objectives. Clicking on the link would take the user directly to the other application and down to the individual activity level. Because it is all done within an enterprise portal, the transition is seamless.

Vendor Problems

ISSUE	SOLUTION
Multiple security integration methods	Integration portal with multiple protocol support
Long implementation times	Single portal and data integration standard

Vendors of curriculum tools, assessments, management software, and content providers are key parts of the education system. The systemic problems that prevent educators from fully using their computer systems also inhibit the ability of vendors to develop and deploy tools to help those educators.

2.3.3. Content Management

Content available in education is increasing at an exponential rate. Content available from publishers, Open Educational Resources, Entity created materials, Educator generated materials as well as student portfolios are all part of the education content ecosystem. To effectively use and manage this content this information must be stored and organized in an easily accessible and usable format.

2.3.3.1. Content Management System

Part of the vision of an enterprise information system in education requires an effective digital library and an enterprise content management system, or CMS. An enterprise content management system allows for the organization of documents, contacts and records that are created and managed in the typical education environment. A CMS structures the enterprise's information content and file formats, manages locations, streamlines access by eliminating bottlenecks and optimizes security and integrity of the assets within the systems. Additionally, most CMS solutions also allow for enterprise search across the system to help provide easy access to the resources most needed.

An optimal content management system will allow for authorized non-technical users to update content within the system as well as manage their own digital repositories of content.

2.3.3.2. Standards Alignment to CMS

As part of the effective usage and alignment of content within the system to system users in need of that data is a dependence on standards, such as Common Core, which will allow for said content that resides within the system to be aligned effectively to users/groups/organizations (i.e. Algebra content aligned with algebra teachers and students) without users having to search for that information. To do this content must be aligned with metadata such as those prescribed in the earlier initiative such as LRMI or Schema.org.

Metadata & Paradata

Metadata (data about data) and paradata (data about assessments or surveys) are essential for the effective use of information within the system. Requiring all data that resides within the system to be tagged, as well as the ability to systematically align that information to other data or information within the system, is vital for the long term usability of the system.

2.3.3.3. Content and Learning Management Plays

As the need for content and online learning tools have increased, so have the number of tools and resources available for educators and administrators alike. The utilization or application of these tools are often grassroots and do not represent an enterprise software solution, this lack of enterprise view can lead to data and content silos which do not support the vision of the overseeing organization

Content Management and Learning Management Platforms	
Sakai	Open Source: Over 350 educational organizations use Sakai as a learning management system, research collaboration system and ePortfolio solution
Moodle	Open Source: Moodle is a Course Management System (CMS), also known as a Learning Management System (LMS)
Assistments	Open License: Online assessment management and delivery platform
Drupal	Open Source: Drupal is a content management platform powering millions of websites and applications. It's built, used, and supported by an active and diverse community of people around the world
Edmodo	Commercial, Open: edmodo is a social learning platform for teachers, students, and parents
Blackboard	Commercial: One of the most used learning management systems in higher education
Agilix	Commercial: is a personalized learning environment that allows

	teacher or school to leverage online learning to map curriculum to standards and deliver content/courses.

2.3.4. Education Data

Education data has gone through as significant transformation over the last decade and will continue to transform both in availability and usage over the coming decades. It is an essential process to develop and maintain a reference data model that will support the growth and usage of education data. One of the most comprehensive, research driven data model and usage initiatives in the US is the work done by CCSSO and IES on the Common Educations Data Standards (CEDS) logical model. This model provides a comprehensive view of the data used in education as well as how to logical instantiate that model.

2.3.4.1. CEDS Logical Data Model

While education institutions across the P20W (Early Learning through K12, Post-Secondary and Workforce) environment use many different data standards to meet information needs, there are certain data we all need to be able to understand, compare, and exchange in an accurate, timely, and consistent manner. For these, we need a shared vocabulary for education data—that is, we need common education data standards. The Common Education Data Standards (CEDS) project is a national collaborative effort to develop voluntary, common data standards for a key set of education data elements to streamline the exchange, comparison, and understanding of data within and across P20W institutions and sectors.

What are the Parts of the Standard?

The CEDS "standards" are comprised of several pieces of information that provide context for and describe data items within CEDS:

a. Domain
b. Entity
c. Categories
d. Element
e. Option Set
f. Related Connections
g. Alternative names and other notes
h. Technical Name
i. XML Schema

On January 31, 2012, the US Education Department (USED) National Center for Education Statistics (NCES) published version 2.0 of the Common Education Data Standards (CEDS) at http://ceds.ed.gov/. CEDS 2.0 includes standard names and definitions for key terms, education domains, entities, attribute categories, data elements, and option sets as well as a fully documented logical data model.

The data model includes two schemas: a Domain Entity Schema (DES) and a Normalized Data Schema (NDS). The DES uses less technical syntax and organizes data elements by domain to represent the conceptual structure of the CEDS elements.

The Domain Entity Schema (DES)

The DES provides a user friendly structure to easily identify CEDS elements organized by domain, entity and attribute category. The domains for CEDS version 2 include:

a. Early Learning (abbreviated as EL)
b. Elementary and Secondary Education (abbreviated as K12)
c. Post-secondary Education (abbreviated as PS)
d. Assessments
e. Learning Standards

Entities are commonly thought of as persons, places, events, objects, or concepts about which data can be collected. An entity provides context for a data element. Some examples of entities are Early Learning Child, K-12 Student, K-12 Staff, Post-Secondary Student, Post-Secondary Institution, and so on There are over 20 entities in the DES.

Attribute categories represent a group of related attributes associated with one or more entities. Some examples are Demographic Information, Health Information, Section Enrollment, and Academic Record, just to name a few.

The Normalized Data Schema (NDS)

CEDS supports standardizing educational organizations and their relationships with other organizations, people, and time. This focus is necessary to support existing state and federal reporting and for analysis and comparison of aggregate statistics. The latest release of CEDS also focuses on use cases that support people's relationship with learning standards and assessments.

The NDS is a third normal form (3NF) structure organized around the key concepts of organization, person, and role. The NDS was developed with the goal of supporting physical implementations that could function as an "operational data store" for

integrated P-20 data providing the most current available view of each organization, person, and role.

The NDS starts with a flexible directory of organizations that can, at times, have multiple parent-child relationships with each other. People exist independently, but they don't have roles outside of their relationship to a specific organization for a specific date range.

Each person shares common attributes, or data points, that allow us to represent all levels as 'Persons.' Each Person has one or more 'roles.' Roles are a time-aware association between a Person and an Organization.

2.3.4.2. NDS Core Structure Logic

The NDS Logical Model provides a logical database model, normalized to Third Normal Form, for integration of P-20 data systems through a well-normalized "operational data store". When physically implemented, a sub-model supporting the audit of edits to all attributes will be utilized.

Comparability of state education data has some exciting possibilities for all educators, administrators and vendors. Much like how XML provides comparability/interoperability for data-in-motion, CDM is for data-at-rest. It serves to provide a level of interoperability that means:

a. Standardized terminology promotes more effective communication and streamlines knowledge transfer
b. Mapping takes less effort
c. Development of reports/imports/exports/dashboards/modules can be shared across organizations
d. Centralized or base-lined design documentation
e. Resources can be shared

In order to provide a data model that promotes comparability and traceability, the data abstraction process needs to reconcile a myriad of sources, interpretations and definitions for each data structure. Creating a highly normalized data model best promotes these requirements.

Normalization

Normalization is a data structuring process to:

a. Eliminate redundancies – Prevents update anomalies and reduces the amount of stored data

b. Ensure the accuracy of data – Prevents insert anomalies and guarantees the quality of the data
c. Understand the data – Discrete objects clearly identify purpose
d. Create scalability – Better accommodate growth
e. Create extensibility – Facilitates modification to the model

A system is considered to be well normalized if it meets the Third Normal Form. C.J. Date said that database design is common sense formalized. Applying normalization is quite similar to factoring algebraic equations; reduce factors to like terms. Identifying whether or not an attribute exists always or sometimes determines the 'optionality' or 'nullability.' Determining what type of relationship (a person has one birth place, a person may speak one or more languages) it has determines the 'cardinality.'

Reference Data

Reference data can be thought of as a custom data type; instead of a valid date or a number, we have the values 'Enrolled,' 'Accepted,' 'Participating.' When a known set of values exists, restricting the field is best accomplished by using a reference table. While constraints can be implemented, the maintenance of the values becomes a database operation instead of an application function. By creating reference tables, change is supported by the model without requiring changes to the model itself.

Surrogate Keys

Surrogate keys were used instead of natural keys in order to simplify joins and conserve space. Joins are simplified in that there is always one field to join to one table. Composite keys, which require one or more fields and data knowledge in order to join tables, were not deemed efficient for the scope of this data model. Additionally, surrogate keys allow the logical primary key to be changed without implementing logic to handle the change. This was considered necessary in order to support the wide range of datasets since some states allow for primary keys to change over time.

While surrogate keys typically are not represented in a logical model, the prevalence of super-type/sub-typed data combined with education data being so closely tied to organization identifiers and person identifiers, resulted in the decision that they be included. Due to the normalization present in the model, determination of primary keys is typically obvious.

Use of Super- and Sub-types

In order to provide a database that is flexible enough to fit multiple business models, configurable hierarchies and reference data are vital. To promote association of these concepts, NDS uses super-type/sub-types construct. Super-types/sub-types may be used when an idea has common and different elements. For example, a parent and an Early Learning child; both can be categorized as people and share certain people elements, such as birth date and home address. However, only the parent will have a job and only the child will have a lunch program.

NDS utilizes four super-types:

a. Person – Data about people
b. Organization – Any thing that is not a person, such as a district, a school or a course
c. Role – A person's data that relates to an organization, such as a student's attendance
d. Location – Physical addresses, phone numbers, email addresses, websites, GPS and any type of data that serves to identify a location/contact method

Naming Conventions

Consistent naming is important to modeling in that it allows information to be more easily digested. The State Core Model utilizes best practices naming conventions:

a. Entity names and attributes names are descriptive and written in upper camel case (first letter of each word/acronym is capitalized), also known as Pascal case.
b. The name of a parent entity may be used as the first part of a child entity. For example, a person's (entity 'Person') demographic information (entity 'PersonDemographic') contains races (entity 'DemographicRace'). We can see how the migration of the name helps us identify the relationship of the data.
c. The singular form is used for entity and attribute names, unless the lowest level of an element is plural (e.g., 'OtherAcademicSubjects' is one idea, not many in that we do not know all of the subjects, we just care whether or not they exist).
d. All reference data entities are prefixed with 'Ref' to indicate the nature of the data.
e. Surrogate keys are the entity name plus 'Id.' A table named 'Person' will have a surrogate key named 'PersonId.'

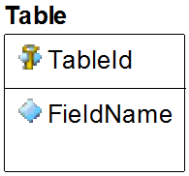
Common Model

Each of the four super-types (Person, Organization, Role, Location) contains information that applies to all types. For example, each person, regardless of role, has demographic information; all types of organizations may have calendar information.

NDS Table and Field Syntax

a. Tables

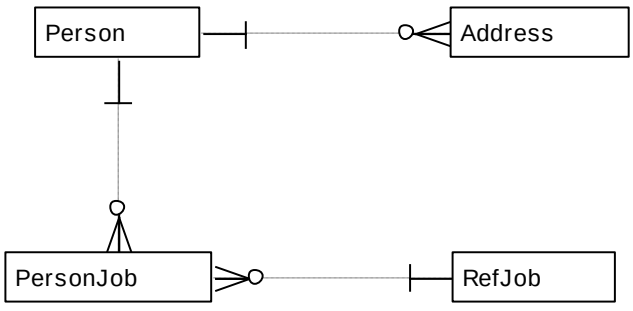
Tables are represented as a rectangle. The rectangle is divided in two by a horizontal line. Everything above the horizontal line is the table's 'primary key'.



The function of the primary key is to uniquely identify one record from all other records within the same table. The State Core model has utilized a design standard of 'surrogate keys.' Surrogate keys do not replace primary keys, but they simplify using them. Essentially, the Dewey Decimal System is a surrogate key mechanism. One number is referenced instead of the title and author of the book. A table with rounded corners means that it is a child of an identifying relationship.

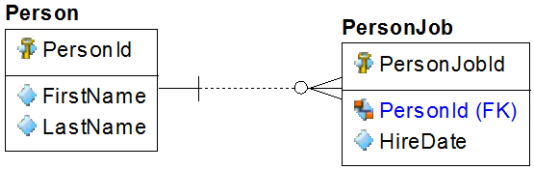
b. Relationships:

The heart of the ERD is illustrating how data relates to itself. By effectively using lines and boxes, we can gather understanding from a simple diagram:



This tells us that a Person has an Address and a Job. We also know that the job has to have a valid piece of metadata (a record in RefJob) in order to be associated with a Person. The majority of relationships within a data model are either 'identifying' or 'non-identifying.' Whether a relationship is identifying or

not has to do with whether the parent table's primary becomes a part of the child table's primary key. To illustrate this point, consider the four tables above. What uniquely identifies a person's job record? Does the Person alone uniquely identify a PersonJob? No, since a person can have multiple jobs. Does the Job uniquely identify a person's job? No, since any number of people can have the same job. Consequently, to uniquely identify a Person's Job, we need to know the person and the job. Since the CEDS Data Model uses surrogate keys, the presence of identifying relationships is reduced to sub-type/super-type relationships.



A non-identifying relationship is represented by a dashed line between two tables. For required joins, the side of the relationship with the perpendicular line indicates the parent table and the side of the relationship with the circle denotes the child table. For optional relationships, a circle is used for both sides of the relationship.

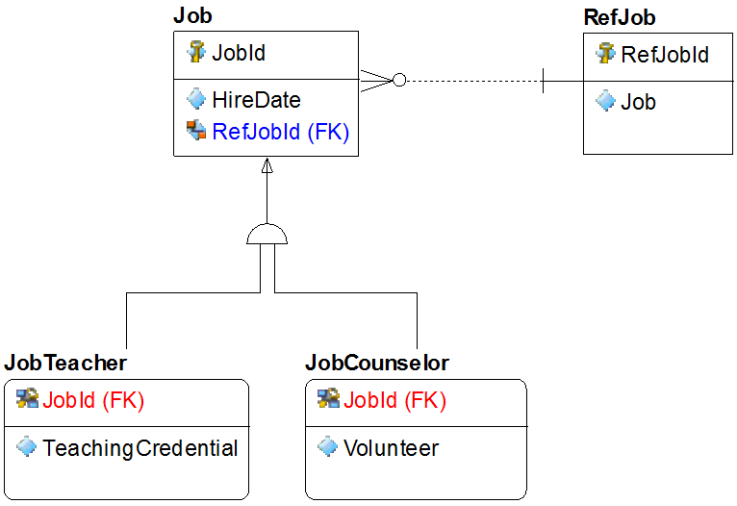
c. Identifying Relationship:

An identifying join means that the parent's primary key is added to the child's primary key.

An identifying relationship is represented by a solid line between two tables. The one or three lines ('Crow's Foot' notation) indicate the cardinality of the relationship.

d. Sub-Type/Super-Type:

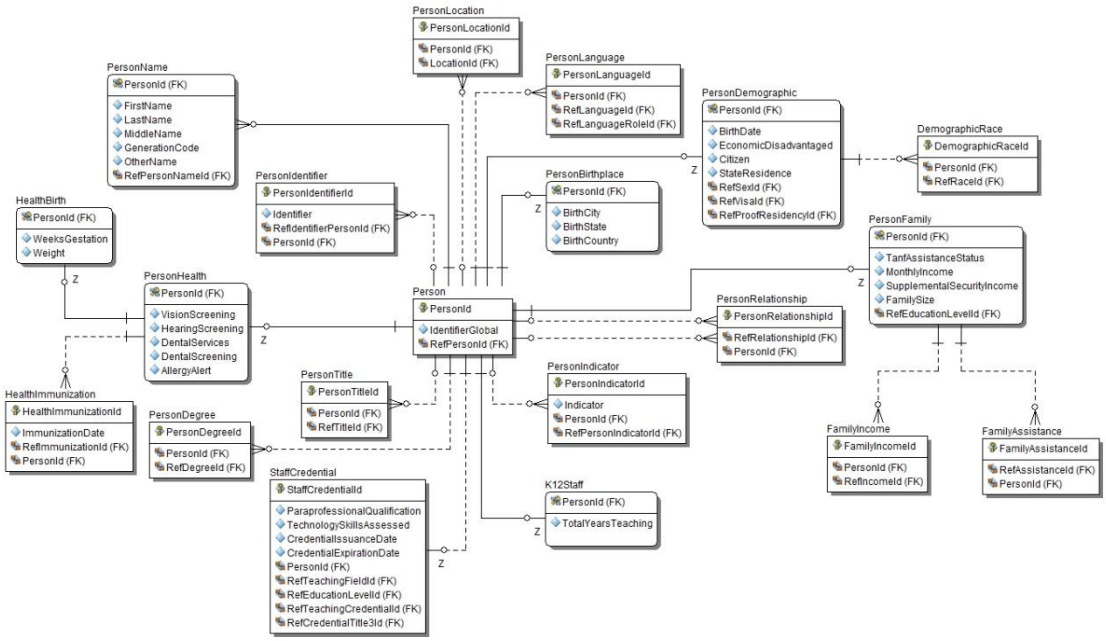
Sub-type/super-type relationships indicate that a record of super-type may have a corresponding sub-type record, but a sub-type record cannot exist without the parent super-type. The power of super-type/sub-typing is that it allows one object to have a different set of properties. By extension, this mechanism allows for multiple tables to be referenced by one common object.



The half circle in the solid relationship line(s) indicates a sub-type/super-type relationship.

NDS Entity Relationship Diagrams

Common: Person



2.3.5. Suggested Education Reports

Reports should be able to answer questions that will help improve the performance of the Education system at all levels, from the highest (country) to the most granular (student and teacher). Reports should be developed that can address the following questions (separated by Data Domain):

a. Organizational Information

i. Basic profile of the school and changes to it over time
ii. What programs are students enrolled in?
iii. How can we tailor academic approaches to fit the needs of the school?
iv. What schools are students coming to this school from?
v. Mobility rate questions (see below)
vi. What programs are being utilized and how much?
vii. Student enrollment profile
viii. Students receiving special accommodations and service (Y/N)
ix. Can look at schools in the district and compare in order to fine-tune approaches for needs of a school (for example, instructional, resource allocation, programs, content being used, and so on)
x. How are similar schools performing in an area? If some schools are performing very well, what are they doing that perhaps the lower-performing schools could try?

b. Student Information

i. Understanding of students' backgrounds
ii. Gives insight to students' strengths and areas they could use improvement
iii. What programs are students involved in?

c. Academic Profile

i. How much time is this student spending in the classroom? By course?
ii. Is a student missing time (and thus learning opportunities?)
iii. How is a student performing in a particular course?
iv. Are students on track to graduate (accumulating the proper amount of credits)?
v. Has the student received any interventions? What were the outcomes?
vi. Does the student have any discipline infractions?
vii. Does the student adjust behavior/have a better outcome from a particular infraction?
viii. How is the student performing on state and local assessments?
ix. Is performance on state and local assessments similar to class/course performance?
    i. If not, why?
x. Does this student move frequently?
    i. If so, does the moving appear to be affecting his performance?
xi. Is this student new to the district and the classes?
xii. Is there a way the student could be "brought up to speed" on particular material?

xiii. Is the student in a program?
xiv. Is there a program that the student could benefit from?
xv. What activities is the student involved in?
xvi. Is there an activity that the student could benefit from?
xvii. How could we tailor academic approaches to meet the needs of this student and to help this student to excel?
xviii. Allows different teachers, counselors, coaches, and others to work collaboratively to maximize student performance

d. Attendance

i. How often are students missing class?
ii. Is a particular student or group of students missing more frequently?
iii. If so, is this affecting their performance?
iv. Is there a school-wide issue with missed learning time? Is there a district-wide issue with missed learning time?
v. If students are missing classroom instruction for a particular time period, how can we arrange the schedule to minimize impact on their learning and performance?

e. **Discipline**

i. What is the discipline rate of the student? The school? The district?
ii. Are there patterns in when discipline incidents are occurring?
iii. Are there patterns in where discipline incidents are occurring?
iv. Is there a particular type of incident that occurs most frequently?
v. What may be causing this incident?
vi.

f. Mobility

i. From where are new students to the district coming?
ii. To where are students leaving the district going?
iii. From where is the school getting students (school, district)?
iv. If students leave, what school are they going to?
v. Why are students coming to a particular school?
vi. Why are students leaving a particular school?

g. Dropout rate

i. What is the school's or district's dropout rate?
ii. How has this changed over time?
iii. Have we implemented programs or policy to try to reduce the dropout rate? How has the rate changed since these were implemented?

iv. Are we seeing trends in the students who are dropping out? (for example, did not perform well in Algebra I, had discipline issues, had attendance issues, and so on)

h. Assessment

i. How are students in specific classes, schools, across the district performing?
ii. What are the district's strengths and weaknesses (down to a standard level, if desired)
iii. Where are students excelling?
iv. Where do students need improvement?
v. How can we group students with similar needs and tailor instruction to meet these needs?
vi. What subject areas/content/standards are being learned well?
vii. What subject areas/content/standards are students not performing well on?
viii. How can we help students to perform better on these standards?
ix. Is there supplemental content?
x. Should we change the content delivery method?
xi. How are students taking alternative tests performing? Are they ready to transition to normal tests?
xii. Are there differences or achievement gaps between key populations (ELL, ethnicity, economically disadvantaged, gender, and so on)?
xiii. How is the student/class/cohort/school/district progressing over time?

i. Advanced Academics

i. What does Advanced Placement enrollment look like?
ii. What courses are students taking at an AP level? What courses are they not taking as much at an AP level?
iii. Are students mastering the concepts at the AP levels?
iv. How are AP students performing on standardized assessments in those concepts?
v. Are students enrolled who should be? (Are all students who demonstrate advanced course potential enrolled?)
vi. Are there too many open seats in a particular course?
vii. Helps allocate resources and make sure the Advanced Academics are being utilized to full potential

2.3.6. Conferences and Events

There are a great number of educational and education technology related conferences throughout the US. There are three conference types in the US, national conferences, regional or state based conferences, and vendor conferences

2.3.6.1. National Conferences:

a. NCES data and technology: http://ies.ed.gov/whatsnew/conferences/?cid=2
b. CoSN: http://www.cosn.org/Events/tabid/4188/Default.aspx
c. ISTE: http://www.isteconference.org/2013/
d. ETS:http://www.k12center.org/events/research_meetings/next_gen_national_conference.html
e. CUE: http://www.cue.org/annual

2.3.6.2. Regional Conferences:

a. MASS CUE: http://www.masscue.org/pages/MassCUE
b. FETC: http://fetc.org/Events/Florida-Educational-Technology-Conference/Home.aspx
c. Vendor Conferences
    i. Blackboard: http://www.blackboard.com/BbWorld/Home.aspx
    ii. Pearson: http://pearsonevents.com/cite2013/

These conferences range variety of topics and focuses but provide various stakeholders and partners with venues to share ideas, developments and new initiatives which help to define both strategy and operations in the years to come.

2.4. Security

When implementing any enterprise education data system in which private and personally identifiable information will be stored and managed, it is vital to have both the requisite technology infrastructure and policy to support that usage case. When establishing a security infrastructure these changes need to be effectively documented, forcing states and districts to implement enterprise-computing models in line with these standards and policies. Information technology is a driving force for improvement of this service delivery. K-12 organizations are increasing the use of Intranet, Web and other technologies to distribute services and data to their communities. Fundamental infrastructure requirements for delivering services through these information technology structures include directories, registries, and authentication and authorization processes.

Understanding the value of establishing an enterprise education portal for effective information delivery, it is most important to have an efficient enterprise security architecture to support that vision. From delivery of reporting and static content to personalization, targeted content delivery, and secure roles, a robust portal website will allow users to have better access to information, communication, and services within a transparent and easily navigable environment. But technology should not be the goal; it is important to maintain focus on overall education objectives that serve to support the education process as it relates to student and school performance, staff and teacher daily functions, and so on.

2.4.1. Authentication and Authorization

When speaking about security it is important to understand authentication and authorization. Authentication is about who you are and authorization is about what you can do within the system. When establishing any enterprise security, having a strong Role Based Access Control (RBAC) model will allow for effective management and access of the system by those who are allowed to see those tools within the system. There are many ways to establish an effective security infrastructure; but, the establishment of the security architecture is one of the most fundamental and vital aspects of an effective and manageable system.

2.4.2. Security Standards

The following security standards are some of the ones used in US education data systems:

a. Oauth

OAuth is an open standard for authorization. OAuth provides a method for clients to access server resources on behalf of a resource owner (such as a different client or an end-user). It also provides a process for end-users to authorize third-party access to their server resources without sharing their credentials (typically, a username and password pair), using user-agent redirections.

b. SAML

Security Assertion Markup Language (SAML) is an XML-based open standard data format for exchanging authentication and authorization data between parties, in particular, between an identity provider and a service provider. The single most important problem that SAML addresses is the web browser single sign-on (SSO)

problem. Single sign-on solutions are abundant at the intranet level (using cookies, for example) but extending these solutions beyond the intranet has been problematic and has led to the proliferation of non-interoperable proprietary technologies. (Another more recent approach to addressing the browser SSO problem is the OpenID protocol.)

c. OpenID

OpenID allows you to use an existing account to sign in to multiple websites, without needing to create new passwords. You may choose to associate information with your OpenID that can be shared with the websites you visit, such as a name or email address. With OpenID, you control how much of that information is shared with the websites you visit. With OpenID, your password is only given to your identity provider, and that provider then confirms your identity to the websites you visit. Other than your provider, no website ever sees your password, so you don't need to worry about an unscrupulous or insecure website compromising your identity. The OpenID Foundation was formed to assist the open source model by providing a legal entity to be the steward for the community by providing needed infrastructure and generally helping to promote and support expanded adoption of OpenID.

d. Shibboleth

The Shibboleth System is a standards based, open source software package for web single sign-on across or within organizational boundaries. It allows sites to make informed authorization decisions for individual access of protected online resources in a privacy-preserving manner.

The Shibboleth software implements widely used federated identity standards, principally OASIS' Security Assertion Markup Language (SAML), to provide a federated single sign-on and attribute exchange framework. Shibboleth also provides extended privacy functionality allowing the browser user and their home site to control the attributes released to each application. Using Shibboleth-enabled access simplifies management of identity and permissions for organizations supporting users and applications. Shibboleth is developed in an open and participatory environment, is freely available, and is released under the Apache Software License.

2.4.3. Access Management

In most current locally deployed or cloud based n-tiered architectures, administrators and system owners have to be concerned with the potential for hacks. Often this is addressed by front end security mechanisms, including session management; but, this does not always address the required security to support database level security. This lack of connection can pose challenges to understanding the transactions taking place within the database and inhibit the overall auditability of the system. Security becomes increasingly complex as the number of elements within application/network increase.

To support effective access management, an organization has to establish not only the technical infrastructure of software and hardware but also security policies. Security Policy is a key consideration of how the system is management, accessed and audited to ensure proper usage.

2.4.4. Relevant US Legislation on Data Security and Privacy

2.4.4.1. Family Educational Rights and Privacy Act (FERPA)

The Family Educational Rights and Privacy Act (FERPA) (20 U.S.C. § 1232g; 34 CFR Part 99) is a Federal law that protects the privacy of student education records. The law applies to all schools that receive funds under an applicable program of the U.S. Department of Education.

FERPA gives parents certain rights with respect to their children's education records. These rights transfer to the student when he or she reaches the age of 18 or attends a school beyond the high school level. Students to whom the rights have transferred are "eligible students."

a. Parents or eligible students have the right to inspect and review the student's education records maintained by the school. Schools are not required to provide copies of records unless, for reasons such as great distance, it is impossible for parents or eligible students to review the records. Schools may charge a fee for copies.

b. Parents or eligible students have the right to request that a school correct records which they believe to be inaccurate or misleading. If the school decides not to amend the record, the parent or eligible student then has the right to a formal hearing. After the hearing, if the school still decides not to amend the record, the parent or eligible student has the right to place a

statement with the record setting forth his or her view about the contested information.

c. Generally, schools must have written permission from the parent or eligible student in order to release any information from a student's education record. However, FERPA allows schools to disclose those records, without consent, to the following parties or under the following conditions (34 CFR § 99.31):
   i. School officials with legitimate educational interest
   ii. Other schools to which a student is transferring
   iii. Specified officials for audit or evaluation purposes
   iv. Appropriate parties in connection with financial aid to a student
   v. Organizations conducting certain studies for or on behalf of the school
   vi. Accrediting organizations
   vii. To comply with a judicial order or lawfully issued subpoena
   viii. Appropriate officials in cases of health and safety emergencies
   ix. State and local authorities, within a juvenile justice system, pursuant to specific State law

Schools may disclose, without consent, "directory" information such as a student's name, address, telephone number, date and place of birth, honors and awards, and dates of attendance. However, schools must tell parents and eligible students about directory information and allow parents and eligible students a reasonable amount of time to request that the school not disclose directory information about them. Schools must notify parents and eligible students annually of their rights under FERPA. The actual means of notification (special letter, inclusion in a PTA bulletin, student handbook, or newspaper article) is left to the discretion of each school.

2.4.4.2. Health Insurance Portability and Accountability Act (HIPAA)

The Standards for Privacy of Individually Identifiable Health Information (“Privacy Rule”) establishes, for the first time, a set of national standards for the protection of certain health information. The U.S. Department of Health and Human Services (“HHS”) issued the Privacy Rule to implement the requirement of the Health Insurance Portability and Accountability Act of 1996 (“HIPAA”).1 The Privacy Rule standards address the use and disclosure of individuals’ health information—called “protected health information” by organizations subject to the Privacy Rule — called “covered entities,” as well as standards for individuals' privacy rights to understand and control how their health information is used. Within HHS, the Office for Civil

Rights ("OCR") has responsibility for implementing and enforcing the Privacy Rule with respect to voluntary compliance activities and civil money penalties.

A major goal of the Privacy Rule is to assure that individuals' health information is properly protected while allowing the flow of health information needed to provide and promote high quality health care and to protect the public's health and well-being. The Rule strikes a balance that permits important uses of information, while protecting the privacy of people who seek care and healing. Given that the health care marketplace is diverse, the Rule is designed to be flexible and comprehensive to cover the variety of uses and disclosures that need to be addressed.

This is a summary of key elements of the Privacy Rule and not a complete or comprehensive guide to compliance. Entities regulated by the Rule are obligated to comply with all of its applicable requirements and should not rely on this summary as a source of legal information or advice. To make it easier for entities to review the complete requirements of the Rule, provisions of the Rule referenced in this summary are cited in the end notes. Visit the Privacy Rule section to view the entire Rule, and for other additional helpful information about how the Rule applies. In the event of a conflict between this summary and the Rule, the Rule governs.

2.4.4.3. Personally Identifiable Information (PII)

The U.S. government used the term "personally identifiable" in 2007 in a memorandum from the Executive Office of the President, Office of Management and Budget (OMB), and that usage now appears in US standards such as the NIST Guide to Protecting the Confidentiality of Personally Identifiable Information (SP 800-122). The OMB memorandum defines PII as follows:

Information which can be used to distinguish or trace an individual's identity, such as their name, social security number, biometric records, and so on alone, or when combined with other personal or identifying information which is linked or linkable to a specific individual, such as date and place of birth, mother's maiden name, and so on.

Links to Legislation

- FERPA*:* http://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html

- HIPAA: http://www.hhs.gov/ocr/privacy/hipaa/administrative/privacyrule/adminsimpregtext.pdf

2.4.5. System and Data Security Approach

As an educational institution progresses in its mission to leverage its rich education and workforce focused data stores into transformational information and insight, the resulting increased utility and transparency of these same data elevates their security risk profiles. As a result, a recommended strategy includes working with those responsible for data management, data governance, security programs/strategies and security governance to insure that the data privacy and securitization requirements are managed utilizing a comprehensive, coordinated, well-orchestrated approach that does not sacrifice functionality and opportunity.

The recommended approach in achieving these objectives commences with classifying data securitization risks into two high level categories. One category defines risks associated with misuse of data through inaccurate reporting, insufficient training, unimplemented data governance strategies, and lack of data flow controls. The second category of risks is associated with infrastructure architectural weaknesses that potentially invite unwelcome data compromise and exploitation. Each of these data securitization risk categories requires attention for all possible states of data. Data state examples include “data at rest” (data resides in any data storage device) or “data in-flight” (data transmission and transport processes).

Developing a security framework will assist in managing both categories of risks in all states of data conditioning. In other implementation this focus has generally been on governance and infrastructure frameworks required to minimize the risks associated with education and workforce data misuse and compromise results from years of direct experience. This experience includes infrastructure architectural design, deployment and monitoring coupled with the leadership and contributions to the authoring and implementation of related policy, programs, procedures and best practices that support the universal goals surrounding the protection of personally identifiable data of our learners and educators.

An effective strategy includes assisting in developing and implementing the mitigating strategies that give transparency into security risk management and provide metrics, measures and indicators that assist in sustaining a secure environment. Specifically, our team brings consultation experience in infrastructure hardening and multi-layer data securitization strategies that include, but are not limited to, implementation of intrusion protection systems (IPS), sensitive data encryption strategies, OWASP (on-line web application security program) alignment, SSL (SSH if required) transport layers, security training and awareness programs.

2.4.6. SSO

Single Sign-On, commonly referenced as SSO, enables access to authenticated systems and content often outside the bounds of one system. Single sign-on (SSO) is a property of access control of multiple, related, but independent application systems. With this property a user logs in once and gains access to all systems without being prompted to log in again at each of them.

Generally we look at SSO in 5 levels of external integration of content and services to a Portal. The integration services provide a seamless use and access to their own systems and feature content within the security and richness of a portal.

LEVEL 1: Application URL

This is a link to a URL embedded on an application page that passes no credentials. It simply requests information from a remote site. It can be within the portal frame, or spawn a new browser session. This takes little to no development, and can usually be accomplished through administrative features offered to a portal. This in fact, is not actually SSO as there is no credentialing being passed or authorization required.

LEVEL 2: Single Sign-On

This means there is a link on the page (or a tab or any normal navigation method) and when it is clicked it either launches a new browser OR stays in the portal frame but it authenticates the user and puts her logged in to the application or service without having to re-authenticate. The portal can use a variety of methods to perform the SSO ranging from standard LDAP integration using Active Directory to Web Services to trust relationships built and defined by SAML.

LEVEL 3: Single Sign-on with Provisioning

Constitute a trust of an application for authentication/authorization information, and may include reciprocal provisioning request for user lifecycle in an IDP. User and Data Provisioning User, organization, role, and application information can be managed in one place for both the portal and the application or service being connected. The directory and identity manager of the portal is the centralized control mechanism and manages access and authentication on both sides and can fully provision users (create, edit, delete) and organizations (create, edit, delete).

LEVEL 4: Integration Service with SSO

At this level the integration can have multiple instantiations within the portal and the portal may control detailed authorization and permissions as well. At this point the service or application is fully embedded in the portal. The portal and the application may even share services or widgets.

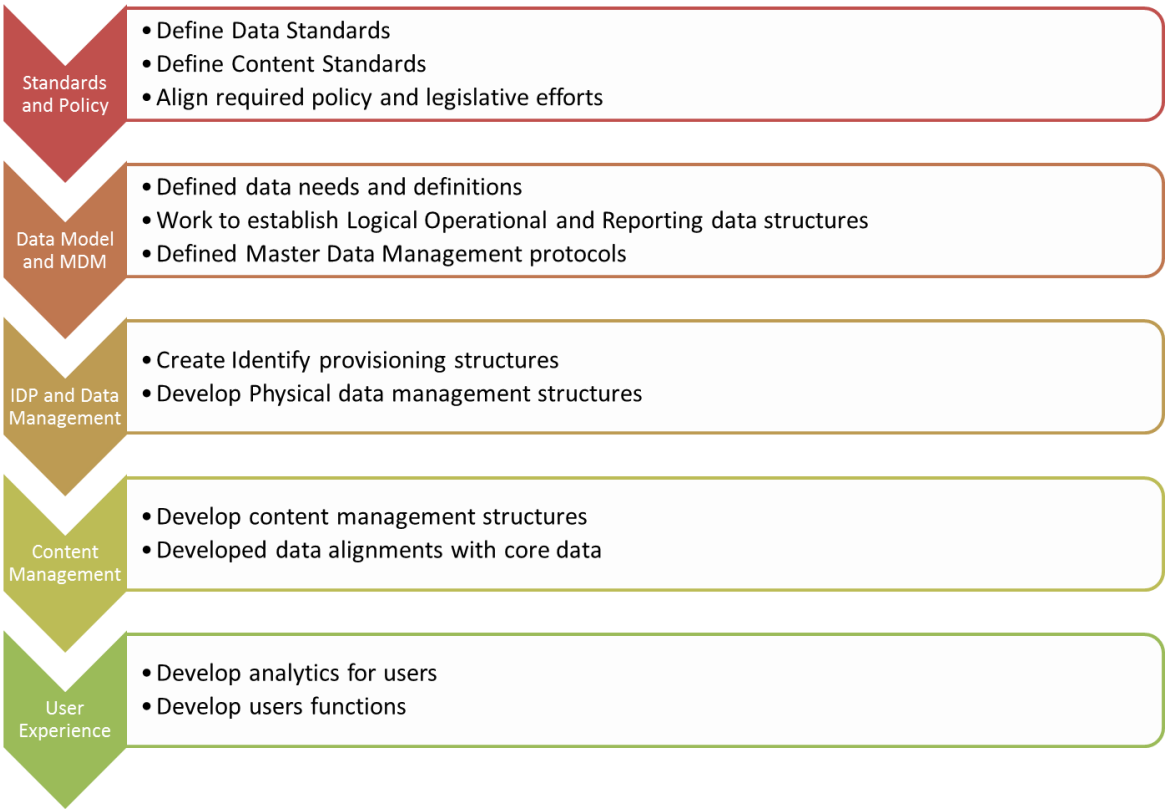
LEVEL 5: Full Integration

The application or service becomes a fully meshed part of the portal environment and the user cannot tell when they are in the portal and when inside this service unless they are explicitly told through documentation or intentional UI. Presentation layer, identity, security, data, and access services are all shared by the application components and the portal components.

2.5. Implementation

When implementing a system of this magnitude there are often challenges with overall project sequencing which need to be considered before and effective and efficient implementation plan can be developed.

As the vision for this implementation is an enterprise data and content portal and reporting system we see the need for the following to be addressed initially.



A central path to a successful implementation is the incorporation of outreach, training and pilot groups from early on within the project. This helps to not only incorporate inputs from your eventual users but also allows for various users to become true stakeholders within the project who are invested in its success and can be your champions when it is rolled out.

2.5.1. Top 10 Lessons Learned

1. **Data Quality**: 65+% of work is around data analysis and bringing awareness of all nuances and findings internally and within the client team is key to success.
2. **Business Change**: A huge value add of creating a longitudinal education data system is the unearthing of erroneous, redundant, and unnecessary processes around data management. The exercises involved in executing the creation of a longitudinal education data system give way to unexpected findings that typically are of great value to business operation and often crucial to accurate reporting. It is imperative to properly document, highlight, and deliver notice of such findings.
3. **User Feedback**: User feedback should and must involve all constituencies. Small focus groups of end users from public or teacher segments can do a great deal in improving report formats and requirements.
4. **Usability and Self-Assistance**: Usability and self-assistance are essential when exposing granular data elements through complex analysis tools. Sufficient time in training and interface/experience design must be present in any solution.
5. **Roll-Out**: The roll-out of a solution should involve road shows, sharing, and listening, with an evolving constant feedback loop; thus creating ownership at all levels.
6. **Sustainability and Extensibility**: Business logic, collection formats, and elements often change on an annual basis. Having a solution and underlying structure that supports this change is central to long term solution viability.
7. **Vendor Relationship**: Maintenance should not require deep engagement with the vendor. Solution and base code should be exposed for use by your support staff, saving untold costs and red tape around deeper vendor engagement. In addition, train staff where necessary around design or the industry common technologies used.
8. **Training**: Creating a training model in which we focus on ownership of all aspects of the solution is vital. Encourage your staff, both technical and business, to be a familiar with the solutions and functional components associated with them as members of our team.
9. **TCO**: Total cost of ownership is not just a slogan; there are the long term support and licensing costs associated with this implementation need to be considered. If done correctly you should be able to maintain the solution with minimal employee resources.
10. **Documentation**: What are the artifacts required for a client to own, use and enhance the project, which require as little support as required. Integrate

documents, videos and other help files to reduce the overall burden and increase the usability of the system.

2.5.2. Project Implementation

The education data system implementation process is a complex and dynamic engagement in which key stakeholder involvement must be solicited during various project cycles. These projects are as much people project as technology project and one must implement the required project controls to address both. The implementation development process needs to be governed by rigid software development and project management methodologies while also allowing for the addition of new requirements and various stakeholder feedback cycles. The roadmap toward accurate time/resource allocation planning includes adapting our thoroughly vetted implementation plan to the educational institution's specific requirements by designing, developing and/or identifying:

a. Measurable, mutually determined project objectives
b. The inter- and intra-team communication protocol, plan, frequency (many times includes daily 30 minute status calls) and methods
c. Detailed project risk and issues management
d. Specific functional strategies and project team membership
e. Role(s) for each project team member and delineating their responsibilities and interdependencies
f. Detailed specific decision making policies and procedures
g. A project plan including a detailed Work Breakdown Structure (WBS)
h. A security program plan
i. A training and knowledge transfer program implementation plan
j. An operational day-to-day implementation management detailed workbook
k. A source data conversion plan
l. A source data quality plan
m. A source data profiling analysis report
n. A key mapping set of artifacts including CEDS alignment
o. Data cleansing procedures
p. Data conversion procedures
q. Data validation processes
r. Logical data models
s. Physical data models
t. Operational considerations
u. System design

2.5.3. Project Sustainability

As with any enterprise architecture project organizations need to focus on the entire sustainability picture. When speaking on sustainability we need to consider not only the capital resource required for things like hardware and software but also the ongoing human resource required for training, maintenance and overall system operations.

Some of the most significant challenges with project sustainability we have identified are as follows:

Challenge #1: Source Stakeholder Identification of Ownership and Accountability

What is the most relevant source of the data, and who is the owner of that data? Often we find the data for a particular report is sitting in an employee's desktop file, although it may reside in other places.

Solution: During discovery, it is critical you identify the authoritative source of data. This can be addressed by having data analysts work closely with your data stewards and mapping each element, to the authoritative source, and how it is collected. You will then need to map this data into the your data model as well as any supporting meta data associated with those collections.

Challenge #2: Data Quality

"Garbage in, garbage out" is an all too common but accurate analogy used to describe the quality of data systems.

Solution: Data can be extracted from any source, but it takes time working with your staff to validate the extracted data and any transformations or calculations that has translated in that process.

Challenge #3: Interagency and Multi-stakeholder Policy/Sharing

All systems need effective outreach and "training".

Solution: Effective outreach starts with a project governance plan in which all stakeholders are engaged in the process and become part of the team. You will need to address issues with data, security, design, etc., early on so that when you roll the system out, users have been a part of the process all along. This takes effort from our staff in developing use case design, mock-ups, and demonstrations, to show users early and often what can be expected, and to use their inputs to shape the end deliverables.

Challenge #4: Support for Multiple Standards

There are many drivers in data system projects and, often, just as many source systems. Frequently, these systems have not been designed with interoperability in mind.

Solution: You can address this by implementing an open architecture, which allows for multiple ways systems can be accessed and data can be loaded. Also by creating multiple project iterations which will be reviewed by a wider stakeholder audience.

Challenge #5: Integration with Consolidated IT

In many of the Departments of Education we have worked with, there is a separation between Education and the Department of Information Technologies in which different organization have different policies and consideration to manage upon.

Solution: Within such environments, you have to do a close and detailed analysis of how to address the inherent restrictions placed on Education solutions by IT. Understanding that it is no longer viable to just put a business case in place to make those changes is critical path for success. In these situations, you work with the IT folks to outline the proposed implementation and document any challenges, in order to either 1) propose new methods which will work for both the Department of Education and the Department of Information Technology, or 2) make design changes to work within these new constructs.

By focusing on key challenges and institutionalizing those challenges with policies and organization structures which can support the long term project vision.

2.6. Conclusion

Throughout this report, the best ways to create an enterprise education ecosystem is highlighted that is policy and standards driven, with proper data and content usage, and that will most effectively support the needs of all constituents of the Indian education system.

Leadership will be required from the federal government, state governments, and the technology industry to make needed advances. At the core of this process is the need to develop a consensus-based, long-term vision and roadmap for interoperability to ensure investments in technology and digital learning are cost effective and meet educator and student needs. To make sure this is successful governance structures must be created to establish an ongoing mechanism to address transparency related to the privacy and security of student data. As well as project governance there needs to be a broader focus on overall standards and

interoperability issues in which both public and private sector can be aligned to meet long term goals. Keys for success are as follows:

a. Unique ID for teachers and students
    i. Ability to create and manage unique identifiers for effective longitudinal analysis and resource provisioning

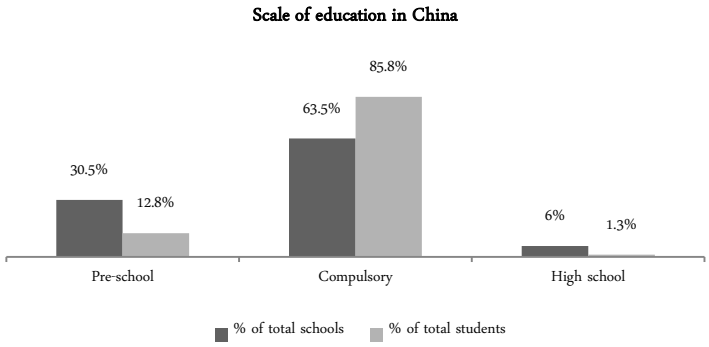
b. Establishment of Learning Standards and objectives
    i. Create the objectives and subsequent standards to support your teaching and learning goals
    ii. Standardized assessment tests to create benchmarks for academic performance across country, region or socio-economically similar communities

c. Creation of data & content standards
    i. Development of standards to support interoperability and alignment

d. Governance entities to be setup for data quality & audits
    i. What cannot be measured cannot be improved so continuous monitoring of the system and progress with set objectives is critical
    ii. KPIs / M&E metrics for evaluating the success of the program

3. Case Study: China

3.1. Education System in China



Source: UNESCO

China, which has the largest population in the world, is a multi-ethnic society. Its population of more than 1.3 billion comprises more than 50 different ethnic groups. Not surprisingly, it has the largest education system in the world in terms of scale, numbers and trends. There are a total of 491,000 schools in the country and approximately 231 million students in 20101. The country has adopted a nine-year (5-14 years) compulsory schooling system (comprising primary, junior high and senior high) in which students have to complete both primary and junior-middle school programme.

The Chinese education system focuses on obtaining core knowledge and does not encourage students to be active participants in learning. This has resulted in lack of independent thinking and initiative-taking capabilities. With the opening up of the country, English teaching has gained more attention in schools. The nation has a high literacy rate of 94% and its students topped the international standard tests coordinated by OECD, competing against students of Singapore, the US, the UK etc.

The Government of China's spending on education in China has reached US$353 million (CNY2.2 billion) (approximately 4% of the GDP) in 2012. It has increased 25 times since 1993 and four times since 2006. Despite this, the figures are not at par with the global average (4.9%). The Government has focused on improving education in rural and remote areas through distance education and invested US$1.77 billion2 (CNY11.1 billion) in rural primary and high schools.

1 "ICT and ODL in education for rural development," inruled website, http://www.inruled.org/iERD/Publication/iERD%20in%20China%20for%20eLA%20(UNESCO-INRULED).pdf, accessed 17 Apr 2013

2 Exchange rate CNY1=US$0.16

3.2. Evolution of ICT in Education

Since its 10th five year plan (2001–05), the Government of China has emphasized on improving ICT to enhance the level of social and economic informatisation. China is currently the world's fourth-largest3 IT market by spend after the US, Japan and Germany.

China had a slow start in its effort to integrate technologies into education due to lack of technological awareness and development. The development of ICT in education has gone through various stages — development of computer-based education during 1980s and 1990s, development of infrastructure buildup during 2000–2007 and the development of application capability following that. The key projects implemented during this period include the following:

a. CERNET pilot project, first TCP/IP-based computer network with nationwide coverage, was launched in 19944.
b. The Government of China launched the "Modern Distance Project"5 in 2000 that transmitted modern distance education programmemes through the use of satellite in rural and remote areas.
c. The "School-to-School" project was launched in 2000 with the aim to bring internet access to approximately 90% of independent primary and high school in China6.
d. Based on the National Educational Technology Standards for Teachers (NETST), a national ICT teacher training programme was conducted to improve awareness and effectiveness of ICT in education.

3.3. Policy Framework

Student tracking: movement of students has to be tracked: school to school, district to district and also state to state if necessary. And this, along with the performance of the student.

[3] "1 Market structure," *New Zealand Trade & Entreprise website*, http://www.nzte.govt.nz/explore-export-markets/market-research-by-industry/Information-and-communication-technologies/Documents/ICT-market-in-China-March-2011.pdf, accessed 17 Apr 2013
[4] "CERNETEvolution," *China Education and research network website*, http://www.edu.cn/introduction_1378/20060323/t20060323_4288.shtml, accessed 17 Apr 2013
[5] ""Modern Distance Education" Project Launched," *People's Daily*, http://english.people.com.cn/english/200004/30/eng20000430_40069.html, accessed 17 Apr 2013
[6] "ICT in Education for Rural Development," *iERD website*, http://www.inruled.org/down/zzq/ICT%20Newsletter%20final.pdf, accessed 17 Apr 2013

The Chinese education system is highly centralized. The Ministry of Education designs and coordinates the implementation of most of the ICT education policies. However, provincial Government in some cases may come up with specific policies for their own province. ICT-related school policies are linked to national policies as developed by the Ministry of Education (MOE). In 2001, the MOE issued primary guidelines for ICT curriculum. It aimed to popularize ICT education as one of the compulsory subject in all elementary and secondary schools before 2010.

National outline for medium and long-term education reform and development plan (2010–2020)

"Technology has a revolutionary impact on education, it must be highly regarded" – National Long Term Plan

The Government of China was not satisfied with the level of ICT development in the education system and came up with a new plan in 2010. In this plan, the Government has focused on modernizing the education system at all levels. It sets the direction for education for the upcoming decade (2010–2020), and ICT in education is one of the key elements of that plan. The key features of the plan are:

a. Informatisation of the educational system
b. Cultivating existing and training new teachers
c. Enforcing education management according to the current laws
d. Guaranteed funding over the whole term of education reform

The plan has put special emphasis on use of ICT and infrastructure building in rural areas aiming to narrow the digital divide among regions and schools7.

China National Educational Informatisation Plan (2011–2020)8

The plan aims to promote integration of education and technology, build a green learning environment, provide resources to build efficient and effective education infrastructure, accelerate construction of digital campus and strengthen the construction of information management and service platform.

The key initiatives that will be implemented under this plan are:

a. Building of educational resource system and public service platform by 2015 to provide learners with quality educational resources

[7] "ICT and rural education in China," *World Bank website*, http://blogs.worldbank.org/edutech/ict-and-rural-education-in-china, accessed 17 Apr 2013
[8] "China National Educational Informatization Plan (2011-2020)," Site blog, https://dl.dropboxusercontent.com/u/8992262/CIP_2011-2020en-2.pdf, accessed 17 Apr 2013

b. Building 20,000 online courses, developing 500 subject-oriented technological tools and platforms, and applying 1,500 virtual simulation system
c. Building an intellectual property protection and incentive mechanism
d. Constructing a digital university and building approximately 1,600 educational informatisation innovation schools and 100 educational informatisation regions
e. Constructing national and local government education management system
f. Covering all schools with national broadband network by 2015. Primary and secondary school to access bandwidth of 100Mbps or above
g. Constructing a nationwide cloud environment

The plan is implemented by educational administrative departments. These departments should, at all levels, draw their respective implementation strategies based on this plan.

The Ministry of Education has the authority to implement national policy for education to achieve the modernisation goal and to improve national competition. The plan is implemented by various educational administrative departments. The departments draw their execution strategies based on the overall goal of the plan9. The provincial education administrations take orders from central government in order to manage the educational institutes in their provinces. The process of management by multiple levels of governments ensures that the institutes are on track and follow the same goal.

3.4. Use of ICT in Schools

The Government of China has been extensively using ICT tools since late 1990s to expand the reach of schools in rural areas and improve the standards of the existing education infrastructure.

The Government implemented a number of initiatives to automate school management services, impart classroom education through e-learning, train primary and high school teachers and build state-of-the art school infrastructure. The Government has funded most of these programmemes and engaged with technology providers such as Microsoft and Cisco to develop the infrastructure and implement advanced technologies. Some of these initiatives are listed below:

[9] " Vocational education and training in China," ford school website, http://www.fordschool.umich.edu/sites/china-policy/files/2011/10/PP716_VET-Paper_Final_042911-1.pdf?bcsi_scan_debboe326e6a7dd8=0&bcsi_scan_filename=PP716_VET-Paper_Final_042911-1.pdf, accessed 29 May 2013

Table: Use of ICT in Schools in China:

School Management Services	MIS Services	Learning Support Services	Governance Services
▪ Internet access in primary and high schools(school-to-school project) ▪ The Government partnered with Cisco to re-build Sichuan's destroyed education infrastructure (Connecting Sinchuan)	▪ Online tracking of school buses ▪ Real time data transfer of Kindergarten kids in Shanghai to be shared with teachers and parents	▪ Development of education through distance learning (Modern distance education project for rural schools (MDEPRS)) ▪ Ministry of Education enters partnership with Microsoft to build ICT infrastructure(Partners in Learning) ▪ Youth Centers offering computer courses ▪ Online learning system for 20 million students ▪ Continuing Education Network for Primary and High School Teachers ▪ K12 Teachers' Continuing Education (TCE) Programmeme	▪ Development of a cloud solution (Cisco Edge 300)

3.4.1. School Management Services

China has successfully initiated programmemes to improving efficiency of school administration and to enable access to near real-time and better quality data for decision support. China has realized the benefit of using ICT in school management services and has been equipping schools with internet access so that ICT can be used in administrative work.

Internet access in primary and high schools (school-to-school project)10: The project was launched by the Ministry of Education in 2000. It aimed to bring internet access to around 90% of independent primary and high school in China by 2010. The goals of the project were to ensure sharing of online education resources among primary school students and teachers, improve teaching quality, and help teachers accept the idea of continuing education that can improve their teaching ability.

[10] "ICT in Education for Rural Development", UNESCO INRULED Newsletter, April-June 2012, http://www.inruled.org/down/zzq/ICT%20Newsletter%20final.pdf, accessed 16 Apr 2013

Partnership with Cisco to re-build Sichuan's destroyed education infrastructure (Connecting Sichuan)11 12: After the 2008 earthquake, Cisco built a public-private partnership (PPP) with the Sichuan Provincial Government to engage in the post-quake rebuild efforts. For the programme, Cisco donated US$50 million as part of its CSR activity.

Results:

Table: Results of PPP in Sichuan Province

21st Century Schools	▪ More than 1,140 multimedia classrooms were installed and 4,500 teachers were trained
Education cloud	▪ Provincial- and county-level education clouds were established ▪ Six curriculum resource centers to serve 16 counties and 26 education sites to allow teachers to download training material
Virtual education	▪ Rural students can now receive instruction from expert teachers in city centers by attending virtual classes delivered over the network
Cisco Networking Academy	▪ Academy has formed educational partnerships with a total of 51 schools in Sichuan, 25 of which were funded through the Connecting Sichuan programme ▪ Educated more than 7,400 students in Sichuan of which 5,300 from Connecting Sichuan funded academies

3.4.2. MIS services

The Government has started region-wide programmemes such as online tracking of school buses and creating MIS to enable teachers and parents access real-time data of kindergarten kids. These programmemes have been recently started with the help of local authorities and private technology providers.

Online tracking of school buses13: In April 2013, the Ministry of Education announced that a national online database will keep track of every school bus in China. It would be a country-wide initiative. The system will address safety of school

[11] "Cisco's 'Connecting Sichuan' Program Transforms Regional Education and Healthcare after Disaster", Cisco Newsroom, http://newsroom.cisco.com/press-release-content?type=webcontent&articleId=950790, accessed 18 Apr 2013

[12] "Connecting Sichuan", Cisco Website, http://www.cisco.com/web/about/citizenship/socio-economic/specialprograms/docs/Connecting_Sichuan.pdf, accessed 18 Apr 2013

[13] Jin Zhu, "Online database to keep tabs on school buses", *China Daily*, http://www.chinadaily.com.cn/china/2013-04/09/content_16385132.htm, accessed 17 Apr 2013

children by monitoring all bus drivers and regulating unlicensed buses plying in rural areas. The local authorities have been asked to collect detailed information on buses that take children to kindergartens and schools.

Real time data transfer of Kindergarten kids in Shanghai to be shared with teachers and parents 14: In December 2012, The Early Learning Department of Shanghai Education Bureau signed a contract with VINCI Early systems. The company will develop and implement Classroom Intelligence solutions in Shanghai's 1,400 government-operated kindergartens where three to six year–old children follow a standard play-based curriculum before beginning primary school. Classroom Intelligence combines cloud computing, tablet technology and data mining to collect real time data about each child's learning status. It will be implemented in all kindergarten schools of Shanghai.

In the first phase, the solution will enable teachers to access real time data of kids. Teachers will have full insight into the effectiveness of their lessons and the degree of understanding of each child. Each child's strengths and weaknesses are identified and a series of recommendations are given to the teacher for each child.

In the second phase, VINCI Classroom Intelligence will connect with parents' mobile devices to link the education in the classroom with their home activities.

3.4.3. Learning Support Services

China has been encouraging computer-assisted learning at both school and college level. The Government and private players are working together to provide learning material to students of all grades through various technologies. The Government has also initiated various initiatives to train its teachers so that they are able to fully explore the vast ICT infrastructure, which is being developed across all government schools.

Development of education through distance learning (Modern distance education project for rural schools (MDEPRS))15: The project, started in 2003 for a four-year period, aimed to develop education in rural China through modern distance education technologies such as computers and satellite-receiving stations. It was

[14] "Deals digest: VINCi technology to provide real-time student data to teachers in China", Business Journal, Dated January 7 2013, http://www.obj.ca/Technology/2013-01-07/article-3143713/Deals-digest-VINCI-technology-to-provide-realtime-student-data-to-teachers-in-China/1

"VINCI signs contract with Shanghai Education Bureau and Launches School Solutions," *VINCI website*, http://www.vincigenius.com/community/vinci-signs-contract-with-shanghai-education-bureau-and-launches-school-solutions/?replytocom=332, accessed 16 Apr 2013

[15] "Modern distance education project for the rural schools of China: recent development and problems", S.Q. Yu and Minjuan J. Wang

launched in the Guizhou province and Lhasa in Tibet. China's Ministry of Education (MOE) has invested an estimated US$1.6 billion (CNY10 billion) in this project.

This project was implemented by using three different models:

Table: Different Models of use of ICT in different categories of schools in China

	Model 1: Establishing CD/DVD-equipped teaching centers	Model 2: Satellite Viewing System	Model 3: Establishment of rural junior high school multimedia classrooms
Target schools	Remote rural schools	Village primary schools	Rural junior high schools
Technology	TV sets, DVD players, and instructional CDs	Satellite TV receiver systems, computers, TV sets, DVD players, and teaching disks	Satellite TV receiver systems, computer classrooms with Internet access, multimedia classrooms, and disk players
Internet access	No	No	Yes
Cost per school	US$480 (CNY3,000)	US$2,560 (CNY16,000)	US$24,000 (CNY150,000)
Achievement	402,000 units	208,000 units	45,000 units

Microsoft partners with Ministry of Education to build ICT infrastructure (Partners in Learning)6:

Microsoft has donated US$10 million for this programme to train teachers, develop distance/digital education solutions, and construct 100 computer classrooms (investment of around US$32,000 (CNY200,000) for each classroom)

2003 **2009**

The first phase of the project consisted of three parts:

Grants Program: It applies ICT to teaching and learning through training and course development

Fresh Star: Under fresh star, computers installed with legal versions of Windows is donated to schools

School Agreement: School Agreement provides complete sets of Microsoft Office at a low price to schools

Microsoft (China) provided funding of US$10 million in this phase to provide training to 1,000 selected ICT schools

The second phase makes systematic arrangements for the contents of project and establishes three sub-projects of equal importance

- Innovative teachers
- Innovative schools
- Innovative students

Youth centers offering computer courses16: Youth centers, such as Jingan District Youth Center in Shanghai, are offering a range of supplemental curricula for elementary, middle and high school students. Additionally high school students are required to spend a certain number of classroom hours at the youth centers. The objective of these courses is to train students with the help of computer-assisted design and IT.

Online learning system for 20 million students17: In 2007, LP+ Group of the UK and Sun Media Group of China entered a joint agreement to develop online learning material for Chinese school students. Under the agreement, LP+ group (UK) will provide an online learning system for secondary school lessons in the Chinese language — with lessons accessible through an internet browser. The online material will be aimed at students in 20 major Chinese cities. Sun Media will provide content across a range of subjects.

Continuing Education Network for Primary and High School Teachers18: The Continuing Education Network for Primary and High School Teachers was launched by Northeast Normal University in December 2002 in cooperation with 18 provincial normal universities and colleges. The network aims to continue education for primary and high school teachers and headmasters. The programme had sponsored

[16] "China's Challenges," *Global Post*, http://www.globalpost.com/dispatch/education/100407/technology-the-classroom-chinas-challenges, accessed 18 Apr 2013

[17] "UK and China sign e-learning deal", *BBC News*, http://news.bbc.co.uk/2/hi/uk_news/education/7010282.stm, accessed 18 Apr 2013

[18] "ICT in Education for Rural Development", *UNESCO INRULED* Newsletter, April-June 2012, http://www.inruled.org/down/zzq/ICT%20Newsletter%20final.pdf, accessed 16 Apr 2013

7 national-level and 35 provincial-level training projects, established 18 provincial-level websites, more than 600 regional learning and resources centers, and more than 60 specialized websites.

K12 Teachers' Continuing Education (TCE) Programme19: Under the programme, K12 school teachers were mandated to integrate ICT in their teaching.20 Also, 190 hours of ICT training was also provided to 10 million K12 teachers in three years (1999-2002) . Now, 100% of senior high schools and over 90% of junior high schools have ICT in their curriculum.

3.4.4. Governance Services

Realizing the potential of ICT education, the Central Government and provincial governments started engaging private players to procure state-of-the-art ICT infrastructure. This infrastructure will help in effective implementation of ICT in various processes such as teacher recruitment and administration, regulation of schools and teacher training institutes, scheme design and implementation. It would help in improving service delivery of school education department and efficiency of school administration and governance requires.

Development of a cloud solution (Cisco Edge 300)21: Cisco Edge 300 is an in-room, all-in-one access control point, which can be used for remote teaching. The solution is specially made to work in rural areas of the country. It does not have fans, which prevent dirt from entering the system, secure enough to prevent viruses, and use as little energy as possible to meet government standards. In 2012, Cisco has sold 8,000 units to the Ministry of Education, which they are currently deploying in about 2,000 schools.

3.5. ICT tools used for various projects

Various programmes and initiatives of the Government of China have been designed and implemented by using advanced technologies and tools. The Government has engaged private sector players such as Microsoft, Cisco and Rullingnet Corporation to develop the technologies and implement in schools.

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19 "ICT in education in China", http://wiki.nus.edu.sg/display/cs1105grouprepports/ICT+in+education+in+China

20 "ICT in Education", UNESCO Bangkok, http://www.unescobkk.org/education/ict/ict-in-education-projects/training-of-teachers/training-of-teachers-and-facilitators/experts-meeting-june-2003/papers/china/

21 "Diversity in Leadership: Aglaia Kong – Modernizing Education in the World's Most Populous Country", *Asia Society*, http://www.globalpost.com/dispatch/education/100407/technology-the-classroom-chinas-challenges, accessed 16 Apr 2013

Table: Different Technologies used in schools for students and teachers

	DVD/ TV	MIS	Advanced Multi-media	Internet	Cloud computing
Online tracking of school buses		✓			
Real time data of Kindergarten kids in Shanghai to be shared with teachers and parents			✓	✓	✓
Modern Distance Education Project for the Rural Schools	✓		✓	✓	
Connecting Sichuan			✓	✓	✓
School-to-School				✓	
Partners in Learning			✓	✓	
Cisco Edge 300- Cloud solution					✓
Youth Centers offering computer courses	✓		✓	✓	
20 million Chinese students to get access to e-learning material			✓	✓	
K12 Teachers' Continuing Education (TCE) Programmeme	✓		✓	✓	
Continuing Education Network for Primary and High School Teachers			✓	✓	

3.6. Management and financing

The Central Government is responsible for most of the funding of projects related to ICT implementations in schools. The Ministry of Education (MoE) is the lead agency of the Central Government for all education project planning. It also co-ordinates with various universities, such as Beijing Normal University, for project implementation.

In some of the cases, private players such as Cisco and Microsoft have also funded projects, for example ”Connecting Sichuan” and ”Partners-in-Learning,” as part of their CSR initiatives and overall country strategy. HP has collaborated with Government of China to implement its education informatisation plan. It created a US$1 million (CNY6.2 million) fund in 2012 to support teacher training through the

use of ICT solutions. With the help of this fund, the teachers will learn how to use ICT effectively and innovatively in classrooms with a personalized learning approach. More than 5,000 teachers from 500 rural and urban schools will be trained through this fund over a period of two years22.

3.7. Technology infrastructure and connectivity

China has reached the informatisation level of moderately developed countries from a reduced status. There are more than 10,000 township-level service stations and 100,000 village-level service spots. Within China villages, telecom coverage is 99.8% — broadband coverage is 96% and network coverage is 91%.

The Government of China enhanced the use ICT infrastructure in education through its various expenditure programmes. The Government implemented various initiatives on education informatisation with significant progress in rural areas. Some of the key initiatives are as follows:

a. More than 440,000 sets of teaching discs and players, 260,000 education satellite receivers and 40,000 computer classrooms are distributed among and built up in more than 360,000 rural primary and high schools in Central and Western China
b. Reliable network coverage for more than 90% of rural junior high schools and more than 80% of primary schools

As a result of moderate level of informatisation, the education system is using a variety of ICT tools in order to provide learning to it students. Some of the key tools used are as follows:

a. Use of Electronic textbooks (Laptop): A pilot scheme was launched in Northwest China in which around 20 schools are using laptop instead of textbooks23.
b. Transmission through satellites: Sky Stream Networks, in association with Lucent Technologies, IBM and ViAccess enabled broadcast of multimedia content to students around the country through the usage of satellite24.
c. Establishment of ”cloud network”: A new product (CISCO Edge 300) was formed with joint effort of Ministry of Education and Cisco to provide online

[22] “HP Launches Education Innovation Fund in China with $1 Million Donation,” *HP website*, http://www8.hp.com/us/en/hp-news/press-release.html?id=1221832#.UXEn2-S-qAd, accessed 19 Apr 2013
[23] “Electronic textbooks on trial in Shaanxi,” *cntv website*, http://english.cntv.cn/program/china24/20130106/106517.shtml, accessed 19 Apr 2013
[24] “Chinese Ministry of Education Selects SkyStream Networks to Enable Broadcast Delivery of Internet Streaming Video Over Satellite to 800,000 Schools in China,” *freelibrary website*, http://www.thefreelibrary.com/Chinese+Ministry+of+Education+Selects+SkyStream+Networks+to+Enable...-a063253582, accessed 18 Apr 2013

communication and virtual teaching for teachers and students within a school, and across schools nationally25.

Different models of imparting training to teachers in rural areas

UNESCO conducted an extensive study on the use of ICT in education system of China. It highlighted that in rural and remote areas of the country, distance education is the most effective option for teachers' training. It identified various learning material and support that is required for different types of rural audience.

	First model	Second model	Third model
Target audience	Students with internet access but unable to attend classes regularly at off-campus learning centers	Students able to attend classes at off- campus learning centers	Students without internet access and unable to attend classes regularly at off-campus learning centers
Learning materials	Paper-version textbooks + online teaching material + other online learning resources	Textbooks + teaching materials + online teaching resources	Paper-version textbooks + disk version "course learning instructions" + other learning resources
Learning support	On-demand broadcast/ online Q&A/online teaching assistance/ synchronous and non-synchronous discussion / online tests / expert lectures	Real-time teaching / on-demand broadcast of teaching material / online Q&A / online learning assistance / synchronous and non-synchronous discussion / online tests/ expert lectures	Teaching material/ teaching disks/ learning assistance material /phone and mail Q&A

3.8. Monitoring and evaluation

The use of ICT tools have helped in improving the reach of education to the rural and remote areas of China. It has also facilitated the learning of abstract ideas and theories. The MOE certifies teachers, standardises curriculum and textbooks, establishes standards and monitors the entire education system in an effort to

[25] "Proactive Innovation Targeting Key Trends Ms. Aglaia Kong, Global VP of Cisco," *cuhk website*, http://big.baf.cuhk.edu.hk/files/6513/4612/5790/E-newsletter1.pdf, accessed 18 Apr 2013

modernise China through education. It monitors the policies and performance from time to time and revamps them with changing scenario.

In an effort to improve monitoring and evaluation system for ICT in education, the MOE has included various safe guard mechanisms in its National Educational Informatisation Plan (2011–2020). The plan specifically addresses the need to develop appropriate indicators for measuring progress and impacts during implementation.

The key indicators that have been utilized to gauge the success of the programmemes relating to "ICT in education" are as follows: 26

a. Proportion of schools with IT curriculum
b. Ratio of computers per student
c. Ratio of computers per teacher
d. Proportion of K12 schools having access to internet, multimedia classrooms and computer labs

3.9. Conclusion

During the last decade, the Government of China's emphasis on improving the use of ICT in education system has borne fruits. The Ministry of Education designs and funds most of the policies and coordinates with different stakeholders like state universities for implementation of these initiatives. The technological development of the country has also helped in improving the penetration of ICT in remote parts of the country. Modern educational teaching methods are already being used in most urban schools while distance education is gaining ground in rural and remote areas through the use of ICT tools.

China's demographic structure is similar to India which could fuel India's ambition under MMP, to achieve efficient and effective delivery of ICT services in education. India's National Policy on ICT in School Education27 (2012) is similar to China's National Educational Informatisation Plan (2011-2020). Both the policies talk about reducing the digital divide in the education system and promote sharing of quality educational resources. They focus on automation of school management services, up-gradation of infrastructure, capacity building of teachers and various ways of financing, monitoring and evaluation.

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26 "To Create a Teacher Professional Development Supporting System by using e-Learning", Prof. Huang, Beijing Normal University, http://www.inruled.org/iERD/Publication/To%20Create%20a%20TPDSS%20by%20using%20e-Learning.pdf

27 " National Policy on ICT in school education," Department of school education, http://www.itforchange.net/sites/default/files/ITfC/revised_policy%20document%20ofICT.pdf, accessed 29 May 2013

China did not use 'One Size fits all' policy measures due to its large and diverse geographic area. It came out with different models to provide teacher and student training in various remote and rural parts of the country. Each of these models has different sets of learning materials and learning support system catering to variety of population. India with similar geographic area and growing internet penetration (current ~12%28 as compared to China ~42%)29) could learn from some of these models and customize them as per its demographic scenario.

The Ministry of Education in China has collaborated with various private players to implement programmes and initiatives aimed at the deployment and use of ICTs in school education. India could similarly leverage the expertise of private players and collaborate with them in developing different ICT tools. The success of e-governance initiatives like National MIS of school buses, e-learning initiatives for both teachers and students and development of digital learning resources for students could be replicated in India as they cater to large sections of the population.

With the emergence of new technologies that could be replicated in an affordable manner, China is expected to tap the ICT advantage and build a strong and IT-efficient education system in coming years.

[28] "Internet penetration in India is barely 12%, so it is still years away from being a game-changer: Shashi Tharoor," Economic times website, http://articles.economictimes.indiatimes.com/2013-04-01/news/38189323_1_delhi-gangrape-victim-game-changer-obama-campaign-team, accessed 29 May 2013

[29] "China's Internet population surges to 564 million, 75 percent on mobile," ZDnet website, http://www.zdnet.com/chinas-internet-population-surges-to-564-million-75-percent-on-mobile-7000009813/, accessed 29 May 2013

4. Case Study: Singapore

4.1. Education System in Singapore

Singapore has a well-developed education system. The country has more than 350 schools for primary, secondary and post-secondary education supported by 32,000 education officers. The annual government budget for the education sector has reached US$8.48 billion (S$10.6 billion) in 201230, which is 3.3% of the country's GDP.31 The country promotes "holistic education", as its schools work toward cultivating creativity and not cramming32. Bilingual policy, emphasis on holistic learning, focus on teacher quality and integration of information and communication technologies (ICT) into learning are the key strengths of the system. The Ministry of Education (MOE) has also formulated a vision of "Thinking Schools, Learning Nation" (TSLN) to describe thinking schools as learning organisations that seek better ways of doing things through participation, creativity and innovation33.

4.2. Evolution of ICT in education

The Government of Singapore considerably emphasizes the use of ICT. The country has a widespread penetration of ICT as 8 in 10 households have access to computers34. Internet penetration is 75% and mobile penetration is 157.2%. The country uses ICT extensively in various strategic areas such as health, armed forces and electronic commerce35.

In the field of education, the usage of ICT has evolved from being a facilitator to a driver of the learning experience. The various phases of the evolution can be summarized as below:

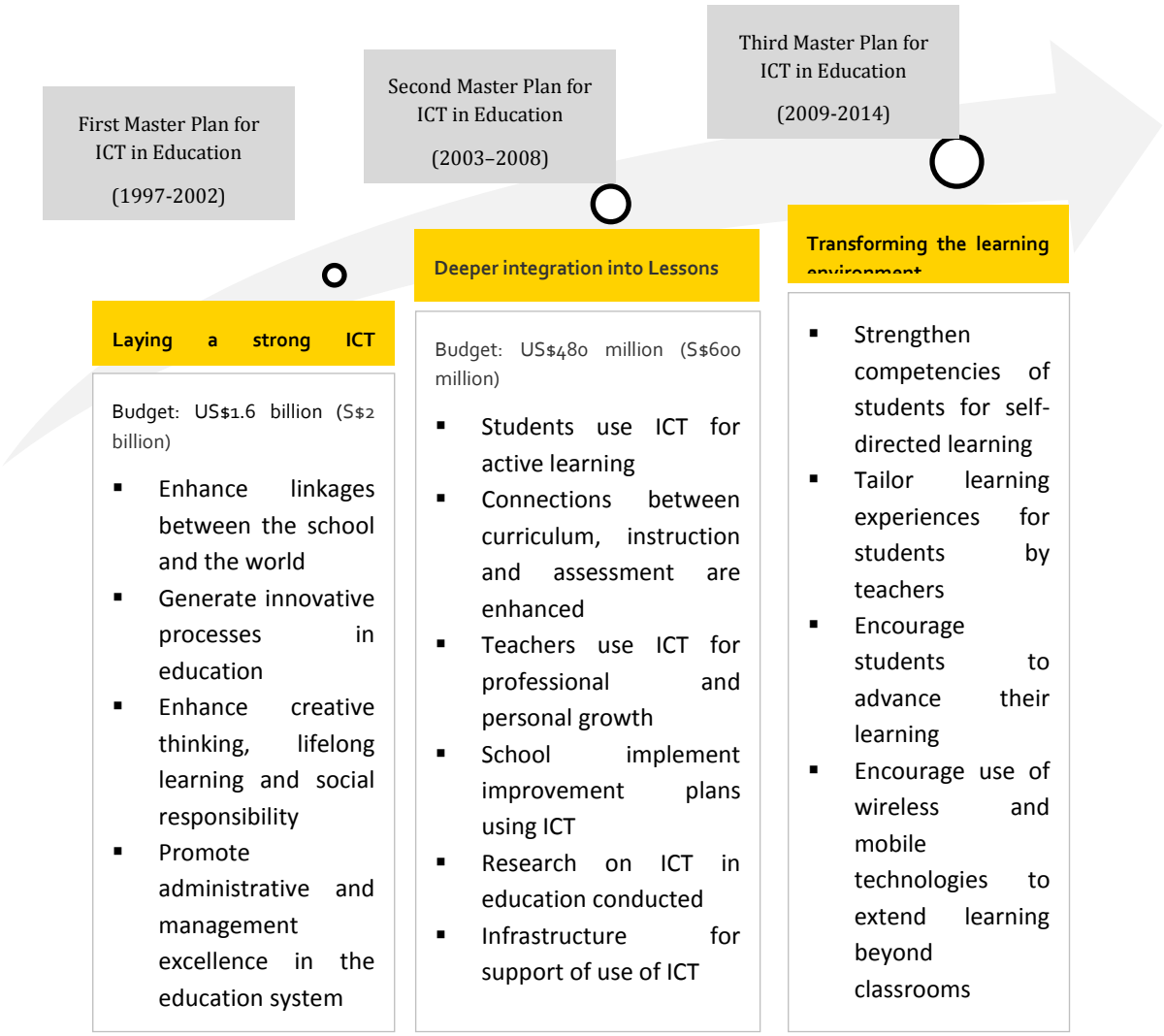
[30] Currency exchange rate used: 1 SGD= US$0.80
[31] MOE Corporate Brochure, http://www.moe.gov.sg/about/files/moe-corporate-brochure.pdf , pg2
[32] "Singapore wants creativity not cramming," *BBC website*, http://www.bbc.co.uk/news/business-17891211, accessed 16 April 2013
MOE Corporate Brochure, http://www.moe.gov.sg/about/files/moe-corporate-brochure.pdf , pg2
[33] "About Us", MOE website, http://www.moe.gov.sg/about/#our-vision, accessed 16 April 2013
[34] "Infocomm Usuage," *IDA website*, http://www.ida.gov.sg/Infocomm-Landscape/Facts-and-Figures/Infocomm-Usage-Households-and-Individuals, accessed 15 April 2013
[35] "Media," *MOE website*, http://www.moe.gov.sg/media/speeches/2008/08/05/opening-address-by-dr-ng-eng-h-1.php, accessed 16 April 2013

Time period	Key actions
Supportive infrastructure (1970-2000)	▪ Singapore adopted the usage of ICT in late 1970s with the setting up of basic information infrastructure. There was introduction of micro-computers by students in computer appreciation clubs as extra-curricular activities. ▪ The ICT in education got further impetus with the launch of National ICT Plan: IT2000 in 1991. The plan aimed at setting up required IT infrastructure in schools and providing adequate support from the relevant industries. ▪ ICT as a formal method of teaching and learning was introduced in 1995 with the Government launching several projects. A project named Accelerating the Use of IT in Primary Schools (AITP) was launched to use multimedia and computers in six primary schools.
Integration (2000-2010)	▪ The government felt the need of integration of ICT into education rather than providing the supportive infrastructure. ▪ It launched several initiatives and programme to achieve the same. For instance, BackPack.NET initiative was launched in 2003 to enhance interaction between teachers and students.
Innovation (2010-Future)	▪ To carry forward its flair of utilisation of ICT in education, it has developed a 10-year Master Plan, "Intelligent Nation 2015". ▪ In the Master Plan, there is a national commitment to enhance creativity and enable innovation. It also plans to achieve 100% computer ownership in homes with school-going children by 2015.36

4.3. Master Plans representing the national policy on "ICT in education"

The Government of Singapore has launched a series of three "ICT in Education" Master Plans over the past 13 years to encourage the use of ICT in education. These plans aim to establish an infrastructural foundation for ICT in schools and to enhance utilization of ICT in educational processes.

[36] "iN2015 Masterplan," *IDA website*, http://www.ida.gov.sg/Infocomm-Landscape/iN2015-Masterplan, accessed 17 April 2013



The first Master Plan for ICT in Education (1997–2002) laid the foundation for schools to harness ICT, while the second Master Plan further implemented effective and pervasive use of ICT in education.

The third Master Plan (2009–2014) currently in progress, aims to continue the vision of the first and second Master Plans. It enables transformation of learning environment and equips students with critical competencies and dispositions for success in a knowledge economy37. The main implementation strategies of the plan are as follows:

[37] "Singapore unveils third Masterplan for ICT in Education", *IN.SG website*, http://www.ida.gov.sg/insg/post/Singapore-unveils-third-Masterplan-for-ICT-in-Education.aspx, accessed 17 April 2013
"MOE Launches Third Masterplan for ICT in Education", MOE press releases, http://www.moe.gov.sg/media/press/2008/08/moe-launches-third-masterplan.php, accessed 15 April 2013

a. Bring ICT into the core of the education process:
   i. The Master Plan will integrate ICT during planning and designing of lesson plans and work through implementation details of curriculum and assessment.
   ii. The MOE will commence use of ICT in assessment in select subjects and levels as a pilot.
b. Focus on improvement of capabilities and skill sets of teachers:
   i. The MOE will upgrade the capabilities of all teachers. It also recognizes that there is a need to have a team of "specialist teachers" to lead the other teachers in effective integration and infusion of ICT.
c. Improvement in the sharing of best practices and successful innovations:
   i. The MOE plans to establish educational labs, where innovations can be prototyped and tested. These labs can also serve as training grounds for both the "specialist teachers" and other teachers.
   ii. These labs will also complement existing LEAD ICT@Schools and 15 future schools by 2015 to spearhead innovative ICT practices.
d. Building up of infrastructure to maximize the potential of ICT:
   i. The MOE will increase bandwidth speed to allow for learning from anywhere.
   ii. The MOE will encourage mobile learning by enabling computing power for every learner.

ICT in Curriculum, Pedagogy & Assessment[38]

Singapore promotes the incorporation of ICT in curriculum. Several projects have been undertaken in the past with the same objective. For instance, project “10’C 10’M 10’T” was launched in 2008 in collaboration with 10 schools, reaching 40 schools by 2010.

Third Master Plan provides for devotion of at least 20% of curriculum to using ICT for support of self–directed and collaborative learning. This target is to be achieved by taking following measures:

a. Embedding ICT-enriched learning experiences into syllabuses: There is embedding of subject-specific ICT-enriched learning experiences into the various syllabuses. These learning experiences will be piloted, scaled up and

[38]“ ICT in Curriculum, Pedagogy & Assessment”, MOE website, ictconnection.moe.edu.sg/cos/o.x?c=/ictconnection/pagetree&func=view&rid=813 , accessed 13 May 2013

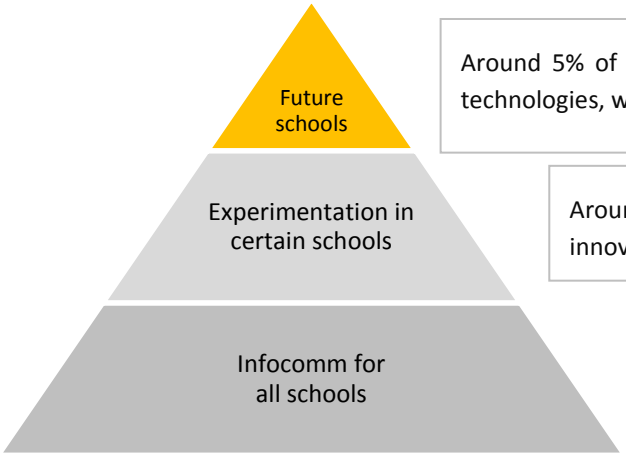
implemented to prepare the ground before formal embedding into the syllabuses.

b. The ICT Connection: Facilitate dialogue among schools on the effective use of ICT in learning and teaching.
c. ICT for Assessment: There are plans to use ICT in assessment for few identified subjects to support ICT in education.
d. Baseline ICT Standards: The baseline ICT standards (basic level of knowledge, skills and values that students require to benefit from a curriculum enriched with ICT) to be integrated into core subjects such as English, Maths and Science so that students benefit from an ICT-enabled learning environment.

4.4. EdVantage programme for further boost to ICT in education

As a part of these Master Plans, Infocomm Development Authority of Singapore (IDA) is implementing its flagship programme, EdVantage that aims to deploy ICT to enable the school system to boost student-centric collaborative learning.

This initiative plans to utilize innovative methods of imparting education with the MOE's support, in three core programmes39:



Around 5% of the schools will experiment with emergent technologies, which will be widely used in future

Around 15%–20% of the schools will be test-beds for the innovative use of ICT in teaching and learning

All schools will become competent in using ICT, with capacity for technology planning, integration and implementation

[39] "Collaboration and initiatives," *IDA website*, http://www.ida.gov.sg/Collaboration-and-Initiatives/Initiatives/Store/EdVantage-Programme.aspx, accessed 17 April 2013

4.5. Key institutions for promotion of ICT in education

The MOE has the overall responsibility of formulating and implementing of education policies in the country. Education Technology Division of the MOE is responsible for planning, implementing and managing of the ICT Master Plan 40. It has the mission of acting as a catalyst in harnessing ICT to enrich learning and teaching.

The MOE also works closely with partners such as the National Institute of Education (NIE) and Infocomm Development Authority of Singapore (IDA) as well as the industry to implement strategies formulated to enhance the role of ICT in education41.

National Institute of Education (NIE)	▪ National Institute of Education is the teachers' training institute of Singapore. ▪ It collaborates with the MOE and its schools to transform the teacher preparation system. ▪ It provides education research and research–based pedagogical curriculum and direction to the ministry.
Infocomm Development Authority of Singapore (IDA)	▪ IDA acts as an ICT advocate, advisor and business consultant to the MOE by providing project management support in the areas of implementation, procurement, development and deployment of ICT-related projects1.

In addition, the MOE gives contracts to external parties to implement ICT plans. It recently awarded a contract to National Computer Systems Pte. Ltd. (NCS), which is valued at US$680 million (S$850 million) for a period of eight years. This contract awarded the Standard Operating Environment (SOE) for schools project, a contract that will enable connectivity among 40,000 teachers and administrators and approximately 500,000 students42.

[40] "Organization Structure,"*MOE website*, http://www.moe.gov.sg/about/org-structure/etd/, accessed 18 April 2013
[41] "The Three MasterPlans in Education," *Wiki.nus website*, http://wiki.nus.edu.sg/display/SPORE/Old_wiki_The+Three+MasterPlans+in+Education, accessed 17 April 2013
[42] "Singapore Ministry of Education Pledges S$850 Million for ICT Development in Schools," *ITU website*, http://www.itu.int/ITU-D/sis/newslog/2010/06/22/SingaporeMinistryOfEducationPledgesS850MillionForICTDevelopmentInSchools.aspx, accessed 15 April 2013

4.6. Use of ICT in schools[43]

Singapore has outpaced other countries in the application of ICT in education over the years. The major ICT applications for education are classroom management, creating timetables and communicating with parents. It is also used for maintenance of a repository of teaching and learning resources for sharing among schools. The other most prominent application is e-learning, that encompasses enhanced learning by use of ICT.

Table: Use of ICT in schools in Singapore

School Management Services	MIS Services	Learning Support Services	Governance Services
▪ School and tuition management system ▪ Automatic attendance system	▪ Management of information relating to students, schools and work processes (School Cockpit system)	▪ Increasing interaction among students and teachers (BackPackLIVE!) ▪ Interactive Learning Trails for collaboration during school trips ▪ Creation of e-learning lessons (Learning Management Systems) ▪ Interactive textbooks for digital education (Science N(T) Next Generation) ▪ Creation of virtual world using Voice Activated Spy Tech (VAST) ▪ Digital games to enhance learning	▪ Governance of clusters of schools (iSHARE) ▪ Governance of sharing of pedagogical innovations (EduLab)

4.6.1. School management services

ICT has been used in the efficient management of schools since the introduction of the first Master Plan in 1997. The following systems help the schools to automatically track the activities of teachers and students. These improve service delivery of school education and efficiency of school administration.

School and tuition management system: School and tuition management software facilitates monitoring of teachers' activities. Furthermore, it enables schools to track

[43] "Business Sectors," *IDA website*, http://www.ida.gov.sg/Business-Sectors/Education/Infocomm-All-Schools.aspx, accessed 17 April 2013
"About edulab," *Edulab website*, http://edulab.moe.edu.sg/cos/o.x?c=/iresearch/pagetree&func=view&rid=250, accessed 16 April 2013

academic progress of students. The system also encourages parent–teacher co-ordination and interaction. It provides for appropriate handling of exams and declaration of results.

Automatic attendance system: Singapore has installed fingerprint readers linked to electronic attendance system in approximately 20 schools. Another form of school attendance system allows teachers to take attendance of a class with the help of a centrally located computer. Automatic attendance system has led to a savings of 90% of the time taken as compared to the manual system. The system can automatically alert parents via sms or email if their kids arrive late or is absent.

Management Services at Balestier Hill Secondary School

Balestier Hill Secondary School (BHSS) adopted Singapore Technologies Electronics' "i-School system" to improve administrative efficiency through reduction of paperwork. The system also led to enhanced communication within BHSS and between BHSS and the MOE.

Table: Example of use of ICT in provision of management services in Balestier school

System	Activities
Time attendance system	The system tracks the students' attendance with the use of personalised contactless EZ-Link cards.
Facilities booking system (FBS)	FBS enables booking of facilities such as computer labs and multimedia rooms through the web.
Facility access control and security system (FACSS)	FACSS provides control of access to rooms using contactless EZ-Link smart cards.
SMS and IVRS	SMS sends short messages to the parents' handphone in case the child is late or absent from school, while IVRS allows parents to check attendance or EZ-Link card details.
Student target setting module	This module is a web-based programme that allows students to set their own targets and goals according to their aspirations.
Electronic canteen	Students can buy food using their EZ-Link contactless smart card through web-based E-canteen (a cashless process).

4.6.2. MIS services

Singaporean education system also uses ICT for collection, analysis and dissemination of information relating to schools. Such services help in better record keeping and updating changes on a regular basis.

Management of information relating to students, schools and work processes (School cockpit system)

The government uses School cockpit system, a web-based system, to effectively manage the information relating to schools. It records school and student related information and work processes. Therefore, it supports the administrative functions and operations in schools. Besides, it helps in increasing the productivity of teachers, heads of department and school leaders.

4.6.3. Learning support services

The major use of ICT in education has been in the field of enriching the learning experience of students and pedagogical capabilities of students. The initiatives lead to better learning environment in schools by increasing collaboration between teachers and students, facilitating collaboration between different stakeholders and promotion of advanced methods of learning.

Creation of e-learning lessons (Learning Management Systems)

Learning Management Systems (LMS) is an internet-based system that enables teachers to create e-learning lessons and activities to facilitate students' learning44. Moodle is the most widely used open source software for the country's LMS.

Increasing the engagement of students (BackPackLIVE!)

MOE, IDA and Microsoft Singapore signed an MOU for an initiative called BackPackLIVE! that focuses on expanding ICT practices among teachers to promote engagement and interaction with students. It is an extension of the earlier IDA-Microsoft BackPack.NET initiative launched in 2003. The initiative cost is $4.4 million (S$5.5 million) for the period 2009–2013. The key focus areas include fostering innovation in schools, promotion of cyber wellness and collaboration with developers to pilot innovations45.

Facilitating collaboration during school trips (Interactive Learning Trails project)

[44] "Country Report on eLearning in Singapore,"http://203.183.1.152/aen/content/conference/2004/file/S2_Singapore.pdf, p. 6
[45] "BackPackLive!," *Wiki.Nus website*, http://wiki.nus.edu.sg/pages/viewpage.action?pageId=86519712, accessed 15 April 2013

Interactive Learning Trails project enables students to take photos and videos of things connected to their subject of learning. They can then share this information with other students, teachers and parents. The project has been undertaken in collaboration with the MOE, other government agencies and schools. It enhances collaboration and engagement among learners during school field trips. It uses technologies such as wireless local area network (WiFi), global positioning system (GPS), and two-dimensional barcode. Currently, there are two learning trails, Sungei Buloh Wireless Trail and Chinatown Interactive Learning Trail.

Providing digital education through interactive textbooks

Science N(T) Next Generation Interactive Textbook (NGIT) is a digital interactive textbook cum teaching-and-learning application that comprises resources in the form of videos, manipulatives and simulations. The aim of the project is to transform a teacher-centric education into one that is able to engage students.

Providing immersive virtual environment (Voice Activated Spy Tech)

Voice Activated Spy Tech (VAST) is a virtual world with a gaming and teacher-led, role-playing component. The project aims to create an immersive virtual environment where students are able to practise speaking English. The key benefits include immediate feedback to the student on pronunciation, fluency, and word stress from a customized speech recognizer. The teacher can manage content and monitor students' progress within the game by using a customized class management and reporting module.

Learning through gaming (digital games for learning)

Digital games for learning aims to create games that are entertaining but at the same time based on strong pedagogy, which results in effective teaching of the concepts. It provides learners an experiential environment to encourage strategy development and community-based collaboration.

E-Learning at Beacon Primary School

Beacon Primary School has adopted BeaconWorld, the school's 3D web-based learning environment created with a consortium from ST Electronics (Training and Simulation Systems). Its major applications are:

- Personal Interactive Enrichment (PIE) Book: The PIE Book is a digital content framework that permits teachers and students to build, organize, read and annotate digital books. It enables students to enhance the text with on-demand dictionary references, a text-to-speech engine, and annotation and bookmarking tools.

- Creative Studio: Creative Studio is a tool to facilitate students to creatively express themselves through various media forms. Students can transform abstract ideas into integrated multimedia productions that help them to communicate their ideas and messages.

4.6.4. Governance services

Singaporean educational institutions use ICT for better school governance. Following initiatives of the schools lead to better sharing of educational resources and pedagogical innovations that are developed in any school.

Sharing educational resources among school clusters (iSHARE)46

Schools in Singapore are grouped in clusters. Therefore, there were attempts to leverage this natural grouping to create cluster-based resource repositories whereby all teachers who belong to a particular cluster have individual accounts to search, upload and download resources. iSHARE was piloted with a project that was carried out to connect three clusters (39 schools) in 2005 to provide access to educational digital resources created by teachers for teachers. Teachers from all schools were linked up by the end of 2008. Approaches adopted ranged from the use of shared folders on the network to the use of commercial as well as open source e-learning platforms.

Spreading pedagogical innovations (EduLab)

EduLab is a joint initiative between the MOE and the NIE. It is designed to surface and spread ICT-enriched pedagogical innovations. It partners teachers in developing pedagogical innovations and ensures that these innovations are adopted by different schools across the system. Before the beginning of each phase of the EduLab programme, ideation is carried out to help teachers generate good ideas. These ideas can then be developed into feasible innovation proposals to be submitted as EduLab projects.

Java simulation design for teaching and learning

- This project used computer models with multiple representations, aimed at increasing student's ability to handle difficult concepts.
- In 2012, this project provided 6 lesson packages featuring 9 computer models, benefitting 2,000 students

[46] "iSHARE Framework for Sharing of Digital Resources to Support Teaching and Learning in Singapore Schools," http://acce.edu.au/sites/acce.edu.au/files/archived_papers/conf_P_1042_iSHARE%20Framework%20for%20Sharing%20of%20Digital%20Resources%20to%20Support%20Teaching%20and%20Learning%20in%20Singapore%20Schools%20ACEC%202008.pdf, p.3

from 5 schools with the aid of 39 teachers.

- Teachers were able to explain difficult physics concepts more effectively to their students with the help of computer models. It also facilitated increased engagement and interaction for students47.

4.7. Education portals [48]

ICT has enabled imparting of education through its various portals. The various websites that provide access to online learning and teaching material are stated below:

Table: List of various websites providing access to teaching learning material

Educational Portal	Description	Website
Art		
ArtDR	A platform that allows teachers to publish, rate and comment on art lessons and packaged resources	http://arts.edumall.sg/
Blitx	An online gallery to showcase, rate and comment on artworks of students	http://blitx.edumall.sg/
Languages		
Chinese Language Word Games	A portal that uses educational games for revision of Chinese characters and words	http://game.iflashbook.com/
Culture Bridge	A website that features topics of interest in Chinese and other cultures with multimedia and interactive resources	http://cultureb.moe.edu.sg
STELLAR	STELLAR strengthens both language and reading skills through the appropriate pedagogical approaches such as children's literature	http://www.stellarliteracy.sg/
Tinta	A website that complements Malya primary curriculum 2008 and provide interactive resources for secondary schools	http://www.stellarliteracy.sg/
Mathematics		
AlgeTools	A learning tool to learn algebra through the use of digital manipulatives	http://algetools.moe.edu.sg

[47] "Existing Projects," Edulab website, http://edulab.moe.edu.sg/cos/o.x?c=/edulab/pagetree&func=view&rid=260, accessed 16 April 2013
[48] "Teaching and Learning Resources", MOE website, http://www.moe.gov.sg/resources/, accessed 14 May 2013

Science		
Sciberdiver	A web portal that match the learning objectives of syllabuses of the primary and lower secondary science.	http://sciberdiver.wikispaces.com/

4.8. Management and financing

The Government of Singapore is primarily responsible for the management and financing of ICT in the country. The ICT master plan, Intelligent Nation 2015 (iN2015), will be implemented at an investment of US$2.6 billion (S$3.25 billion).

MOE is responsible for the funding of education in the country. The spending on education has grown at a CAGR of 5.61% during the period 2001-2011. The annual budget for 2012 is US$8.5 billion (S$10.6 billion). Similarly, it is also the primary financier of ICT in the education sector. It also floats tenders and awards projects to private players.

Private sector has a secondary role in the management and financing of ICT in education. ASKnLearn, a key private player, was founded in 2000 to support the several initiatives of the government. In 2009, it accounted for supply of e-learning solutions and ICT training to 150,000 students across 35% of all Singapore government schools49. In addition, certain flagship programmes of the country have private players investing in them. Microsoft Singapore will collaborate with the MOE and IDA to invest US$4.4 million (S$5.5 million) for BackPackLive! e-learning initiative.

In any case, technocrats are essential to carry out MOE's ICT initiatives. The partnership between technocrats and the Government is evident from the inclusion of various private players in the Edvantage programme. Some of the key private sector partners are listed below:

Table: Private partners in the Edvantage programme

Company	Key products
ACP Computer Training and Consultancy Pte Ltd.	Learning Management System (CyberSphere™) Social Media Awareness with the Right Tools (SMART)

[49] "ICT in Education in Singapore: Perspectives from the private ICT sector", An Expat Educator in Asia, http://xpatasia.edublogs.org/, accessed 14 May 2013

Activate	MOE GPS-Based Educational Game Total Defense Educational Game for Anglo Chinese School
Amdon Consulting Pte Ltd.	Interactive Textbooks (Ambook™) Multiplayer Educational Games (Gut Feel™, ParaLife™, Energy Craze, Origin of Ancients™)
Commerce Online Pte Ltd.	Learning platform E-Commerce portals
G Element Pte Ltd.	Learning Trails System
iCELL Network Pte Ltd.	School networks Education wireless trails

4.9. Technology infrastructure and connectivity[50]

The presence of technology in education in the country has come a long way since its introduction in 2003. Students were provided tablet PCs to learn both inside and outside the classroom. Teachers uploaded a year's worth of lessons online and results were outstanding. The MOE was the first educational ministry in Asia to provide cloud computing tools, i.e., use of Google Apps (Education version) suite of online communications and collaboration tools to around 30,000 teachers and staff in more than 350 schools.51 Its Schools Standard ICT Operating Environment (SSOE) project aims at provision and management of desktops, network and ICT support in all schools52.

Currently, the education system of Singapore uses advanced forms of technology such as collaborative environments, mobile apps, tablet computing, gamification and learning analytics. MOE has commissioned the country's premier independent game studio to develop a multi-player online game that will have intelligent tutoring technology and speech recognition mechanism. Crescent Girl's School (recognized by MOE) uses learning analytics tool (WriteToLearn) to analyse written text based on linear algebraic models. The software also teaches students how to correct their mistakes53.

Singapore also plans to adopt new technologies such as web-based artificial intelligence chat bots. These bots will collate and analyze response of students to

[50] "Singapore leads the way in education technology," *The Singapore Promise website*, https://home-in-singapore.sg/default.aspx?tabid=1544, accessed 14 April 2013
[51] "Media," *MOE website*, http://www.moe.gov.sg/media/press/2009/09/moe-adopts-open-standard-inter.php, accessed 17 April 2013
[52] " Over 120,000 devices rolled out to 351 MOE schools in Singapore under the Schools Standard ICT Operating Environment (SSOE) programme," *NCS website*, http://www.ncs.com.sg/media-detail?page=ssoe_rollout, accessed 17 April 2013
"Singapore Ministry of Education to provide 120,000 devices to schools," *The Followers website*, http://blogs.terrapinn.com/internetshow/2012/08/31/singapore-ministry-education-provide-120000-devices-schools/, accessed 14 April 2013
[53] "Technology Outlook,"http://www.nmc.org/pdf/2012-technology-outlook-for-singapore-k12-education.pdf, p. 18, 20.

identify learning patterns and assess needs. Its Next-Generation National Broadband Network will support education initiatives in Future Schools through high speed connectivity of 1Gbps and beyond.

We Learn: a mobile education project54

"We Learn" is a mobile education project that uses 3G-enabled smartphones aiming to transform learning from traditional, teacher-centric model to student centric, inquiry-oriented and collaborative model.

Technologies used:

- Windows Phone smartphones (3G-enabled)
- 3G mobile broadband connectivity via SingTel's 3G wireless network
- MyDesk, a Mobile Learning Platform (MLP), populated with a range of educational apps that facilitate tools for 24/7 learning. MLP also has a digital classroom message board and a cloud-based Teaching Management System.

4.10. Monitoring and evaluation [55]

MOE is responsible for the continuous implementation of ICT in education. It sets targets and monitors the achievements of application of ICT-related initiatives in schools.

Besides, there are specialised systems to monitor the use of ICT in schools. School Cockpit Administration Centre of the MOE is responsible for deployment of IT systems to schools. It also track changes in policies and procedures and their impact on IT systems for schools.

The key indicators that have been utilized to gauge the success of the programmes such as Master Plans relating to "ICT in education" are:

- Numbers of schools using ICT-enabled applications
- Enhancement of pedagogical skills of teachers
- Engagement of teachers and students to result in an enhanced learning experience
- Better integration of ICT in curriculum/assessment

4.11. Conclusion

Singapore has one of the most advanced education systems in the world. It began the use of ICT as early as 1970s when it set up basic information infrastructure. Since then, it has come a long way with latest being the adoption of a plan that

[54] "WE Learn: Building the 21st Century Classroom with 3G Smartphones in Singapore," *Qualcomm website*, http://www.qualcomm.com/media/documents/files/wireless-reach-case-study-singapore-we-learn-english-.pdf, pg1
[55] "Singapore leads the way in education technology," *The Singapore Promise website*, https://home-in-singapore.sg/default.aspx?tabid=1544, accessed 14 April 2013

encourages nation-wide innovation. It has primarily been achieved due to its three Master Plans and an effective action by government through the Ministry of Education. The government has launched several programmes and initiatives to integrate the use of ICT in education, which includes advanced methods of learning such as one-to-one computing, interactive textbooks and digital games.

Singapore can serve as a benchmark for India's MMP to achieve delivery of critical services to all stakeholders i.e. students, parents, teachers, school authorities and states. It has evolved from the same stage of adoption of ICT in education as India is currently facing. Therefore, the country can provide lead as to what needs to be done in the field of e-governance, e-learning, digital learning and generation of integrated reports for administration. The system such as automatic attendance system and school and tuition management system enable effective governance. Besides, there are various programmes that enhance the overall learning experience for students and the pedagogical knowledge of teachers. These initiatives can provide India with the desired outcomes and an action plan to achieve the transition from starter to pioneer in usage of ICT in education.

Singapore will continue on the path towards bringing advancement in the use of ICT in education by adoption of new methods of technology. For instance, Next-Generation National Broadband Network will schools with provide high speed connectivity of 1Gbps and beyond. As a result, Singapore is expected to continue to set standards in usage of ICT for education in the world for the next generation of students.