A Maturity Model for Assessing the Use of ICT in School Education

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(Submitted April 11, 2011; Revised September 26, 2011; Accepted November 25, 2011)

ABSTRACT
This article describes an ICT-based and capability-driven model for assessing ICT in education capabilities and maturity of schools. The proposed model, called ICTE-MM (ICT in School Education Maturity Model), has three elements supporting educational processes: information criteria, ICT resources, and leverage domains. Changing the traditional and exclusive focus on ICT, five Leverage Domains are defined: Educational Management, Infrastructure, Administrators, Teachers and Students. The Leverage Domains generate a hierarchical structure with a second level named Key Domain Areas. These areas should be measurable and controllable, so they are related to a third hierarchical level, called Critical Variables, allowing the model’s elements to be assessed qualitatively and quantitatively. The capability and maturity of these variables associated with the intersection with the other two elements establish five levels of capability. The proposed model is strongly supported by the international standards and best practices for ICT management. It has been validated through data collection instruments and its associated web-support tool was also refined with a small pilot study. In summary, the proposed ICTE-MM model provides a basis for self-assessment and improvement planning. It is not just a diagnostic tool but has also been found to be useful for guiding the principals in ICT investment.

Keywords
Evaluation methodologies, Secondary education, ICT in education, Maturity model

Introduction
Different studies indicate that several parameters considerably affect the implementation of new technology in the school environment (Condie & Munro, 2007; Kozma, 2008; Zamani, 2010; Underwood et al, 2010). For example, the opinions and attitudes of principals with regard to Information and Communication Technology (ICT) adoption influence the extent and quality of technological applications’ usage (Pelgrum, 2001). In fact, two schools with the same infrastructure, same human resources and same students can have very different results. There are concrete cases in which a mere change of the school’s principals has generated, with the same teachers, striking results in a short time (Waissbluth, 2010). Given this, principals and administrators need a vision to help them towards their goals. It is especially important at the school level for the principal to have a vision of what is possible through the use of ICT, and to be able to work with others to achieve that vision (Sun, Heath, Byrom, Phlegar, & Dimock, 2010). As an example, consider the following very well-established technology vision of a school (Nido, 2011):

“The purpose of technology use at school is to support teaching and learning. Technology is a powerful learning tool that, when properly integrated into a challenging curriculum, improves learning and helps us achieve our educational goals.

Students are active learners who use technology responsibly to solve problems, develop critical thinking skills and communicate ideas. Teachers integrate technology across the curriculum where appropriate to enhance instruction and assessment of student learning. They take advantage of staff development designed to improve teaching and learning with technology. Technology provides parents with user-friendly access to up-to-date and meaningful information about the school and their children's academic status. The school administration is committed to improving the efficiency of school technology by providing current and effective resources, appropriate training and qualified personnel.”

Every school needs an ICT plan to achieve its vision, but according to Zhihua and Zhaojun (2009), evaluation is usually the weakest component of ICT plans. There are several factors involved, but an important one is that policy makers often have unrealistic expectations about the learning improvements that will result from ICT initiatives. For example, when you consider that it takes an average of four to five years for most teachers to reach a level of
technological proficiency at which they can use computers fluidly and effectively, then an impact on student learning will not occur any sooner.

On the other hand, the degree of success that a school has in implementing ICT will depend, in part, on the quality and maturity of its ICT plan. Therefore, the school needs to monitor its progress towards ICT integration and use the evaluation results to plan its ICT program, e.g., identifying needs, problems, and opportunities as well as specific aspects of the program such as professional development, technical assistance, and resources. Evaluation is neither easy nor inexpensive, but when it is an integral part of the ongoing ICT planning and infusion process, it is well worth the effort (Spector, Merrill, van Merrienboer, & Driscoll, 2007).

It is clear that schools need a periodic evaluation mechanism to know where they are. This mechanism also indicates how to advance (more rapidly) towards the correct direction (roadmap) without losing time, efforts or resources. Evaluation is necessary, but unfortunately there are no standardised approaches. The choice of an evaluation method would depend on what aspect of ICT and education we want to evaluate; consequently, there is a wide range of assessment tools in ICT and education. An example of these proposals is that from Rodriguez, Nussbaum, López and Sepúlveda (2010). These authors present a monitoring and evaluation scheme for a specific ICT for an education program that supports teaching and learning using mobile, computer-supported collaborative learning. Using the information provided by the program, the authors analyse the impact of the innovations adopted by teachers on student achievement.

The development of capability maturity models has been a strong trend in various technological and organisational areas. These models are proving to be useful because they allow individuals and organisations to self-assess the maturity of various aspects of their processes against benchmarks. The best-known models are those belonging to the Capability Maturity Model Integration family developed by Humphrey at Carnegie Mellon University (CMMI, 2006). These models are typically constructed with five levels, where each maturity level provides a new foundation of practices on which subsequent levels are built. Although they were developed for the software products and services, their capability maturity level structure and the mechanisms for determining those levels have been replicated by many other models in other areas (Valdes, Solar, Astudillo, Iribarren, Concha, & Visconti, 2011). Some applications of the maturity model concept in e-learning are detailed in Harris (2004), Neuhauser (2004), and Marshall and Mitchell (2006). All these proposals were developed as an E-learning Maturity Model to provide a means by which tertiary institutions (universities and polytechnics) can assess and compare their capability to develop, deploy and support e-learning (focused on learners rather than teachers and institutions). An example of these applications in school education is shown in Zhihua and Zhaojun (2009). They present a maturity model framework applied during the ICT Test Projects in Shanghai rural schools, providing appropriate structures to deliver effective educational experiences through ICT use. The framework includes six models: “Technology,” “Curriculum,” “Leadership/Management,” “Workforce,” “Inter/intra-institutional linkage” and “External linkage.” Each model consists of a number of dimensions, 63 dimensions in total for the six models. Each of the dimensions within these models may be treated on a six-point Likert scale with positive scoring (Likert, 1932); a school that satisfies all the attributes within a given level of a dimension is assigned an appropriate score. The authors suggest that the models could be used as an action guideline for school managers, one that would prevent deviation from the scheduled targets. The maturity model of Zhihua and Zhaojun (2009) is not based on international standards.

A maturity model should be developed based on the internationally recognised standards of ICT use in education (Bonina & Frick, 2007). It should be adjusted to the given school’s local conditions and measure the degree of compliance with the internationally recognised standards (Olsson, 2006). It allows one to diagnose the situation, and from there generates a roadmap that guarantees a virtuous cycle of continuous improvement. The roadmap helps to optimise the ICT investments and allows the school to reach higher levels of maturity.

The proposed maturity model suggests a way to measure the use of ICT standards in the school. This model, based in CMMI (2006), is a process improvement approach that provides organisations with the essential elements of effective processes. The model will be called "Maturity Model for ICT in School Education" (ICTE-MM). The following sources have been considered as inputs in designing the proposed model:

- Models that provide the standard structure of a CMMI (2006).
- ISTE's National Educational Technology Standards (NETS), the NETS for Teachers (NETS-T, 2008), the NETS for students (NETS-S, 2007), and the NETS for Administrators (NETS-A, 2002).
• Technology Standards for School Administrators (TSSA, 2001).

The ICTE-MM model was validated with 19 stakeholders through different data collection instruments, a complementary self-assessment web tool was pilot-tested with six schools, and a fine-tuned version was generated that incorporates the participants’ feedback and an ICT, implementation roadmap for each evaluated school.

The proposed ICTE-MM model allows one to evaluate a school against the best international practices of educational ICT use, including formulation of organisational strategies, management of ICT, operative management, and capabilities of the school and its human resources (teachers, students and administrators). The next section establishes the problem statement and the general structure of the model. The section “Logic of Proposed Model: Leverage Domains and Key Domain Areas” presents the details of the model’s components as well as describes a rationale for the model. We then explain the validation process of the model and a pilot study of the web tool. In the last section, we conclude by discussing the main advantages of the model.

**Problem statement**

The research done by Zhihua and Zhaojun (2009) suggests that schools that are more e-mature improved their performance levels significantly and more quickly than those that are not. Saiti and Prokopiadou (2009) observe that the usage of new technologies in school administration is vital to upgrade administrative processes. Similarly, Marshall and Mitchell (2006) conclude that the results of the application of the e-learning maturity model have been found valuable for strategic planning activities in universities. In general, the e-maturity model of Zhihua and Zhaojun (2009), as well as Underwood et al. (2010) proposal, tries to answer the question: “Does maturity model have a positive impact on learner outcomes?”. The purpose of our proposal is specifically to answer the following questions: “Does ICTE-MM support principals to make appropriate decisions on ICT investment? Does ICTE-MM support principals to identify how to develop future actions?”

According to Waissbluth (2010), Chilean principals have non-professional faculties to lead, and a consensus has not developed around basic aspects, as much administrative as pedagogical, of the management and leadership of organisations. In the Chilean context, Hepp, Hinostroza, Laval and Rehbein (2004) note that “introducing ICT into the schools, without a proper staff development plan and without a pedagogical perspective, is a low-return investment.” Where resources are limited, this lesson really must be learnt quickly (Wagner, Day, James, Kozma, Miller, & Unwin, 2005).

Public schools with limited resources have no budget to hire an in-house expert exclusively for technical assistance. Several studies (Eteokleous, 2008; Saiti & Prokopiadou, 2009) indicate that ensuring the quality and permanency of technical assistance constitutes one of the important factors for the efficient introduction and exploitation of new technological capabilities.

All these evidences suggest that principals need support to make decisions about ICT investments. In this paper we propose a maturity model in order to provide principals with virtual technical assistance (roadmaps) to make appropriate decisions on whether to expand or modify a particular policy or ICT investment and to identify how to develop future actions.

**Research context**

The study investigated computer use in the schools of Santiago, Chile. The population of Santiago is about 6 million. Nationally, there are 10,605 schools distributed among four categories according to their financial sources: 6,250 public schools (59%), 3,217 subsidised schools (30%), 1,068 private schools (10%) and 70 schools of entrepreneurial corporations (0,1%). There are 2,576 schools, equivalent to 24.29% of the national total, of which 611 are public, 1,615 are subsidised, 317 are private and 33 are entrepreneurial corporations. As for the number of students, the total enrolled at the regional level in 2007 was 1,405,200 (Mineduc, 2009).
Figure 1. Hierarchical structure of (5) domains, 25 KDA and CV
 Proposed Maturity Model for ICT in School Education (ICTE-MM)

Following the ISTE's National Educational Technology Standards (NETS-A, 2002; NETS-S, 2007; NETS-T, 2008) and TSSA (2001), we defined five Leverage Domains: Educational Management, Infrastructure, Administrators, Teachers and Students (Figure 1). The Leverage Domains generate a hierarchical structure of levels. The second level is named Key Domain Areas (KDA). These areas should be measurable and controllable and are related to a third hierarchical level called “Critical Variables” (CV). Each KDA can be measured by whether it meets its goals, which are determined by the CV that determine the given KDA’s capacity.

The “Information Criteria.” To satisfy the school requirements, the information must satisfy certain criteria which constitute the ICTE requirements for this information. These criteria for the information provided by a given KDA are:

- **Effectiveness:** the information must be relevant and pertinent as well as being delivered timely, correctly, and consistently.
- **Efficiency:** the information must be generated by the most productive and economical use of resources.
- **Confidentiality:** the information must be protected from unauthorized disclosure.
- **Integrity:** the information must be accurate and complete.
- **Availability:** the information must be available when required by the stakeholders, and its associated resources and capabilities must be safeguarded.
- **Compliance:** the information must comply with those laws, regulations and contractual arrangements to which the school is subjected, i.e., externally imposed educational criteria as well as internal policies.
- **Manageability:** information must be easy to deal with and usable by management to operate the school.

The “IT Resources.” The Leverage Domains require “IT Resources” to generate, store and deliver the information required to reach the school objectives. IT resources are:

- **Applications:** information systems and manual procedures used to process data and generate information.
- **Data:** on every format required by the school and processed by the information systems.
- **Infrastructure:** technology (e.g., hardware, operating systems, database management systems, networking, multimedia, etc.) that enables the processing of the applications.
- **Facilities:** the environment that houses and supports the IT infrastructure.

![Figure 1. Structure of the model showing the three dimensions of interrelated elements](image-url)
Logic of proposed model: Leverage domains and key domain areas

Leverage Domains are the model’s core elements because they are used to establish the capability levels, which are in turn compared with the current status of a given school. Five leverage domains and 25 KDA (Figure 1) were defined by studying international standards along with input and feedback provided by instructional technology experts and educators, including classroom teachers, administrators, teacher educators, and curriculum specialists (Tomei, 2005). We detail two domains, Management and Infrastructure, including the description of their critical variables. Due to limited space, the other three domains, Administrators, Teachers, and Students, are described in a general context (see Teachers and Students’ variables in Figure 1).

Management

This domain is based on Technology Standards for School Administrators (TSSA, 2001). It provides criteria to evaluate the ability of the school to articulate an ICT consistent vision. In other words, the school should have an ICT strategy aligned with the school’s overall strategy, and there should be an explicit commitment to the ICT. The management domain’s KDAs are as follows:

(MAN-1) School Management. This domain allows for the verification and qualification of plans in accordance with school administration, specifically for the measurement and monitoring of the following six CVs: action plan for ICT use in administration; technology plan in administration; monitoring and Evaluation plan; verification of the personal use of ICT in administrative positions; generation of report cards, registration, qualifications (i.e., SIMCE and PSU, nation-wide school evaluations in Chile); and follow-ups of student/teacher cases (record of educational cases for students and teachers).

(MAN-2) Vision, Strategies and Policies. This domain allows for the management of all ICT resources according to the school’s vision, strategy and priorities. At the same time, it aligns the plan with national educational policies. It specifically allows for the measurement and monitoring of the following CVs: alignment strategies; commitment of senior management; communication with the school community; resource allocation (policy for the use of internet resources; and policy for the acquisition of inputs and technological resources meeting school needs).

(MAN-3) Organisation and ICT Management. This domain outlines activities helping the school to organise and manage ICT. It is evaluated through the following CVs: planning guidance IT infrastructure; IT infrastructure planning; defining the organisational structure; and IT process roadmap.

Infrastructure

This domain is based on the maturity model described in Valdés et al. (2011). It provides guidance on how the school can develop its multimedia resources to provide the foundation for ICT implementation. This domain contains the following KDAs:

(INF-1) Software. This measure allows for the development of infrastructure-oriented application; it is defined within the context of the school’s educational objectives and its integration with other internal and external systems. It is evaluated through the following CVs: operating system; educational software; and Administrative Software.

(INF-2) Networks. This domain measures the network architecture that defines the communications infrastructure for the transmission of information. Its CVs are the following: internet; wi-fi; and intranet.

(INF-3) Hardware. This measure allows for the development of an ICT infrastructure that defines the technologies and standards for the technical components that enable the ICT initiatives. The variables are as follows: access to the computer room; quality of technological equipment for educational use; access to equipment deployment information multimedia; computers available for education; and access equipment information capture.

(INF-4) Maintenance Plan. This domain allows for measurement planning that maintains the operability of ICT in the school. Its CVs are as follows: maintenance of equipment; operational maintenance supplies; and presence of a maintenance plan.
(INF-5) Security. This measure allows for the development of a security infrastructure that defines the technologies and safety standards to ensure that internal and external transactions are secure. It is measured with the following CVs: condition safety; insurance contracts; health conditions; personnel for security work; and backup information.

Administrators

These standards are indicators of effective leadership for ICT in schools based on NETS-A (2002):

(ADM-1) Leadership and Vision. Educational leaders inspire a shared vision for comprehensive integration of ICT and foster an environment and culture conducive to the realisation of that vision.

(ADM-2) Learning and Teaching. Educational leaders ensure that curricular design, instructional strategies, and learning environments integrate appropriate ICT to maximise learning and teaching.

(ADM-3) Productivity and Professional Practice. Educational leaders apply ICT to enhance their professional practice and to increase their own productivity and that of others.

(ADM-4) Support, Management, and Operations. Educational leaders ensure the integration of ICT to support productive systems for learning and administration.

(ADM-5) Assessment and Evaluation. Educational leaders use ICT to plan and implement comprehensive systems of effective assessment and evaluation.

(ADM-6) Social, Legal, and Ethical Issues. Educational leaders understand the social, legal, and ethical issues related to ICT and model responsible decision-making related to these issues.

Teachers

This domain is based on the international standard NETS-T (2008). Teachers design, implement, and assess learning experiences to engage students, improve learning, enrich professional practice and provide positive models for students, colleagues, and the community. All teachers should meet the following standards and performance indicators. This domain’s KDCs are as follows:

(TEA-1) Student Learning and Creativity. Teachers use their knowledge of the subject matter, teaching and learning practices, and ICT to facilitate experiences that advance student learning, creativity, and innovation in both face-to-face and virtual environments.

(TEA-2) Digital-Age Learning Experiences and Assessments. Teachers design, develop, and evaluate authentic learning experiences and assessments, incorporating contemporary tools and resources to maximise content learning in context and to develop knowledge, skills, and personal attitudes.

(TEA-3) Digital-Age Work and Learning. Teachers exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society.

(TEA-4) Digital Citizenship and Responsibility. Teachers understand local and global societal issues and responsibilities in an evolving digital culture and exhibit legal and ethical behaviour in their professional practices.

(TEA-5) Professional Growth and Leadership. Teachers continuously improve their professional practice, model lifelong learning, and exhibit leadership in their school and professional community by promoting and demonstrating the effective use of digital tools and resources.

Students

Within a solid educational framework, ICT can help students to live, learn and work successfully in an increasingly complex society that is rich in information and knowledge. Students and teachers should use digital technology effectively. This domain’s KDAs are based on the following international standard NETS-S (2007):
(STU-1) Creativity and Innovation. Students demonstrate creative thinking, acquire knowledge, and develop innovative products and processes using ICT.

(STU-2) Communication and Collaboration. Students use digital media to communicate and work collaboratively, at times long-distance, and to support individual learning and contribute to the learning of others.

(STU-3) Research and Information Fluency. Students apply digital tools to gather, evaluate, and use information.

(STU-4) Critical Thinking, Problem Solving, and Decision Making. Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

(STU-5) Digital Citizenship. Students understand human, cultural, and societal issues related to ICT and practice legal and ethical behaviour.

(STU-6) Technology Operations and Concepts. Students demonstrate a sound understanding of technology concepts, systems, and operations.

Capability model and maturity determination

The capability is a measurement of the state of each KDA that contributes to support the school’s development. The capability of a KDA is determined by using the Capability Level (CL) of each of its Critical Variables (CV); in other words, the capability of these variables to satisfy certain requirements is evaluated. The capabilities of the critical variables are averaged to give a final KDA CL.

To accommodate ICTE strategies with different variables relevance, weights \( W \) are used for each variable group. Thus, the \( CL \) of a KDA is the weighted average of the CLs of its variables \( CV \) (Eq. 1).

\[
CL_{KDA} = \text{Average}[\text{CAP}(CV_1) * W_1, \text{CAP}(CV_2) * W_2, \ldots, \text{CAP}(CV_n) * W_n]
\]  

(Eq. 1)

The weights \( W_i \) used in this first model application are all equal, but the model allows to adjust their values according to the needs.

Maturity is a property of the school as a whole, and the maturity level \( (ML) \) is obtained from the KDA capacity levels that the school has \( (CL_{KDA}) \). There are several options to determine an organization maturity, namely:

1. Minimum CL among all KDAs
2. Average CL of all KDAs
3. Predetermined KDA configuration, using a set of values for all KDAs in model.
4. Configuration of high-priority KDAs, using a set of minimum values for all KDAs in the model.

The last criterion (Configuration of high-priority KDAs) was adopted in ICTE-MM. The school \( ML \) corresponds to a predetermined configuration of KDAs in predefined \( CLs \) (Eq. 2). See Table 1.

\[
ML_1 = \text{Conf1}(CL_{KDA1}, \ldots, CL_{KDAk}) \\
ML_5 = \text{Conf5}(CL_{KDA1}, \ldots, CL_{KDA5})
\]

(Eq. 2)

Table 1. Example of organizational ML with a set of high-priority KDAs

<table>
<thead>
<tr>
<th>Domain</th>
<th>KDA</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>School Management</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Vision,</td>
<td>Strategies &amp; Policies</td>
<td></td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>ICT Management</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td>Network</td>
<td></td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network</td>
<td>Hardware</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td>Maintenance Plan</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td>Security</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrators</td>
<td>Leadership &amp; Vision</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
This mechanism was selected for ICTE-MM for its flexibility to allow graduating progress according to specific ICTE strategies, since it only requires to fix a minimum set of KDAs that are important for a given ML; development criteria and rates for other KDAs are left to the school. The actual criteria to use can be extracted from domain specialists or school leaderships. Once the current ML is assessed, the model allows one to identify the states required to advance to a higher level and to propose a “roadmap” to improve the school.

The model considers five levels for a staged evolution of KDA capability. Each KDA includes variables with capability levels of their own; a weighted average of the variables’ capability levels determines the KDA capability level. A set of common patterns was identified to determine the discrete capability levels. For instance, level 1 means that capability does not exist, although the school may have recognised the importance for such capability; in level 2, the capability exists, but it is neither structured nor formalised; in level 3, the capability exists and it is well documented and structured; in level 4, the capability is structured, and its metrics and automatic tools have been defined and standardised to improve its effectiveness and efficiency; finally, level 5 implies all of the capabilities above plus the use of best practices and international standards in its achievement.

**Description of KDA capability levels**

As a sample of how KDA capability levels are defined, the capability model of one KDA is described in Table 2 (School Management). As defined in the “Management” section, “School Management” allows for the verification and qualification of plans in accordance with school administration.

<table>
<thead>
<tr>
<th>Critical Variable</th>
<th>Level 1 “Initial”</th>
<th>Level 2 “Developing”</th>
<th>Level 3 “Defined”</th>
<th>Level 4 “Managed”</th>
<th>Level 5 “Optimised”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action plan of ICT use in administration</td>
<td>There is no plan</td>
<td>There is an informal plan</td>
<td>There is a formal plan</td>
<td>There is a formal and standardised plan</td>
<td>There is a plan, and it is annually reviewed</td>
</tr>
<tr>
<td>Technology plan in administration</td>
<td>There is no plan</td>
<td>There is an informal plan</td>
<td>There is a formal plan</td>
<td>There is a standardised plan</td>
<td>There is a plan based on the use of best practices</td>
</tr>
<tr>
<td>Monitoring and evaluation plan</td>
<td>There is no plan</td>
<td>The plan is informal</td>
<td>There is a formal plan</td>
<td>There are some automatic tools</td>
<td>There is a plan based on the use of best practices</td>
</tr>
<tr>
<td>Verification of the personal use of ICT in administrative positions</td>
<td>There is no verification</td>
<td>There is an informal verification</td>
<td>There is a formal procedure</td>
<td>There is a standardised verification process</td>
<td>There is a procedure based on the best practices</td>
</tr>
</tbody>
</table>
The KDA “Vision, Strategies and Policies” must satisfy the ICTE objective of managing and conducting all “IT resources” according to the school strategy and its priorities. Its relevant “Information Criteria” are Effectiveness and Availability, and the main “IT Resources” required are Applications and Data.

Its level of capability is determined by six critical variables, but we show details of the following four variables: (1) Strategy alignment with the national educational directions. (2) Principal commitment with the implementation of school initiatives. (3) Periodic communication to all involved people within the school. (4) Resource assignment commitment with the implementation of the organizational school strategy.

The CLs are defined below. Within each level four assertions are presented, one for each variable related to the KDA.

- **Level 1 “Initial”:** (1) There is evidence that the school has recognized that the strategy alignment is important and needs to be addressed; however, there are neither actions nor approaches that tend to be applied. (2) There is no awareness and need for the principal to get involved early with the school initiatives. (3) There are no formal actions to communicate the school initiatives to the people in the school. (4) There is no evidence of resources specifically allocated for the ICT and education implementation.

- **Level 3 “Defined”:** (1) The ICTE Vision is well defined and it is integrated to the school strategy. There is a policy about ICT and educational strategy planning and it is well documented. (2) Principal and teachers are committed to and get involved early in the ICTE initiatives. (3) The ICTE vision, policies and strategies have been communicated to and are well understood by all personnel in the school. (4) Enough monetary resources to support ICTE initiatives have been assigned. Its allocation is included in the school’s annual budget.

- **Level 5 “Optimised”:** (1) The vision is periodically reviewed according to stakeholders’ needs and new technologies. The strategy and policies are periodically updated according to feedback from stakeholders, teachers, and educational policies. The strategy planning process is continuously compared with the international standards. (2) Principals have an explicit role assigned in the IT strategy planning process. (3) Personnel, stakeholders, and teachers are considered when the ICTE vision is developed. (4) Resources assigned to the ICTE initiatives are periodically adjusted according to a cost/benefit analysis and to stakeholders satisfaction.

**Validation of the ICTE—MM model**

The evaluation methodology associated to the ICTE-MM model establishes activities, schedules, institutions, workflows, work products, roles and responsibilities, to provide effective assessments to schools using the ICTE-MM model (Sabattin, 2009). The evaluation methodology is supported by a web tool, which supports the gathering and processing of information generated in each evaluation based on the ICTE-MM model.

Table 3 shows the participants and data collection instruments used during the validation process. In order to check validity we use more than one data source to obtain information about key aspects of the model: The proposed model has been presented to instructional technology experts (2), teachers (6), administrators (5), and principals (6). These recipients represented schools of different maturity levels (according to annual ICT investment), sizes (number of students) and types (Pub: public; Sub: subsidised; Pri: private). A survey was conducted to determine the relevance of the CV included in the ICTE-MM model, and a questionnaire was administered to determine whether the model was a valid and useful tool for guiding principles in moving towards best management practices. The questionnaire...
was sent to 19 stakeholders as shown in Table 3, and all of them (100%) answer it in less than 5 days. So, according to Margaret Sanger Center International (2009), the results are representative of the group of stakeholders to whom the questionnaire was mailed. The results show that 80% of the CVs were considered of high or very high relevance. Most remarkable is the case of the “Teachers” domain, which yielded a relevance perception of 92%. Due the current model weights of critical variables are equal, all participants (100%) agreed that future versions of the model should refine these weights.

Table 3. Participants in validation process

<table>
<thead>
<tr>
<th>Technology experts</th>
<th>Teachers</th>
<th>Administrators</th>
<th>Principals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pub</td>
<td>Pri</td>
<td>Pub</td>
</tr>
<tr>
<td>Number of participants</td>
<td>2</td>
<td>2</td>
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During interviews, we assured the principals that what they were going to say was in confidence and that the identity of speakers would not be revealed. As participants were guaranteed anonymity, we can ensure they were honest in their responses (research validity). Since there are only three interviews, all three were conducted by one experienced and trained interviewer, avoiding invalidity in comparisons of data across different interviewees. The interviewer received training about the project and his role, and he received an interview protocol to conduct the interview. The training includes evaluation objectives, review of data collection techniques, and the importance of following instructions and the application protocol.

The principals (88%) stated that they agreed with the criteria for moving from one maturity level to the next. Five of the six principals found that a tool like this could be very helpful. The remaining one, a principal of a private school, did not need a tool like this because the school had hired an in-house expert for technical assistance.

Pilot study of the web-support tool

A pilot study conducted in a set of schools was performed during September 2009 with the following objectives: validate the model and its associated web-support tool; test the applicability of the model to schools with different characteristics; and obtain feedback from schools.

A sample of six heterogeneous schools was selected in terms of type, organisational size, and degree of technological advancement. All of them are based in the Metropolitan area of Santiago, Chile. The KDA set was divided up and assigned to three different management field roles: Administrator (director of the school, not always a teacher, but sometimes with a Ph.D. in education), IT Management (head of IT unit, normally a teacher), and Teacher. Therefore, at least three teachers were required to participate in each school.

A two-hour workshop was conducted to explain the web tool, a call center was available to answer questions during ten days and questions were answered by email as well.

The ICTE-MM model was validated and commented on by participants in the pilot study. This pilot study was supported by a web tool that supported the gathering and processing of information generated in each evaluation. The web tool was developed in PHP, using PhpMyAdmin and MySql to run in Joomla. We created six accounts to access the web tool, and we sent usernames and passwords to each participant. The web tool is available for any school and can be periodically used to monitor improvement of capabilities and maturity levels at the website http://tice-mm.inf.santiago.usm.cl (in Spanish).

An assessment is performed on a school by answering the web tool’s questions. The result is an evaluation (capabilities of each KDA and school maturity) plus a proposed capability maturity improvement roadmap. The pilot test was helpful to find out how long data collection takes: participants took ten days to answer all the questions of the web tool. They validated the model’s structure, applicability, and capability and maturity calculation scheme.
Furthermore, the feedback we received enabled us to make improvements to the structure of the model. As a result, we moved two CVs from one domain to another one.

Conclusions

The main benefits identified in the ICTE-MM model application are:

- It is a reference framework to identify the areas that support an ICTE strategy, based on internationally recognized standards for ICT management and education.
- The proposed ICTE-MM model provides a basis for self-assessment and improvement planning. In terms of theoretical implications, it is not just a diagnostic tool but has also been found to be useful for guiding the principals in moving towards best practices in management and ICT investment.
- The Leverage Domains, along with their KDA and variables that determine the capability maturity, are involved in a dynamic cycle, the school requirements acting as the main triggering input. This cycle allows for each school to achieve continuous improvement of ICT use in education, making it easier for them to transit towards higher maturity levels through planned roadmaps. One of the most important practical implications of the model is that the application of the ICTE-MM provides data to formulate technological projects and to base budgetary requests tailored to the individual school. This may help the principals to base their decision making on facts.
- It has a methodology to determine an improvement roadmap; besides the 5 leverage domains, 25 KDA and 103 CVs, the model incorporates organizational capabilities and maturity. Each KDA critical variable has minimum required values for higher MLs, marking improvement roadmaps for the school.
- The developed model was built and tailored to the characteristics of public schools in a developing country. This target school has a low budget and no in-house expert for technical assistance. Consequently, the ICTE-MM model is operationalised with a web tool for self-assessment of critical variables that acknowledge the capabilities of each school to carry out ICTE initiatives and guide principals in technical decisions.

Finally, this model distinguishes between capacity, a characteristic of KDA, and maturity, as a property of the school as a whole. The level of maturity allows one to define a "roadmap" to improve the school’s ability to address the challenges of education in the country.

Acknowledgments

This work was partially funded by DGIP-UTFSM, Project No. 241142 and the Electronic Government Center of the Informatic Department - UTFSM.

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