Applying SPICE to e-Learning: An e-Learning Maturity Model?

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Abstract

The Capability Maturity Model and SPICE approach to software process improvement has resulted in a robust system for improving development process capability in the field of software engineering. We apply these same ideas in the area of e-learning in order to explore whether similar insights could be generated for institutions engaged in online delivery of teaching. In order to test this idea, a set of potential process areas are presented, based on a well known set of e-learning benchmarks and a trial analysis of a project is conducted. We suggest that this model offers a means for institutions to identify systemic weaknesses in their e-learning development, delivery and management that potentially can inform future resourcing and strategic priorities.

Keywords: e-learning, CMM, SPICE, process improvement.

1 Introduction

A significant challenge facing most tertiary institutions is containing the rising cost of e-learning infrastructure. Despite the large sums of money being spent uncertainty remains over whether the investment is resulting in improved learning outcomes for students (Conole *et al*. 2000, Taylor 2001). In an attempt to move from an area characterised by individual heroics and unsustainable projects driven by passionate teachers there have been numerous attempts to document "best practice" such as Chickering's Seven Principles (Chickering and Ehrmann 1996), the work of the National Learning Infrastructure Initiative (NLII, Hagner 2001) and the benchmarks created for the Institute of Higher Education Policy (2000). These heuristics have been complemented by a development of technical standards such as the Shareable Content Object Reference Model (SCORM 2001) and the work of the IMS Consortium (IMS 2003). The problem is the need for a more holistic approach with a focus on best systems rather than on individual practices:

"…the author had envisioned the presentation of a wide range of 'best practices' that would resemble a menu-like opportunity for interested institutions to choose from. This original intent was misguided. … 'cherry-picking' a variety of practices is not recommended. Instead of focusing on 'best practices', a more profitable emphasis should be placed on 'best systems.' By and large, institutions that have demonstrated the highest levels of success in faculty adoption excel in most of the practices areas listed above. These institutions offer a comprehensive and integrated package of support services and engagement practices" (Hagner 2001).

All of this work has resulted in many recommendations and wise counsel for institutions, but the challenge remains identifying limitations with current institutional e-learning practices. Such a detailed understanding is needed if institutions are going to incrementally improve organisational e-learning capability (Laurillard 1997). As well, the post-DotCom environment requires institutions adopt a critical attitude to e-learning improvements. Thus it is important to choose from the range of possible areas needing improvement, those that result in the greatest benefits to the institution as a whole.

In many ways the challenge facing institutions is similar to that which faces organisations engaged in the development of complex software systems and which resulted in the development of process improvement models such as the Capability Maturity Model (CMM, Paulk *et al*. 1993) and SPICE (Software Process Improvement and Capability dEtermination, El Emam *et al*. 1998, SPICE 2002). The similarities have lead us to consider applying the same approaches used in the development of the software process improvement models to the development of a potential e-learning process improvement model or eMM (Marshall and Mitchell 2002, 2003). In this paper we explore what such a model might look like and explore how it might be applied in the evaluation of institutional e-learning capability.

Process category	Brief description
Customer-Supplier	Processes that directly impact the customer
Engineering	Processes that specify, implement, or maintain a system and software product
Project	Processes that establish the project, and co-ordinate and manage its resources
Support	Processes that enable and support the performance of the other processes on the project
Organization	Processes that establish the business goals of the organization and develop process, product, and resource assets which will help the organization achieve its business goals

Table 1: SPICE version 1 process categories

Process category	Brief description
Learning	Processes that directly impact on pedagogical aspects of e-Learning
Development	Processes surrounding the creation and maintenance of e-Learning resources
Co-ordination	Processes surrounding the oversight and management of e-Learning
Evaluation	Processes surrounding the evaluation and quality control of e-Learning through its entire lifecycle.
Organisation	Processes associated with institutional planning and management

Table 2: eMM Process Categories

2 Moving from CMM and SPICE to an e-Learning Maturity Model

The development of the CMM and SPICE models resulted from extensive consultation and workshopping industry practitioners in order to identify practices that resulted in high quality software development. These processes were then extensively validated and tested through additional pilots and evaluations (El Emam *et al*. 1998). In the case of SPICE, this work resulted in a model that identifies five main areas or process categories (table 1). These categories are used to organise a collection of processes and the practices that contribute to the effective performance of individual processes. Elsewhere (Marshall and Mitchell 2002, 2003), we have presented the development of related categories for e-learning which are presented in table 2. What is missing, however, is the actual processes and practices needed for effective e-learning delivery by institutions. If we were to follow the original process used in the SPICE trials (El Emam *et al*. 1998) we would need to attract sufficient interest in the applicability of this approach so as to gain access to and support from a representative range of institutions. This would then allow for the identification and validation of processes and practices. In order to stimulate discussion and analysis of this idea, we have taken a less resource intensive approach and developed an initial set of process categories based on the research literature, in particular the *Quality on the Line* benchmarks (Institute for Higher Education Policy 2000).

We believe the approach of using the *Quality on the Line* benchmarks is valid as they are based on an extensive survey of successful projects and organisations and are thus likely to be reflected at least in part in a more extensively validated set of practices. These benchmarks form the nucleus of a collection of processes that we can use to illustrate the applicability of the eMM model as a means of identifying ways to incrementally improve organisational e-learning capability. It should be noted that we do not propose that these processes are exhaustive or that the model can be defended as authoritative, rather they are illustrative and able to be criticised and improved through use and analysis.

3 Development of processes from benchmarks

The benchmarks provided in the *Quality on the Line* document, while well regarded, contain a number of limitations when applied. A number of the items contain conjunctions or multiple aspects which while related, are able to be measured, and more importantly, improved independently of each other. In order to operationalise the benchmarks, we have first regrouped them according to the modified version of the SPICE categories (table 2). Where benchmarks contained aspects that clearly fell into two categories, they were broken down and reworded to accommodate the different aspects appropriately.

The initial benchmarks were then reviewed and broken down further within the categories to remove conjunctions or to separate multiple items. As well, the language of some of the benchmarks was revised to remove specific technologies or to make more explicit the process that is being recommended.

In order to ensure that the processes reflected a comprehensive understanding of e-learning capability we compared the resulting processes with two other sets of heuristics or "best practice" sets, Chickering's *Seven Principles* (Chickering and Ehrmann 1996, Graham *et al*. 2001) and of Hagner (2001). This resulted in the addition of six more processes.

e-Learning Maturity Model: Levels	
Level	**Focus**
5: Optimising	*Continual improvement in all aspects of the e-Learning process*
4: Managed	*Ensuring the quality of both the e-learning resources and student learning outcomes*
3: Defined	*Defined process for development and support of e-Learning*
2: Planned	*Clear and measurable objectives for e-learning projects*
1: Initial	*Ad-hoc processes*
0: Not performed	*Not done at all*

Table 3: Levels of process capability

This approach resulted in the set of processes displayed in left hand side of table 4. As can be seen, the list becomes long quickly and once detailed practices are added to the individual processes, rather unwieldy to comprehend initially. Once this framework is validated, it will be comparatively easy to add additional processes and their associated practices into the categories as they are identified by field studies and detailed evaluations of institutional projects and e-learning infrastructures.

4 Measurement of the proposed practices

In order to evaluate the practicality and validity of the processes identified and the model, we have applied them in the analysis of an e-learning module within an existing teaching programme at a New Zealand University. This was chosen for its familiarity to the researchers rather than as an exemplar of best practice. When performing a detailed study of an organisation's capability one would want to ensure that a number of courses or programs were studied, and that these would be representative of normal practice, rather than being exemplar projects which attracted unusual levels of support or development assistance. As well, the evaluation was done on the basis of the knowledge of the assessors rather than on documented evidence that would be the normal practice. Finally, while self-assessments have some value for reflection and are generally cheaper, an independent evaluation provides external validity and confidence that can be useful when using the results to motivate organisational change.

As with the SPICE process, the model we are using defines six levels of process capability (Table 3). Each process is broken up into practices which are assessed at each level using a four point scale (not adequate, partially adequate, largely adequate and fully adequate).

In a fully developed system, each of the processes is defined by a set of practices, each of which contribute to the overall process capability. For the purposes of this trial and in the interests of brevity in this paper, the processes were evaluated holistically and a single result reported, rather than the more detailed analysis that could be done. Obviously, the more detail used, the more confidence that will be had in the robustness of any observations of process quality and the suggestions for improvement that would be derived from the results.

4.1 Background to trial of the model

The module being trialed is part of a Masters level programme which is offered nationally in three modes - on campus in a conventional classroom setting, by distance using a weekly audioconference seminar, and in Auckland, using classroom sessions taught by lecturers who travel to Auckland for the purpose, and audioconferencing using a local tutor for support. There are approximately 50 students in the on-campus class, and 50 in each of the other modes. All modes are supported by printed course materials, and other electronic forms of communication, such as a Learner Management System (LMS), email, listservs, and CDs and disks (these include the resource analysed in this paper as well as cataloguing and database software demonstrations etc.) The challenge of distance teaching is further complicated in New Zealand by the comparatively poor telecommunications infrastructure of many regions (Doesburg 2001) which prevents the use of many online teaching approaches beyond email and limited web page access.

The module is supported by a web and CD-ROM based resource for the teaching of interpersonal communication skills to students, both locally and at a distance. The challenge was to provide a resource that could be used within the classroom both by students and the teacher and also be used at a distance in order to recreate aspects of the classroom experience for those students. As well, the intention was that the resource would be extended and developed over a number of years and thus it had to be easily maintained and expanded as required.

4.2 Results from measuring practice compliance

The results from the trial evaluation are given in the right-hand columns in table 4. The results are presented in summary form in this way in order to clearly indicate where systemic weaknesses might be found. The intention is to develop a tool that can clearly indicate weaknesses in process capability across an organization rather than within one specific project, and so detailed analysis of a particular weakness is generally not as useful as the higher-level overview.

The first process category, *Learning*, is perhaps unsurprisingly the strongest. Development of the material being analysed was driven by a particular programme's

teaching needs and consequently those aspects of the work have been concentrated upon. The focus on particular needs however, is possibly responsible for the weakest result in this category, L10, which reflects a consideration for issues of accessibility and variety in learning styles. The resources developed have not been designed explicitly to ensure that alternative rendering tools such as blind readers work, and while certainly flexible in design, this has been done from a teachers perspective rather than a learners.

The next category, *Development*, is weak in comparison to the first and reflects the relatively ad-hoc nature of the development process and the support around it. While technical assistance was provided and well controlled, little detailed analysis of its effectiveness has been conducted and there is little evidence of information being collected and used to help improve the development of other resources.

The results for the *Coordination & Support* category are also weak with a couple of exceptions that can be explained by their relationship to the subject material being taught. It is not surprising that a course on Library studies has paid particular attention to accessing information resources of different types. Otherwise this category, as with others is suggestive of a mixture of ad-hoc work and some formal management.

The *Evaluation* category is potentially the weakest, reflecting a lack of formal institutional reflection and analysis of this type of resource. While formal processes exist within the organisation to evaluate and maintain quality of courses and programmes, e-learning capability is largely unaffected by these currently perhaps reflecting the comparatively few projects actually being deployed.

The final category, *Organisation*, is also weak and reflects the absence of formal e-learning standards and processes. Most processes are well performed at a basic level as they are a reflection of more general administrative requirements on teaching delivery and student support. The absence of formal standards in the area of e-learning is clearly apparent, as the absence of review and formalised analysis of weaknesses with current e-learning approaches.

The results suggest that the institution has a number of areas in need of improvement. The weakest areas are in Development processes and in Evaluation processes. Of the two areas, Evaluation is the more serious problem as it generates the information that can be used to inform decision making and resource allocation. A single analysis of this type is not sufficient to make any firm recommendations but the result is certainly consistent with an environment in which learning and teaching are valued but more formal e-learning development processes are not. As well, the lack of strong strategic planning and management oversight of the e-learning process is evident. This weakness is apparent when the higher levels, *Managed* (4) and *Optimising* (5) are examined, only four of the forty three processes are assessed as even partially reaching level 5 and only 10 achieve level 4.

Achieving the higher maturity levels in this model reflects an organisation that is not only monitoring how well it is delivering e-learning across a range of metrics, but is also actively engaged in a reflection and self-analysis process that avoids complacency. A high level of eMM maturity indicates an ability to deploy scarce resources effectively in order to maintain a high level of e-learning process capability in a rapidly changing technological and societal environment.

5 Discussion

As George Box (1979) said "all models are wrong; some models are useful". The intention of this paper is to illustrate how the process capability maturity approaches of software engineering can be applied to inform tertiary institutions attempting to improve their ability to engage in e-learning. We believe that the model presented has a number of advantages over traditional benchmarking (Marshall and Mitchell 2002):

i. Firstly, an e-learning model could provide a road map for higher education institutions looking to improve their e-learning processes. Most academics are familiar with the ad-hoc approach to e-Learning where development of resources and support of students have more to do with individual heroics than good institutional planning. While some tertiary education institutions have embraced e-Learning in a major way, many are looking for a clear model to guide their ongoing development of resources and enhance their support processes. It is clear that a series of signposts or a map that might guide institutional planners in areas of resource allocation and staff and student support has some merit.

ii. An accepted framework might also provide academics with the necessary means to encourage greater institutional involvement and provide University management with the framework necessary to frame long term institutional planning. The advantage of the proposed model is that it presents a high enough overview that it can usefully understood without a need to examine detailed reports and metrics.

iii. Support for institutional planning might be enhanced by the ability of an institution or even a school to benchmark its current capability in an effort to identify and prioritize necessary improvements in its current practices. The lack of a unifying framework for e-Learning makes it difficult for institutions to compare themselves against other bodies in meaningful ways. Importantly the model would allow for different technical platforms, organizational models and pedagogical beliefs. This might aid inter- and intra- institutional collaboration by allowing entities to identify areas in which improvements may produce the most immediate value as well as establish a framework for collaboration on future initiatives.

Learning: ***Processes that directly impact on pedagogical aspects of e-Learning***						
		1	**2**	**3**	**4**	**5**
L1.CDB3	Courses are designed to require students to engage themselves in analysis, synthesis, and evaluation as part of their course and program requirements					
L2.TLB1	Student interaction with faculty and other students is an essential characteristic and is facilitated through a variety of ways					
L3.	Faculty clearly communicate how communication channels should be used during a course or programme					
L4.	Faculty manage student expectations over the type and timeliness of responses to student communications					
L5.TLB2	Feedback to student assignments and questions is constructive and provided in a timely manner					
L6.TLB3	Students are instructed in the proper methods of effective research, including assessment of the validity of resources					
L7.CSB2b	Learning outcomes for each course are summarized in a clearly written, straightforward statement					
L8.	Assessment of students communicates high expectations					
L9.	Student work is subject to clearly communicated timetables and deadlines					
L10.	Courses are designed to support a diversity of learning styles and to ensure accessibility					
Development: ***Processes surrounding the ceation and maintenance of e-Learning resources***						
D1.CDB1a	Guidelines regarding minimum standards are used for course development, design and delivery					
D2.ISB2	The reliability of the technology delivery system is as failsafe as possible					
D3.CDB1b	Learning outcomes, not the availability of existing technology, determine the technology being used to deliver course content					
D4.FSB1a	Technical assistance in course development is available to faculty					
D5.FSB1b	Faculty are encouraged to use technical assistance when (re)developing courses					
D6.FSB2a	Faculty members are assisted in the transition from classroom teaching to online instruction					
Coordination & Support: ***Processes around the day-to-day management and support of e-Learning delivery***						
C1.ISB3	A centralized system provides support for building and maintaining the e-learning infrastructure					
C2.CSB3	Students have access to sufficient library resources that may include a “virtual library” acessible through the World Wide Web					
C3.CSB4	Faculty and students agree upon expectations regarding times for student assignment completion and faculty response					
C4.SSB2	Students are provided with hands-on training and information to aid them in securing material from a range of sources consistent with the discipline or subject.					
C5.SSB3a	Students have convenient access to technical assistance throughout the duration of the course/program					
C6.SSB3b	Students are provided with detailed instructions regarding the electronic media used in a course prior to commencing it					
C7.SSB3b	Students are able to practice with any technologies prior to commencing a course					
C8.SSB4a	Questions directed to student service personnel are answered accurately and quickly					
C9.SSB4a	A structured system is in place to address student complaints					
C10.FSB3	Instructor training and assistance continues through the progression of the online course					
C11.FSB4	Faculty members are provided with support resources to deal with issues arising from student use of electronically-accessed data					

Evaluation: ***Processes surrounding the evaluation and quality control of e-Learning through its entire lifecycle.***						
E1.EAB1a	The programme's educational effectiveness is formatively and summatively assessed with multiple, standards based, and independent evaluations					
E2.EAB1b	The programme's teaching/learning process is formatively and summatively assessed with multiple, standards based, and independent evaluations					
E3.EAB2a	Summative data such as enrolment numbers, completion rates, and costing is used as a measure of effectiveness within course/programmes					
E4.EAB2b	Success of technology/innovation used as a measure of effectiveness within course/programmes					
E5.EAB3	Intended learning outcomes are reviewed regularly to ensure clarity, utility, and appropriateness					
E6.CDB2	Instructional materials are reviewed periodically to ensure they meet programme standards					
E7.FSB2b	Faculty capability in making the transition from classroom to online teaching is formally assessed during training					
Organisation: ***Processes associated with institutional planning and management***						
O1.	A documented set of formal criteria are used to determine access to funding and other resources which support course and programme (re)development					
O2.ISB1a	A documented technology plan is in place and operational to ensure quality of delivery standards					
O3.ISB1b	A documented technology plan is in place and operational to ensure the integrity and validity of information delivered, collected and stored					
O4.CSB1a	Before starting a programme, students are advised of any particular requirements of that programme to ensure they possess the personal and technical skills needed for that programme					
O5.CSB2a	Students are provided with supplemental course information that outlines course objectives, concepts and ideas					
O6.SSB1a	Students are provided with supplemental course information that outlines admission requirements, tuition and fees and other relevant administration information					
O7.SSB1a	Students are provided with supplemental course information that outlines requirements for additional resources such as books or other materials					
O8.CSB2a	Students are provided with supplemental course information that outlines student support services.					
O9.CSB1b	Before starting a programme, students are advised of any particular technological requirements of that programme to ensure they have access to the minimal technology required by the course design					

Not adequate		Partially adequate		Largely adequate		Fully adequate	

Table 4: Process categories and results from trial evaluation

iv. Another area in which the model may quickly show a benefit is in its use as a way of organizing the diverse collection of ideas and heuristics in the e-learning literature so that individual practitioners or teams can conduct informal self-assessments. Feedback from such experiments will provide a valuable input into the evolution of the model presented and also ensure that new heuristics can be identified and codified for testing and use.

Perhaps most importantly, like the software process improvement approaches, the model might form the basis for an ongoing discussion within the e-learning community with a view to identifying the key practices, heuristics or activities necessary for achieving improvements in e-learning activities.

It is important at this stage to identify an important caveat for the use of the models. One of the main criticisms aimed at any maturity model is the prescriptive nature of the framework. It is important that any use of the model avoid displacement of goals from the true mission of improving process to the artificial mission of achieving a higher maturity level (Bach, 1994). Clearly there will be a number of successful organisations undertaking e-learning initiatives who have not followed the process described in the model yet still achieve continual

improvement in their processes. By understanding their success, rather than by limiting it, the utility of the eMM model will be improved rather than becoming a constraint to quality and innovation.

The set of processes we have presented are just a start, an initial position for criticism, analysis and improvement. We feel that if this model is to be useful, it requires participation and cooperation from many institutions. Only by detailed examination of many projects and programmes will a rich range of processes be identified which can contribute to e-learning capability, and only through that examination will the detailed practices be identified and validated.

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