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EC - IDM

The Electronic Commerce Integrated Development Methodology For Small Firms

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1. INTRODUCTION

Electronic Commerce (EC) technologies have the ability to reshape industry structure, and in doing so modify the rules of competition, which, in turn, lead to new methods of competing (Thong, 1999; Hawkins et al., 1999). The technological shift from traditional methods to Internet-based methods of trading has facilitated cost and competitive advantage (Auger and Gallaugher, 1997). However, to maximise EC gains it is critical that organisations understand the phases of technological assimilation and also the managerial issues involved in implementing new technologies. This specifically requires a coherent and combined approach to EC technology deployment, Business Process Reengineering (BPR) and associated activities such as Organisational Learning (OL).

Research conducted by Turban et al. (1999) indicates that Information Systems Development (ISD) can provide a stimulus for productivity and quality improvements, through process improvements, automation, and associated initiatives. It is therefore evident that there is a very close relationship between BPR and ISD. Furthermore, research reveals that many leading authors view Information Technology (IT) as being a critical enabler of BPR (Bartram, 1992; Davenport, 1993). Stoddard and Jarvenpaa (2000) believe that the absence of IT capabilities can be a major inhibitor to BPR.

Learning is a dynamic process by which organisations adapt to the changing nature of the environment. The major emphasis of reengineering business processes is to fundamentally rethink and radically redesign each process in turn. In technology driven BPR everyone involved in the ISD project must possess a detailed understanding and knowledge of the potential impacts of the initiatives on work practices and organisational structure. Consequently an organisation must facilitate learning in order to enable

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organisational members to adapt to the new environment successfully. As the pace of change increases the need for organisation-wide learning becomes increasingly important, consequently OL has come to prominence. Hence OL should accompany BPR in ISD projects. As regards EC ISD initiatives research conducted by Chaston et al. (2001) revealed a direct correlation between organisations with a structured learning system and a high level of involvement with the use of Internet technologies. Most mainstream ISD methods including Structured Systems Analysis and Design Methodology (SSADM) & Unified Modelling Language (UML)/Unified Process (UP), have been developed with large organisations in mind. In Ireland, and indeed in many western economies, small firms make up the majority of knowledge-based economic activity. Consequently, the development of a comprehensive ISD methodology for Small-Medium Enterprises (SME's) in knowledge-based economies requires particular attention of ISD researchers.

Currently, few strategic guidelines in ISD provide an integrated approach to BPR, OL, and AD (Application Development) in a coherent methodology. Furthermore, traditional ISD generally does not consider the specific needs of EC applications and their particular contexts. Consequently, many firms have had to implement EC initiatives without a coherent methodology to help ensure they are able to negotiate this complex space as effectively as possible. Without the provision of such a methodology, many EC efficiencies are lost due to the operation of parallel paper-based and automated processes (Auger and Gallaugher, 1997). It is therefore critical for an organisation wishing to undertake the development and implementation of an EC application to follow a strategic methodology, which comprehensively outlines the major factors influencing such an undertaking. This paper presents an ISD methodology, which explicitly incorporates BPR, OL and AD for an EC initiative.

2. INTRODUCTION: THE NEED FOR AN ISD EC METHODOLOGY

ISD literature reveals a direct correlation between EC and BPR (Thong, 1999; Hawkins et al., 1999). Giaglis et al. (1999) reiterates this correlation by advocating that EC applications bear a close resemblance to BPR efforts. In order for an organisation to engage in any type of EC it is necessary to undertake the examination of existing business processes. Such an examination necessitates the identification of those business processes that require automation or elimination (Moreton & Chester, 1998). During a BPR project the major emphasis is placed upon fundamentally rethinking and radically redesigning each process in turn, and it is also evident that any EC initiative should also be viewed as a BPR opportunity. However, in order to do this, organisations must possess an understanding and knowledge of the specific business processes involved; highlighting the importance of facilitating OL within an organisation. Consequently a close relationship between EC, BPR, OL and AD can be explicitly identified given that few ISD approaches coherently address these dimensions of EC-based ISD. The following research questions can be identified:

1. To what extent do we need to develop a coherent ISD methodology incorporating BPR, OL, and AD within the EC domain?
2. How do you enable an organisation to work effectively as a direct response to the development, adoption, implementation, and deployment of an EC application?

However, very few methodologies facilitate the provision of both strategic management and control for ISD. This paper addresses itself to this problem.

3. KEY BUILDING BLOCKS OF AN EC ISD METHODOLOGY

The design methodology utilised in this study incorporates three distinct but interrelated standards for AD. The choice of methodologies incorporates a unique blend of characteristics which include: immediacy and continuous evolution; a highly iterative and incremental software development process; the ability to reverse developmental changes; and the integration of testing throughout the development lifecycle. The methodologies in question incorporate: the WebE process and framework, Rapid Application Development (RAD), and the Dynamic Systems Development Method (DSDM).

WebE - the WebE process and framework is used to create high quality Web applications. Web-engineering borrows many software engineering fundamental concepts and principles. The application of WebE to the framework in question incorporates functionality such as:

1. Immediacy and continuous evolution, which dictates an iterative and incremental development process.
2. An emphasis on aesthetics.
3. The provision of customer evaluation of the prototype.

RAD - is an approach adopted for the development and maintenance of IT-based applications (DSDM Consortium, 1997). The application of RAD to this framework incorporates a number of characteristics:

1. Highly iterative and incremental software development process through the use of tools and techniques and through the utilisation of prototyping.
2. Reduced development time by performing activities concurrently and by delivering capability in an incremental manner.
3. Support for the use of reusable components.
4. Through the provision of speed and portability RAD is deemed suitable in the development of applications with an ease of maintenance and modification.

Nonetheless, ISD is a complex activity, which requires careful management, and this is not well supported within the RAD methodology. To overcome this DSDM was identified as the third methodology to be incorporated. DSDM provides a management and control framework for RAD (Bennett et al., 1999). Its objectives and application within the context of this study incorporates:

1. Fitness for business purpose is a criterion for the acceptance of deliverables.
2. Changes during development are reversible.
3. Requirements are identified at a high level.
4. Testing is integrated throughout the development lifecycle.

This research also recognised that, regardless of the design methodology chosen, it is essential to examine and define a notation building block i.e. a modelling notation, in order to provide a design specification for the application in question. The modelling notation adopted was the UML. UML targets the modelling of systems using object-oriented concepts and is generally applied as a means for developing blueprints for software development (Larman, 1998).

Having established the key components it is important that these be organised into a coherent strategic methodology. The next section develops and sets out such a methodology, which will then be tested in an empirical study.

4. PROPOSED METHODOLOGY – EC-IDM

The goal of EC-IDM is to enable businesses, particularly SME's, to build and deploy a broad spectrum of robust, secure, scalable, interoperable, portable EC applications for ISD projects in a quick and easy manner in strategic alignment with these organisations.

The EC-IDM approach focused upon the incremental building of functionality in line with BPR objectives and the rolling out of OL activities such as education and training programmes. EC-IDM consists of a sequential series of phases, which are grouped into 'sectors' (see Figure 1).

The rationale underlying the development of EC-IDM is the provision of a methodological approach for the effective management of ISD, in strategic alignment with business strategies and existing information systems. The methodology is made up of reusable components organised as a complete integrated methodology that can be specialised for specific EC contexts.

The primary benefits of methodologies such as EC-IDM, as advocated by Fayad and Schmidt (1997), are intended to be modularity, reusability, extensibility, and inversion of control provided to developers. However, when developing such methodologies it is essential to resolve issues such as: development effort; learning curve; integratability; maintainability; validation and defect removal; and efficiency, all of which are targeted by EC-IDM.

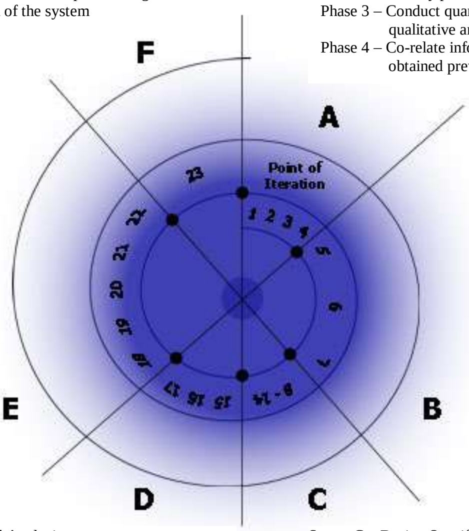

Figure 1: Divisional sectors of EC-IDM

4.1 Preliminary Analysis

Sector A consists of four phases, which are primarily concerned with preliminary analysis at the onset of the development lifecycle. A feasibility study is conducted on the development of the application, and, in turn, the gathering of user requirements through the use of qualitative analysis.

The primary deliverable from this sector is the broad functional, non-functional, and usability requirements of the application, which may be documented through the use of use cases and other support materials. The identification of such requirements provided developers with an insight into the areas where BPR would be required in the organisation. These areas provided the necessary detail in order to identify the processes to be reengineered.

4.2 Business Analysis

Sector B consists of three phases with a direct emphasis placed upon BPR. Essentially, once the previous areas have been identified and understood, a method must be chosen for the level of process improvement to be implemented. It is then considered important to determine which processes require re-engineering within each area identified and which are considered to be in-line with end-user requirements captured previously.

The primary challenge is to identify those activities or processes, which are distinctive, cross-functional, and value adding. Managerial input and commitment is important in order to ensure success on the process change (Heygate, 1993). Thus, the secondary challenge is to decide on the level of process improvement to be adopted.

At the conclusion of this sector of the framework the primary deliverable is the Business Analysis Specification, which illustrates the processes to be reengineered, and the level of process improvement to be adopted.

4.3 Design Specification

Sector C consists of seven phases. This sector was deemed the most important of EC-IDM with regard to the integration of OL, BPR and AD in ISD.

The focus of this sector is the identification and evaluation of information technologies and architectures to be deployed, whilst also incorporating OL features such as education and training of end-users.

The primary objective of the remaining phases within this sector concern traditional ISD-type activities, which mainly deal with the design and modelling of the application using an appropriate design notation. Finally, a series of validation tests are designed to validate design and ensure conformance with end-user requirements.

4.4 Detailed Analysis

Sector D emphasises the evaluation and selection of the hardware, software, and security architectures to be utilised during ISD. This sector includes technology evaluation and architecture selection, and examines how OL can be integrated into the evaluation process for the above technologies. Education and training are deemed to have an impact on a number of different phases of EC-IDM during this sector, and in subsequent sectors. Within this sector the primary concern with regard to OL is the appraisal of tools and technologies for ease of use and learning for end-users and the potential of such tools and technologies for adoption and expansion at a later stage.

At the conclusion of this sector the developer should have ascertained a clear and precise understanding of the technologies available for the development of an ISD application with regard to functionality, usability, accessibility and training.

4.5 Implementation

Sector E of EC-IDM encompasses the execution of five phases of the framework, which are primarily concerned with ISD and hence the validation and testing of the developed prototype with its primary end-users. Outcomes from the Design Specification should be used at this point.

It also involves OL through the establishment of an extensive education programme for users on the proposed system capabilities and how these capabilities fit into the new business processes, including motivations for processual change and dialogues concerning major principles underpinning the business process changes and EC functionalities. There must also be configured a subsequent training programme on the current, specific capabilities of the prototype. Research on sensemaking in ISD suggests that it is important to ensure close coupling between the education and training activities and the technical design activities at this stage, and in subsequent stages (Stapleton, 2001). This sector also facilitates the test and validation of the prototype against end-user requirements to ensure a direct correlation between the prototype and user expectations in addition to requirements captured from management.

4.6 Refinement

As stated previously the rationale behind this sector, Sector F, is to refine the functional prototype developed. This sector is composed of one phase, focused on the refinement of the prototype developed in order to develop a working model of the system. The sole purpose of which is to identify system failures and the non-capture of user and management requirements and non-conformities highlighted from the previous sector. This therefore presents essential feedback to the developer from which point reiteration commences through the necessary phases of EC-IDM, in order to ensure the delivery of a more functional application.

5. RESEARCH FINDINGS

Now that the methodology has been set out the following section details the findings of the preliminary study highlighting both the functionality of EC-IDM and also some drawbacks and improvements which are necessary.

5.1 The Need For A Combined OL/BPR/AD Approach: Pilot Study

A semi-structured questionnaire was compiled, and a pilot investigation was conducted to assess the adequacy and comprehensiveness of the research design and of the instrument to be used for data collection. This study was highly exploratory in nature and little has been done to incorporate BPR, OL, and AD into a coherent methodology for EC. Consequently, the findings set out here are from a research instrument, which drew heavily from qualitative methodologies and did not attempt to gather much statistical data. Whilst this approach gathered rich data from EC application contexts, it did not help to establish generalised findings, which is a weakness of the study. The study started with very general discussions of EC needs with SEBIC (South Eastern Business Innovation Centre). From these discussions 6 key questions emerged as important for the development of EC-IDM:

1. The level of EC technology integration within the participating companies at the time of investigation.
2. The importance of the development of EC initiatives within the companies and the associated ISD approach undertaken by the companies.
3. The level of understanding and support of the management team regarding ISD.
4. The existing technologies, if any, in place within the companies.
5. The primary benefits of EC technology to the companies.
6. Identification of potential users of the EC technology.

Forty-Seven organisations were subsequently targeted at random and nineteen organisations responded to the questionnaire. Summarising, the analysis of the questionnaire data provided the following findings:

- a clear, detailed indication of the feasibility of undertaking an EC ISD project,
- the approach adopted for the development of the application in each firm,
- the end-users of the application and their perceptions of the technology.

It was found that none of the organisations surveyed adopted a combined BPR/OL/AD approach to the development in question. Typically the approach was ad-hoc and all respondents told how the EC initiative failed to meet any of their expectations as a direct consequence of such an approach. Respondents told how they felt that they were unable to fully understand how to integrate the technology, or how to prepare their organisation to utilise the technology effectively. This emphasised the earlier contention set out in Section 1 that the lack of guidelines specifically associated with EC initiatives leads to serious problems on the ground for SMEs in Ireland. Given that the problems reported here seem to be systemic within the ISD approaches utilised by these organisations, it is possible that the problem existed beyond the specific Irish context. These respondents felt that they did not make any effective use of EC, and many were rather wary about the technology and its potential benefits going forward. They typically reported their EC application to be substandard with regard to functionality, maintainability and scalability. Furthermore the applications did not deliver effective business processes.

Ten organisations clearly signalled their intent to undertake further significant ISD activity on their EC capability in the immediate future, in order to increase their EC presence and overcome their current functionality and business effectiveness difficulties. These organisations were specifically targeted to participate in the second phase of this study designed to test EC-IDM. The next stage of the study revisited these ten organisations primarily in order to assess their level of commitment to EC ISD activities going forward, and from there to select one highly committed organisation which would be willing to utilise and assess EC-IDM in this initiative.

5.2 Main Study

The aforementioned ten organisations became the basis of detailed interviews designed to attain an understanding of the further development of their EC application. The resultant data was used to assess the level of commitment of these organisations to EC. The selection criteria used were not solely concerned with functionality but also with the level of process change required in order to realign the organisation with the ISD, and the ways in which the organisation would be committed to educating its users, learn from its development process and its reported desire to use EC as a lever to improve organisational effectiveness. In order to test and validate EC-IDM one organisation was approached which would invest resources into these non-technical activities. Anonymity had to be ensured in order to address ethical considerations in the context of the research (Stapleton, 2001; Fahy, 1995). In order to identify the processes and the associated level of change required it was then necessary to measure the effectiveness of such changes and identify the motivations of the organisation with regard to the ISD activities.

Before assessing EC-IDM in this organisation, the key process-driven changes require documentation in the second stage of the research. Summarising, the key changes experienced by these organisations included: faster lead times; market exposure; and competitive advantage.

Whilst examining the organisational motivations, it was also deemed necessary to identify and examine areas of concern with regard to the development, including:

1. The re-training and education of both employees and end-users.
2. Implementation of changes in work practices.
3. Process changes.
4. Security issues, related standards and protocols.

5.2.1 Benefits of EC-IDM

The final part of the longitudinal study focused upon one organisation, which demonstrated a high degree of commitment to further EC development initiatives. This organisation conducted an extensive EC ISD project utilising the proposed EC-IDM. There were both organisational benefits to the approach, but also severe limitations to the EC-IDM approach. The findings are summarised in the following sections.

5.2.1.a. Organisational Impact of EC-IDM

EC-IDM ultimately focuses on the use of ISD to leverage organisational benefits through the adoption of EC technologies. Thus, EC-IDM recognises that the outcome of ISD is not just technology, but a holistic, socio-technical solution manifested as a more effective organisation.

The impacts upon the organisation can be summarised as follows:

Complexity and Sensemaking – the organisation that adopted the EC-IDM methodology found that the undertaking of the EC initiative was far more manageable as a project and respondents reported that they found it easier to understand the complexities relating to ISD.

Iterative Development – the iterative approach of EC-IDM, in addition to the tight coupling of prototyping and OL proved very useful. This was particularly true in relation to enabling people to buy into the processual change that EC was to introduce. Respondents told how the application made sense at each stage of development and, consequently, they felt they obtained 'maximum leverage' whilst managing small chunks of business risk as they iterated through the methodology. EC-IDM was based upon an incremental lifecycle, which enabled identification of key areas, which would subsequently require further technical and process development. This again helped establish necessary dialogues between the development and user groups, and build ownership of the project amongst users.

Power and Control – management had experienced difficulties in previous projects where the major portion of control over ISD projects was handed over to technical teams who did not appreciate the organisational impacts of the development activity. Using EC-IDM management were able to ensure that the power structures associated with the project were more appropriate than in previous projects undertaken and therefore they felt that they retained more ownership of the development. This was surprising given that EC-IDM does not specifically address power issues, and further research is needed to establish how this aspect of the framework can be developed. Ultimately, it is likely that the impact upon power structures, which proved to be a major success factor, is related to the sensemaking support which combining OL and BPR into ISD delivered. This has been found in other studies of similar systems such as ERP (Stapleton, 2001).

Organisational Alignment – respondents felt that by using EC-IDM the EC application proved to be more organisational aligned, particularly in terms of the strategic objectives associated with the project. The strategic alignment of the EC initiative was driven down into operational realities, and this meant that the operational activities of the firm were felt to be more effective in terms of the primary mission of the organisation.

5.3 Drawbacks of EC-IDM

The use of EC-IDM proved far more effective than the ad-hoc approaches that had been previously adopted by the organisation whilst undertaking EC development in the past. However, the immaturity of the methodology was evident and did give rise to a number of drawbacks, which are detailed below.

Lack of Contextual Appropriateness – the research attempts to set out a generic methodology for SMEs in Ireland across all industries. The proposed framework thus deals with all aspects of EC with the primary aim to develop an application whereby an organisation can transact business via the Internet. However, not all businesses or organisations wish to actively adopt 'full-blown' EC and, indeed, EC models such as Choi et al. (1997) illustrates how differentiated EC adoption can be (Turban et al., 2000). Therefore, the framework requires:

1. to be further developed or enhanced with regard to the degree of interest or participation within the domain of EC,
2. to address contextual attributes of specific EC application domains.
   Indeed, it may prove beneficial for EC-IDM to be modified for application to one single business domain.

Repositioning of Phases – Some of the phases may need to be repositioned, depending upon the domain in which the methodology is utilised, the level of complexity of the application and the level of development expertise in the organisation. In particular, the findings suggest the repositioning of the following phases.

1. Sector 4, which focuses on Detailed Analysis. This may be more appropriately executed earlier in the ISD lifecycle in order to allow the developer to become more familiar with the technologies chosen and which underlie the application under development. Alternatively, it is possible that the execution of phases, within each sector of the lifecycle itself should be problematic as has been suggested elsewhere in studies of sensemaking in ERP systems (Stapleton, 1999). This will require further investigation in the context of EC ISD initiatives.

2. Sector 5 should be reassigned as Phase 21, 19, 20 and 22 in sector 4. The reasoning for the reassigning of the phases is in the presentation of the prototype firstly to the initiators of the development and consequently to the end-users to ensure management support throughout.

Also, sector 5 could possibly be extended to incorporate an additional phase in order to place greater emphasis on the education and training of end-users in relation to the application at this stage of development. Findings suggest that the education of users with regard to the functionality and capabilities of the new application, enhances positive attitudes towards EC adoption and will therefore ease the conversion process.

Emphasis on OL – the emphasis placed on OL was generally too weak in EC-IDM and in particular not enough OL was utilised within the Refinement Sector. While it was addressed in a limited way, the importance of education and end-user training was not addressed sufficiently (Halpin & Stapleton, 2003). Indeed, the level of resources required during post-implementation activities was generally under-estimated. This can be directly linked again to the adoption of the linear, life-cycle model as a strategic underpinning of EC-IDM. Other studies have shown that this model tends to underestimate the importance of complexity in the post-implementation stage (Halpin & Stapleton, 2003; Wilcocks, Feeny and Islei, 1997)

In short, whilst EC-IDM provided some guidelines and contributed to a more successful outcome to the EC initiative, it was also a rather immature methodology with particular drawbacks associated with its over-emphasis upon technical imperatives. A refined, and potentially more useful, version of EC-IDM will require a rebalancing of the ISD process towards OL and sensemaking in the later stages of ISD, and in particular during the refinement sector. The next section of this paper sets out the general conclusions of the study and suggests further research is required.

6. SYNTHESIS OF PRELIMINARY ANALYSIS

To what extent is it necessary to develop a coherent ISD framework incorporating BPR, OL, and AD within the EC domain?

Findings indicate that it is necessary to develop a coherent ISD methodology incorporating BPR, OL, and AD within the EC domain because it encapsulates all the major issues outlined by the respondents to the study conducted here. Once these issues were addressed the respondents were happier to go forward with EC development and more importantly were more confident that it would be successful

How do you enable an organisation to work effectively as a direct response to the development, adoption, implementation, and deployment of such an EC application?

Organisations who developed, adopted, implemented, and deployed their EC application using EC-IDM felt that they were far more proactive rather than reactive to change than previously. Whilst respondents felt that EC-IDM had severe limitations, there was a definite need for some sort of combined ISD methodology incorporating BPR, OL and AD. Nevertheless, findings indicated that significant modifications to EC-IDM would be needed to fully lever such an approach.

7. CONCLUSION & FUTURE DEVELOPMENTS

With the complexity surrounding EC, and the misunderstandings and misinterpretations of management, regarding the concept, it is hardly surprising that managers are apprehensive regarding the initiation of the development and implementation of an EC application. Should management possess a clear understanding of the principles which underlie the concept of EC, then the development of an EC application would be perceived less complex in nature, and thus, less perilous an undertaking.

Comprehensive in nature, EC-IDM covers all aspects of developing an EC application from preliminary analysis to business analysis, right through to a design specification, which then leads to detailed analysis, implementation, and finally refinement. It is through the execution of all six sectors of EC-IDM that a functional prototype should be delivered. Through subsequent iterations, the prototype may be refined and/or expanded in a manner to capture the full functionality required of the application.

Nonetheless the execution of EC-IDM may not apply to all EC applications. Indeed some applications may only execute a small subset of phases within each sector. Further research is required to develop a 'mini-method' of the methodology for these applications along similar lines as Mumford's quickETHICS (Mumford, 2001).

Additionally, having completed a rich qualitative study, a large-scale quantitative study is needed in order to establish the generalisation of the findings – this is an obvious weakness of the research instrument and one, which will require further work. Also, another area for further research is the identification of associated benefits and drawbacks of the proposed methodology in comparison to existing methodologies, which was not explicitly addressed here.

As mentioned previously, one of the main objectives of the proposed methodology was the combination of BPR, OL and AD. However, due to the underestimation of the importance and the magnitude of OL by the authors, not enough time was dedicated to the integration of OL into EC-IDM. The authors have a primarily technical background, which might explain this problem. Hence, further research is required and will be considered in greater detail in the next revision of the methodology. Indeed, it is likely that the methodological emphasis may be too rigid in focus. Instead, EC-IDM may need to be reworked into a more flexible framework, rather than methodology per se (Ciborra (1997). This also addresses the need for the sensemaking perspective identified earlier.

Finally, it is evident that EC-IDM needs to be significantly enhanced and extended in order to be capable of supporting increasingly sophisticated EC requirements.

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