



Research/Technical Note

Design and Validation of School ICT Monitoring & Evaluation Framework: A Case Study

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Abstract: With the rapid development of school ICT, students and staffs ICT activity data are rich enough for school ICT monitor and evaluation. This paper proposes an evidence based school ICT evaluation framework, which includes four parts: data collection, data security and privacy protection, information analysis and evaluation analysis, evaluation and decision-making recommendations. Combined with the iso8000-61 data quality standard and the core elements of school ICT evaluation, the reliability of data collection technology and the availability of collected data are verified. Through interviews, the school teachers and ICT are responsible for the concerns of data security and privacy protection in the research and application of education big data. The experimental results show that the school ICT evaluation based on the fact data has outstanding performance in the aspect of problem diagnosis and the guiding significance of the evaluation conclusion, and has more practical guiding significance. At the end of the paper, some suggestions are put forward for the promotion of technical framework, data security and privacy protection.

Keywords: Evidence Data, Data Usability, School ICT, Evaluation Framework, Data Analysis

1. Introduction

In the era of big data, a large number of objective data have been produced in people's daily information activities such as Management Information System using, blog surfing and publishing, social media interaction, which are natural record of student and staff ICT activities [1]. With the help of big data (BD) technology and internet of things (IoT) technology, people's daily lives are logged and kept in binary data [2]. IoT supported MISs can provide school managers more ways to monitor and evaluate school ICT quality [3]. BD supported science research and discovery become more popular in many fields, like business promotion, online healthcare, social hot spots discovery and education data mining. In education, BD are often used in evaluation, planning, consulting, registration

fields for students, teachers, course developers, administrators and so on [4]. School information and communication (ICT) management information systems (MIS) accumulated abundant data from teachers' and students' daily ICT activities. All these data can be applied to describe, assess and guide school ICT status. Monitoring and Evaluation in schools informs practice, leadership and plays an important role in accountability and school improvement [1]. The monitoring and evaluation is to provide objective information that can inform decision-making for continuously improving organizational Performance for efficient and effective fulfillment of the division mandate, and delivery of education services to achieve the desired output and sustainability of Education outcomes [5].

In this article, we introduce a school ICT monitoring and evaluation framework, which aims to evaluate school ICT

activities and to give out further develop advices. The framework contains three components (show as figure 1), which are data collecting client, ICT evaluation elements and data analysis tools. In the case, we examined the client's data collecting stability, the elements' effectiveness.

2. Related Works

Monitor and evaluation system have been used in performance management for decades of years in many fields like health care [6], food safety [7], social problem analysis [8] and education [9]. School monitor and evaluation systems enable schools to respond to issues immediately and concerns affecting the effectiveness of programs and efficiency of programs delivery, to provide immediate feedback on the efficacy and weaknesses of program implementation at the school level, to respond to technical and training needs of teachers; and to identify enhancements to educational policies and guidelines [10].

Effective M&E of school inputs and outputs can be achieved through record-keeping and regular reporting systems. In order to figure out whether or not school resources are being spent according to plan, and the teaching method is delivering the desired educational outcomes [11]. Palombi and his workmate introduce a learning management system (LMS), called OntoSIDES. The LMS is an ontology-based learning management system in Medicine, which traces students' activities and the correction of exams are linked and related to items of an official reference program in a unified RDF data model. Automatic mapping-based data materialization and rule-based data saturation provides an integrated access to useful information for student progress monitoring, using a query language, allowing users to express their specific needs of data exploration and analysis through a user-friendly interface [12]. Data-driven decision making in education typically refers to teachers, principals, and administrators systematically collecting and analyzing data to guide a range of decisions to help improve the success of students and schools [13]. School M&E data can from Data can also come from a range of different sources (students, parents, teachers, regional, national) and reflect information at various levels such as: individual student, class, school, regional and national and international [14].

ICT is considered a powerful tool for educational change and reform. Due to ICT's impact on improving student academic performance, helping teacher to teach and optimizing school decision and so on, ICT program assessments and evaluations have been carried out as the programs go on. STaR (School Technology and Readiness), SRF (Self-Review Framework) and PCEIP (Pan-Canadian Education Indicators Program) are the mostly referenced ICT assessment project. The American Texas STaR Chart gauged progress in meeting the recommendations in the long-range plan for technology [15]. The STaR chart was developed around the following four key areas of the LRPT: (1) teaching and learning, (2) educator preparation and development, (3) leadership, administration, and (4) instructional support and

infrastructure for technology. The SRF is an English government issued tool which is designed to help you determine the quality and effectiveness of all aspects of design and technology provision in your school and it is has been divided into four domains covering design and technology provision: (1) curriculum planning, (2) teaching and learning, (3) leadership and capacity, and (4) resources and safety [16]. PCEIP presents a statistical portrait of the elementary, secondary, and postsecondary education systems in various formats such as data tables, fact sheets, and reports. These products can be accessed on-line via the *Statistics Canada Web* site. The goal of PCEIP is to provide consistent and high-quality information on education from all provinces and territories to support informed decision making, policy development, and program creation (Canadian Education Statistics Council, 2016). In fact, the PCEIP is not a specific ICT evaluation tool. It's a set of indicator tables to capture a wide range of data in education, including the five main areas below: (1) a portrait of the school-age population, (2) financing education systems, (3) elementary-secondary education, (4) postsecondary education, and (5) Transitions and outcomes. As to data collection methods, these data may come through researchers' interviews, questionnaires, MIS database or government statistics.

Here, we propose a school monitor and evaluation framework to collect school daily data automatically, to evaluate school ICT quality and effectiveness according to the statistics and analysis of the data, and to give out suggestions for further school ICT planning. The framework consists four parts: a school computer process tracing and data collection client, data usability and framework security mechanism, school ICT evaluation elements and school ICT quality analysis. In order to verify the framework, we conduct case study in a middle school, the data collected and analyzed show great practicability and applicability of the framework.

3. School ICT M&E Framework Design

There are four parts of the school ICT M&E framework. They are Data Collection Client, School ICT Data Analysis, Data Usability & Framework Security Checking Mechanism and School ICT Evaluation Elements. The architecture of the framework is show in figure 1.

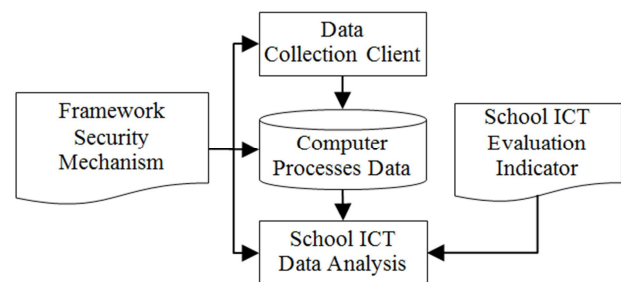


Figure 1. The architecture of the framework.

3.1. Data Collection Client

Data Collection Client is a terminal software run on school

computers, mobile learning PADs, classroom LCD touch screen computers and other so like terminal ICT equipment. The software is memory resident since the terminal is powered on and trace the terminal software processes, send the process information to database at specified time intervals. The data items of processes to be collected and stored are as the flowing two relation table structure. School room is a location where the computer is setup and refers to different types of computer using. Subject is a course teacher mainly taught. These two data items are recorded when the client software is being installed on a computer.

Relation table structure (1): Computers (computer ID, room, subject, register date)

Relation table structure (2): Processes (computer ID, process name, process title process start time, log time)

3.2. School ICT Evaluation Elements

According to the collected time series terminal process data and exiting school ICT evaluation principles, we select school ICT tools, resource using, ICT management and ICT service as the data analysis guidelines.

3.3. School ICT Data Analysis

School ICT data analysis is a human-data interaction process. ICT analyst query, account and model data, so as to find evidential accounting data or pattern, to diagnose the status of school ICT, to evaluate its quality, to find latent problems, to hammer out future ICT development plan.

3.4. Framework Security Mechanism

There two parts of rules to ensure the security of school ICT M&E. One is data encryption, the other is data analysis rules. In detail, we use global unique MAC address to identify each terminal client. When ICT analyst are doing

the data analysis, the following rules should be complied: (1) Source data and procedural data are authorized to ICT analyst only to access; (2) School ICT analysis report only contains overall summative data, and personal related data should not be included; (3) The result report are only for the purpose of ICT quality diagnose and future development guide.

3.5. Experiment Design

We installed the data collection client on a middle school's 92 computers. These computers are in four types of rooms, teacher office, classroom, administrative office, student computer room. The number of computers of each type can be seen in Table 6. Experiment went through a whole school year, which spans from 2019-2-17 to 2020-1-18, 394 days in all. The clients write the computers' current running process data to Database every 5 minutes.

4. Framework Experiment and Verification

ISO8000 data quality management standards (ISO 8000-61, 2016) emphasize that data usage is the key layer of three data quality layers, which are data collection, data processing and data usage (Perez-Castillo, Carretero, Caballero, & et al, 2019). In our study case, we verify the framework's usability according to these three data quality control layers.

4.1. Data Collection Stability Analysis

During the school year, data collection clients collected 835,210 pieces of computer process information, 2,119.8 piece every day, one computer generates 23.8 pieces of process information per day. Table 1 shows some sample recorded process data.

Table 1. Some of the collected data samples.

	Process Name	Process Title	Log Time
1	KuGou	Comprehensive ability test volume 2A - cool dog music Oxford English grade 7 Volume 2	2019/5/27 7:32
2	wps	People's education press, Ministry of Education edited the courseware of Ma Shuo (45 PPT in total). Pptx - WPS Education Edition	2019/5/31 7:51
3	360se	Smart Education Assistant - 360 secure browser 9.2	2019/6/10 13:36
4	QQPlayer	[movie paradise www.dy2018.com]Avenger alliance BD bilingual doublet.mkv	2019/5/24 8:09
5	iexplore	Two Bombs and One Star meritorious scientist 20120411 CCTV ZONE (cctv.com) - Windows Internet Explorer	2019/6/21 14:40
6	explorer	104-5 buoyancy and sinking	2019/6/4 7:44
7	POWERPNT	Hukou Waterfall courseware.pptx - Microsoft PowerPoint	2019/5/30 7:56
8	WINWORD	Lotus Pond Moonlight - Microsoft Word	2019/5/29 14:11
9	360zip	Compressing: 2018 sports culture and Art Festival. Zip - 360 compression	2019/5/29 14:11
10	QQ	Two conversations to Xiao Mei and Zhi	2019/6/10 6:58

The process information's log time is time series data. It's date-time distribution can be seen in figure 2. There are three data collection blank area (Labeled as 3), which correspond to Chinese 2019 Spring Festival, 2019 Summer vacation and specified school activities. At those time, the Database

stopped receiving clients' data. The area labeled as 2 is work time which spans from 7:00 to 18:00. While the rest area labeled as 1 is not the work time, but it shows off-normal computer process' activities.

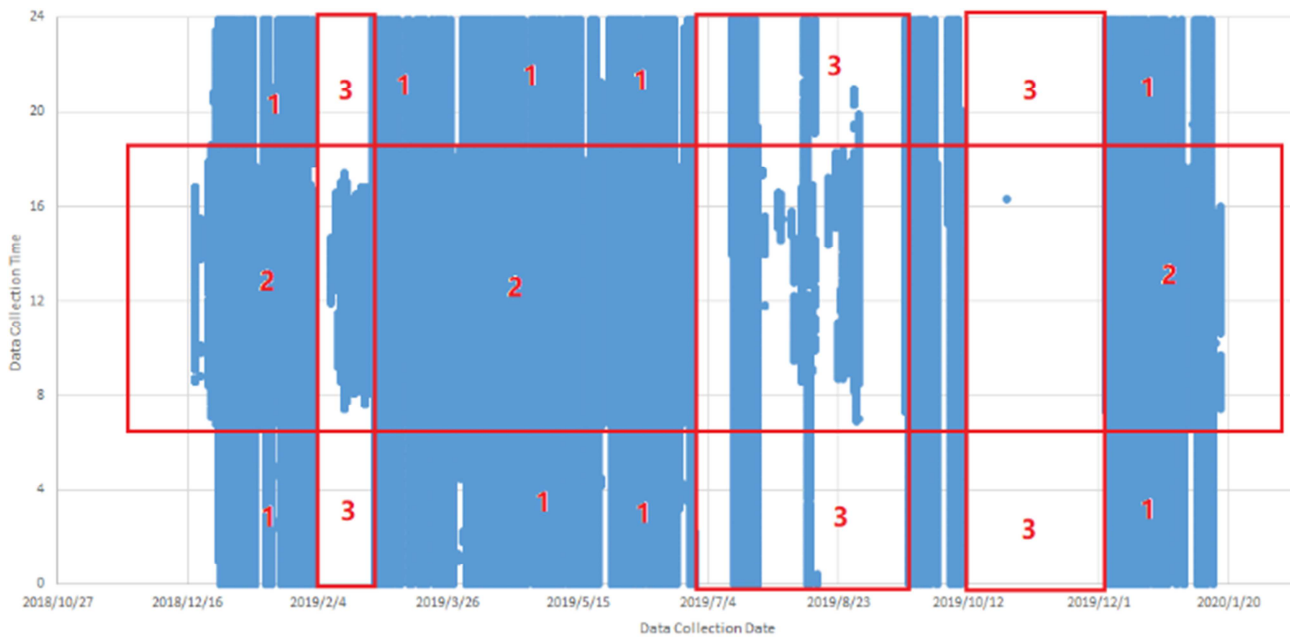


Figure 2. Computer process log time's date-time distribution.

On the whole, the designed data collection client works well as it's supposed to. The collected computer process log time is consistent with teaching activities in the school year.

4.2. Data Usability Verification

In order to verify where the collected data can be used to evaluate school ICT quality. The article evaluates the select school ICT quality according to four indicators, which are ICT tools, resource using, ICT management and ICT service. The

methods used includes descriptive statics, serial time analysis, outlier analysis and face to face interview.

4.2.1. ICT Tools Using

Different types of rooms location have different ICT tools requirement. It shows different type of users' ICT tools preferences. The top 10 mostly used ICT tools in different types of school rooms are shown in table 2.

Table 2. Top 10 mostly used ICT tools in different types of school rooms.

Teacher Office		Classroom		Administrative Office		Computer Room	
Process Name	Log Times	Process Name	Logged Times	Process Name	Logged Times	Process Name	Logged Times
SVO White Board	197410	SVO White Board	30659	Baidu Browser	4725	Visual Basic 6.0	2758
WPS Office	36799	Microsoft PowerPoint	4841	WPS Office	2400	Electronic Classroom - Student	1955
Microsoft PowerPoint	30759	360 AD Popup Window	3815	QQ Social Media	1585	IE Browser	1324
360 AD Popup Window	22734	BaoFeng AD Popup Window	2517	360 AD Popup Window	1522	Microsoft Excel	806
SVO Video Booth	19614	BaoFeng AD Popup Window	1350	WPS AD Popup Window	714	Electronic Classroom – Teacher	79
Windows Media Play	18470	IQIY Player	817	Sohu Audio & Video Client	509	WPS AD Popup Window	33
WPS Presentation	10748	SVO Teacher Assistant	687	Department Final Account Report	401	Keyboard Monitor	19
360 Zip	10336	Microsoft Word	686	IE Browser	350	QQ Social Media	17
WPS	10158	360zip	595	Jurong institutions Salary Management	287	Macromedia Flash	13
QQ Social Media	10058	WPS AD Popup Window	474	Windows Media Player	186	English Human-Machine Dialog System	12

From the data in table 2, the following ICT evidences can be drawn out. First, electronic whiteboard is widely used in teachers' lesson preparation and classroom teaching. Second, WPS office and Microsoft office are the mainly tools in school. It's also can be seen that teachers and administrative staff have

some differences in ICT tools using. The third, Baofeng, IQIY, Windows Media Player are frequently used video player. The last, Tencent QQ is the most popular social media among teachers and students. Besides, we also find some subject specific ICT tools (shown in Table 3), though these tools are

very few.

Table 3. Subject specific ICT tools.

Subject	ICT Tools
ICT	Mythware e-Classroom, Smart Network Audio Management System, Scratch
Math	Geometry Sketchpad
Physics	Master of Physics, Circuit Virtual Lab for Middle School
Chemistry	Labdig Simulation Experiment, e-Chemistry Instruction System
English	English Dialog Examination System-School Training Version, international phonetic alphabet (Audio)
Geography	Google Earth

4.2.2. Resource Using

Based on extremum analysis, the article picks out the tools which log times is less than ten. These tools are classified into Table 4. Combined with the data in Table 2, office tools are mostly used, like Microsoft Office, WPS Office, while media edit tools and instruction resource integration development tools are seldom used. The mostly used type of resources are

PPT presentations, micro-videos and audios. It's noteworthy that other types of resources like mobile learning resources, flash courseware and theme based or knowledge based courseware are too few. In the process logs, we didn't find independently running interactive courseware. The types of courseware relatively scarce.

Table 4. ICT tools which log time is less than 10.

Tool Category	Tool Name
Teaching & Learning administration	Dingyi Teacher Assistant, Xiaoxian Edu Assistant, Lisheng Exam Paper Revision System, Mengchang Alarm Clock, etc.
Courseware making	Flash, Geometry Sketchpad
Image Process	Illustrator, Photoshop, Beautiful Pictures, 360 Picture Viewer, JPG Resize
Courseware	11.3 Power, Story of the Peach Blossom Valley-Courseware, Circuit Virtual Laboratory-Middle School, Labdig - Physical Simulation Experiment, Neo Imaging
Video Edit	Quick Media Edit, Network Camera, Liwo Video Convertor
Network Disk	Baidu Network Disk, 360 Network Disk
Others	Format Factory, Adobe Reader

Another accounting data reveals that government led resource systems are not welcomed by teachers. Table 5 shows the teaching resources system which have been used and their log times. Due to its full text keyword search engine technology and its tremendous document database, Baidu

Wenku are the most popular teaching resources system. While government provided resources system do not perform well, like National Education Resources Public Service Platform, Zhenjiang Primary and Secondary School Teachers Training Platform.

Table 5. Teaching resources system used.

Resource System	Web Address	Logged Times	Resource System	Web Address	Logged Times
Baidu Wenku	wenku.baidu.com	70	Ancient poetry website	www.gushiwen.org	4
Zhixue Website	www.zhixue.com	53	Docin	www.docin.com	4
Xueke Website	www.zxxk.com	26	Zhenjiang Primary and Secondary School Teachers Training Platform	desktop.zje.net.cn	3
Zujuan Website	www.zujuan.com	11	Digital Chemistry Teaching Platform	jg.bozedu.net	2
National Education Resources Public Service Platform	www.eduyun.cn	8	Chinese Website	www.zhyww.cn	1

4.2.3. ICT Management

The article takes computer using time length and daily working time to reflect ICT management quality. Table 6 is the four types of computer daily using time length.

Table 6. Computer daily used time length.

Room	Computer Numbers	Log Times	Daily Used Time Length
Administrative Office	2	18279	2.28
Classroom	3	53681	4.46
Computer Room	45	13727	0.08
Teacher Office	42	529737	3.15
Average		153856	2.49

Figure 3 is the 92 computers' powered on days. We can see from the figure that the days of computers labeled as A01 to A57 are powered on are less than 50 in a school year, while computers labeled as A75 to A92 powered on days are more

than 300 days. Some of the computers are used frequently, and some computers are seldom used. Combined Table 6 and Figure 2, it can be seen that classroom computers have the longest daily used time.

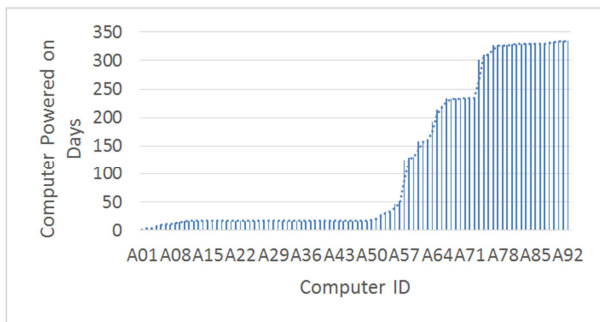


Figure 3. Computers powered on days.

Besides, Figure 2 reveals an administrative loophole. There two areas labeled as 1 covers the off-work time, but there are many computer process logs and further data analysis shows these process are not active. It means that some computers are not power off when the staff left.

4.2.4. ICT Service

Among the logged 433 types of process, there are 101 popup advertisement windows. The log time is 63,759. These windows popup randomly and disturb the learning or working flow. ICT assistant service or technique train is helpful to reduce abnormal advertisement windows popup times.

4.3. School ICT Suggestions

Based on the above four aspects analysis of the collected data, the article gives some advices for school ICT development. These advices are also part of the validation of the school M&E framework.

First of all, various types of teaching resources using and normalized daily use should be encouraged. Different types of resources have their own creative ideas in their teaching problem solving. Resource database construction should keep continuity. A list of resources could be made and keep it update to date and make it known to all new teachers annually.

Secondly, ICT service providers should hammer out a proposal list of commonly used ICT tools for staff to maintain their computers or mobile. With such ICT tools list, the management and maintenance of ICT environment will be convenient. How to use and configure these ICT tools should be part of new teachers' ICT training, including choosing credible software source, install and configuring software, avoiding deceptive software.

The third, there are two points about ICT management. One is that taking action and regularly checking say more than putting ICT rules and regulations on the wall. ICT staff may know the rules and regulations, but may not operate according to them. So scheduled or non-scheduled checking can improve ICT management quality. It can keep ICT equipment and environment in good state, and improve their usability, prolong their lives. Another point is that these rules and regulations should be adjusted and target the problems found in the last school ICT M&E.

Lastly, the purpose of school ICT M&E is to improve the whole school ICT performance. So the collected data serves to analyze, diagnose and instruct school ICT development. Any

data in the framework should not be school staff personal related. Keeping staff personnel off the evaluation is one of the framework's requirements, and it's also a data security mechanism.

4.4. Recognition of the Framework

We invited 50 staffs to take parting in the experiment. In order to get to know school staff's attitude towards the installed data collection client and their concerns about personal privacy, we conducted two rounds face to face interview.

The first round interview was one to one free talk when we installed the data collection client on teachers' notebook computers. The interview began with the introducing the client's function and the purpose of the school ICT M&E framework. Then we talked about their personal privacy concerns and protection mechanism. In general, their main concerns are very concrete, which can be concluded as whether: (1) 43 staffs worry that whether their QQ chat content will be collected, (2) 39 staffs worry that the pictures, courseware, instruction plan and other personal documents will be copied, (3) and 5 staffs worry about that their video game, watching movie and so like entertainment data may affect their idle in administrator's eyes. At last, 4 teachers refused to install data collection client politely, and 42 staffs' computer process data were collected eventually.

The second round interview was conducted at the end of experiment. The 15 invited interviewees are from the above 42 staffs. The interview topics center on the following three questions:

1. Does the data collection client interrupt your daily job?
2. Does the above data analysis results have effects on you?
3. Does you accept the school ICT M&E framework and the data collection client?

As to question (1), 7 staffs says they just feel somewhat uneasy after the client has been installed in their computers. After one or two weeks they do not feel the existence of the client. On the question (2), all of the staffs don't think the analysis results have relationships to their personal affairs. Those who do not power off their computer after work feel a bit shame, and think that such school ICT M&E framework helps to find practical problems lying in school daily ICT activities. The last question, all of the staffs will accept the installation of the data collection client if it is for the purpose of school ICT M&E and is supervised by super government. They also address the importance of personal information security and personal data protection.

Another two school ICT conductor's attitudes are very consistent in two main proposals. First, they are very expecting such school ICT M&E framework to monitor school ICT activities, to find problems to be improved, and to support school ICT construction decision. Second, they are also very worried about the data security and personal information protection. They suggest that such school ICT M&E work should incorporate with district ICT construction and investment policies and be supervised by district education government.

5. Discussion

Due to the collected data is confined to computer process information, the evaluation indicators are not integral enough to fully represent the whole school ICT status, especially those about students and staffs' ICT performance. Multi-source data from school information systems are required to build a more accurate school ICT evaluation indicator model according to students, teachers and schools' performance from different aspects [17]. From questionnaire structured data to unstructured multi-source big data, more complicate index coefficient weight normalization is needed [18]. Besides, the methods used in the article are basic statistics and outlier analysis. Many other big data analysis tools can be used for complicate data. The remained problem is data security and personal information protection. ICT M&E is a systematic project and it requires the cooperation of school ICT stakeholders [19].

6. Conclusion

With the development of school ICT hardware and software tools, school ICT activities are recorded in various management systems [18]. All of these digitalized data can be collected for the purpose of School ICT M&E [19]. All these data play an important role in evidence based evaluation in big data eras. The framework introduced in the article spans from data collection, data analysis, framework evaluation to personal data protection. The designed data collection is efficient to collection ICT terminal process information for school ICT evaluation.

7. Future Work

ICT M&E is a data tracking and utilizing work, aims to provide critical ICT data to inform stockholders ICT development strategies and formulate sound ICT policy. This article introduces and validates a school ICT M&E framework theoretically and a case study. But it's popularization in district schools, there are still much to be done.

Firstly, education government should hammer out educational specific data governance policies, (1) to specify personal data scope, which data can be collected, and which data cannot be collected; (2) to make school ICT M&E framework as part of school ICT development plan, and to bind school evaluation with school ICT develop investments.

Second, school ICT development is a long term and dynamic changing progress. So data supported ICT evaluation indicator are also changeable to meet the dynamic ICT needs according to last time evaluation results [21].

Third, new school ICT monitor data collection tools are need to gather heterogeneous data from multi sources, including MISs, IoT terminals, Web logs and so on. Each kinds of data have different features in data gathering methods.

Last, more big data processing and analysis tools should be used to get full value out of the collected data to support

school ICT decision making and policy make. Many unstructured data, like multimedia courseware, instruction audio & video have abundant useful information, such as course instruction ideas, teach emotion, teacher-student interaction.

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