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Gaye Kiely
University College Cork

Brian Fitzgerald
University of Limerick

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AN INVESTIGATION OF THE INFORMATION SYSTEMS DEVELOPMENT ENVIRONMENT: THE NATURE OF DEVELOPMENT LIFE CYCLES AND THE USE OF METHODS

Gaye Kiely
AFIS Department
University College Cork
gaye.kiely@ucc.ie

Brian Fitzgerald
Department of Computer Science and IS
University of Limerick
brian.fitzgerald@ul.ie

Abstract

In the present age, information systems are integral to the day-to-day operations of most organisations. However, information systems development (ISD) is very much a volatile area. In addition, the ISD environment has changed considerably in the past few years due to both technological advances and acceleration in the speed of business in general. For these reasons, the purpose of this study was to investigate the nature of the ISD environment with particular emphasis on development life cycles and ISD methods. The findings of the study indicate that the ISD environment area is one of which practitioners are constantly developing greater understanding. The nature of ISD is very much a volatile one and cannot be easily generalised to accommodate the use of standard life cycles and ISD methods. Practitioners in the ISD field readily acknowledge the uniqueness of each ISD project and that ideal conditions for development cannot always be recreated. In particular, practitioners support the idea of using their past experiences and knowledge to develop the best solution to the development projects requirements.

Introduction

We are in the information age. Technology, computers and the Internet permeate through every area of modern life. In the business world, information systems have become integral to the successful day-to-day operations of organisations. Combining this with the rapid obsolescence of technology [Rockart and De Long, 1988], it becomes apparent how critical the successful completion of ISD projects are to a company's continued survival in the current business climate. Information systems are integral to the operations of the majority of organisations presently. The majority of organisations would state that if their information systems were not available for even a short period of time it could have a detrimental affect on their continued operations. Information systems have become the lifeblood of these organisations, they support all of the activities of the business. However, despite this criticality ISD is still a very volatile area under the influence of a number of variables such as budgeting, scheduling, personnel skills and technological limitations. Organisations are faced with developments coming in overdue and over-budget – many accept this as a fact of life [Baskerville *et al*, 1992].

The objective of this paper was to investigate the nature of the ISD environment currently prevailing in organisations with a particular emphasis on the nature of the systems development lifecycle currently used, and also the manner in which ISD methods are actually deployed. The remainder of the paper is laid out as follows: In the next section, issues relevant to the ISD environment are briefly presented, including the systems development lifecycle concept, and ISD methods. Following this, the research method employed in this study is described, and the findings of the study are presented and discussed. The paper concludes with a discussion of the implications of the findings of the study for ISD research and practice.

The Information Systems Development Environment

The field of information systems is a relatively new one. The first commercial systems were developed in the 1950s [Friedman, 1989] and in the intervening years information systems have become integral to organisational operations. Gradually, computer systems became widespread within organisations and grew more sophisticated due to increased needs of users and advancing technology.

However ISD was not a stable process. The emphasis was on the programming aspect of development and there was no set practice for how systems should be built [Friedman, 1989]. That a new information system was functional, cost-effective and accepted by the intended users was largely a “hit-and-miss” affair. As a result of this environment, the term ‘software crisis’ was coined in 1968 to describe the problems which plagued the development of information systems.

The ‘software crisis’ is commonly taken to mean the high level of project failure; budget overruns and missed deadlines within ISD. These are standard problems, which have plagued development of information systems and continue to do so at present [Korac-Boisvert & Kouzmin, 1995]. Information systems projects continue to fail at an alarming rate and the problem of ‘runaway’ development projects has never been more serious. For example, a recent study estimated that American companies spent \$59 billion in 1995 in cost overruns on runaway IS projects [Johnson 1995 - cited by Lyytinen & Robey, 1999].

Initially in the 1960s, IS was a new area and there were no standards in place to monitor development and evaluate end-results. Practitioners in the IS field became concerned with the nature of development and how the process might be controlled. An early solution was found within the academic areas of science and engineering [Baskerville *et al*, 1992; Quintas, 1996]. The idea was to break up the development process into logical phases such as analysis and design to better manage the development process.

The Systems Development Life Cycle

The earliest reference to the SDLC (Systems Development Life Cycle) in ISD was Canning in 1956 [Avison & Fitzgerald, 1995]. This life cycle approach to development began to be used as a prescriptive device to control projects [Friedman, 1989] and throughout the 1960s the SDLC was modified and elaborated upon. The SDLC developed over a period of time [Royce, 1970] and was introduced into IS development in the late 1960s. The SDLC was supposed to introduce rigour and consistency into development by splitting development into distinct phases (feasibility, analysis, design etc.) with associated activities. The SDLC did attempt to eradicate a number of bad practices apparent at the time in development. It supported the creation of documentation, went some way to supporting training and providing greater control. It split development into phases. However, the SDLC was not the “silver bullet” [Brooks, 1987], but merely a marked improvement on what had gone before. Despite the application of the SDLC, development project continued to fail at a consistent rate.

Throughout the 1970s and 1980s development problems persisted, there were well publicised reports of IS project failures and excessive costs of development [Korac-Boisvert & Kouzmin, 1995]. Whilst this crisis continued, the development environment was altering rapidly. The development environment of the 1990s was greatly changed from that of the 1970s, despite both being plagued by problems [Friedman 1989]. Technology has become more sophisticated in the intervening years. In addition, there is now a wider variation in projects, (such as data warehousing, e-commerce etc.) and as a result of advances in technology, projects could now be more sophisticated in their structure [Baskerville *et al*, 1992]. Regardless of this changing environment, the traditional SDLC as refined by Royce [1970] is still very much present in modern ISD projects, whether it is explicitly stated or not.

However, the traditional SDLC may no longer be an appropriate representation of IS developmental phases. The ISD environment characteristics have altered so much in the past thirty years that it is questionable as to whether a seven-phase development cycle is still the standard for development projects at present.

Information Systems Development Methods

Methods became part of the development process in the 1960s and 1970s as developers became aware that instances of IS development were escalating and some regulations or guidelines might be useful. Following on from the SDLC, these early methods sought to further standardise the development process and bring greater stability to the area. SSADM (Structured Systems Analysis & Design Method), IE (Information Engineering) and YSM (Yourdon Systems Method) are typical of traditional methods.

Traditional methods are easily identifiable by their characteristics. Whilst each may differ in certain aspects, they are all coming from the same basic principle – the structured, scientific paradigm [Korac-Boisvert & Kouzmin, 1995]. In addition, this approach has met with many criticisms since its creation [Bjorn-Anderson and Hedberg, 1977; Land, 1980; McFarlan, 1974 – *cited by* Korac-Boisvert & Kouzmin, 1995]. This emphasis on control has led to traditional methods being labelled as ‘inflexible’. By trying to control all the variables associated with development, the hard methods tie developers in to a certain development path and it can be argued that this stifles creativity [Baskerville *et al.*, 1992]. A relevant concern may be the argument that traditional methods prolong the development process, as all phases are carried out in sequential order. Long development processes are not particularly welcome in the current, high-speed business environment.

The majority of methods adopted by organisations are derived from ideas from the 1960s-1970s. This is a fact supported by much of the literature concerned with ISD methods [Baskerville *et al.* 1992; Fitzgerald, 2000; Kouzmin & Korac-Boisvert, 1995; Larrasquet & Clare, 1996]. These methods were designed in a time when ISD was in its infancy and the very nature of these traditional methods reflects this point. Typical traditional methods take a rational, incremental approach to development with an emphasis on the ability to control each facet of development. It is what Korac-Boisvert & Kouzmin [1995] refer to as a “top-down” strategy.

Large organizations still utilise these project management methods originally borrowed from the engineering and construction industries during the 1960s [Kouzmin & Korac-Boisvert, 1995]. This is a strange occurrence when the extent of technological and social advances are taken into account from the past thirty years. Yet, in the area of ISD, techniques and methods from thirty years ago are still used frequently. This might be appropriate if the methods were effective and if the environment in which they are used had not changed but this is not the case. The environment has changed beyond recognition in the past 30-40 years [Korac-Boisvert & Kouzmin, 1995] and traditional methods cannot in any way be considered a perfect aid to development – in fact, the opposite is very much the case [Baskerville *et al.*, 1992].

The origins of the concepts upon which methods are based can be found in the engineering and science fields. Literature regarding the area frequently cites other academic areas as the source for IS methods [Kouzmin and Korac-Boisvert, 1995]. In particular, ideas were drawn primarily from engineering and science. The concept of “divide and conquer” – breaking the development down into manageable phases [Baskerville *et al.*, 1992]. However, these concepts do not necessarily fit the area of ISD.

Information Systems Development (ISD) is not solely a technical process. Any IS development incorporates a number of interrelated elements such as the technological, the business and the social. Zuboff [1991] states, “using the technology to its full potential means using human beings to their full potential”.

This argument that ISD is more than a technical problem is a point supported by literature [Baskerville, *et al.* 1992; Brooks, 1987; Fitzgerald 1996; Kouzmin and Korac-Boisvert, 1995; Vitalari and Dickson, 1983]. However, although it is taken as fact that ISD is not just technical, this factor is not typically supported by traditional methods. Traditional methods for the most part, disregard the influence that the social aspects can have on development.

Discussion involving the flaws of traditional methods leads to the question of whether methods are relevant at all in the current age. Perhaps there should be no methods at all, that there should be no set method for development in organisations. This is an intriguing viewpoint but one that is probably not realistic at present in the area of ISD. People and organisations like to use methods, even if they are flawed because they project an air of stability and confidence in the IS area (which has picked up a reputation for being chaotic and unstable). This is an opinion supported by Wastell [1996] who states that “methods are elaborate devices used as a “social defence” for containing the acute and potentially overwhelming pressures of systems development”. Whether or not it is the case (and it has been fairly conclusively argued not to be), methods have been hailed as a cure-all to IS ills.

The real question to be considered is whether these traditional methods are relevant in their current incarnation. Judging from the many criticisms that are currently attached to traditional methods [Kouzmin & Korac-Boisvert, 1995; Larrasquet and Clare; Baskerville *et al.*, 1992] their relevancy appears to be in doubt. Traditional methods have only limited application in the present age because software development is no longer a predictable and static process. Development is now ad-hoc and emergent in nature. Therefore methods should accommodate the changing nature of development. In the majority of cases hard methods are not the ideal option and other alternatives should be considered. Korac-Boisvert and Kouzmin [1995] state that “all IT development projects are not amenable to a conventional methodology and conventional project management techniques”.

Research Method

The research was conducted in Ireland by means of a postal survey conducted, which sought to gather data about the present ISD environment and the role that ISD methods play in this area. Among the issues explored were the following:

- The ISD projects being conducted in Irish organisations.
- The typical development lifecycle of an information system within these organisations.
- The use of methods within these projects and the nature of these methods within IS development.
- The way methods are perceived by practitioners in the area of ISD, and the value that these individuals place upon method usage.

The survey was tested extensively before being distributed to 500 trading companies within Ireland. For example, a pilot study was conducted with twenty respondents who had varying degrees of knowledge within ISD. Respondent's responses and suggestions were used to improve the clarity and structure of the survey. The intention for the study was to have at least 100 surveys returned. However, the low return rate for mail surveys is well documented in research method literature [Gillham, 2000] and therefore to ensure at least 100 respondents, 500 surveys were posted. This figure was decided upon due to the return on a prior survey in the same area being approximately 20% [Fitzgerald, 1998; Hardy *et al*, 1995; Mahmood, 1987; Palvia & Nosek, 1993; Russo *et al*, 1995; Sitek & Sumner, 1986]. More than 100 companies participated in the survey in the end. Each organisation was questioned on a maximum of one ISD project for the survey.

In other research the sample used for this project would almost certainly raise issues of sample bias and would therefore question the reliability and validity of the data collected. However, in this study the interest lay mainly in understanding and discovering the experiences of the individual projects, not in applying these findings to a larger sample.

Research Findings

Background Information

The organisations surveyed were the top 1000 trading companies in Ireland and for this reason, the majority of respondent organisations were medium-to-large sized enterprises. This meant that staff numbers in these organisations were no less than 150 personnel.

In addition, the industries represented by respondent organisations were diverse. Industries included manufacturing, services, media, technology, telecommunications, retail, construction, government and distribution. However, the majority of respondents were in the manufacturing sector (35%), followed by 'Other Industries' (retail, distribution, construction, government etc.) at 28%.

Low levels of respondents in other industries can be accounted for by the sample used for the survey. Using the *Top 1000 Trading Companies* list would result in the majority of respondents being manufacturing organisations such as Pfizer Pharmaceuticals or services organisations such as VHI (Voluntary Health Insurance). Surveys originating from Financial, Media or Technology industries would be lower, due to their placement in the *Top 1000 Trading Companies* List.

Survey Findings

Staff Numbers and Project Duration

Survey findings show a marked decrease in development timescales and project staff numbers. This illustrates the continued downsizing of development and reflects the emphasis on the need for speed in business. It also reflects the changing nature of the systems that are being developed. For example, e-commerce projects take 6 months to develop on average, whilst traditional application developments take 11 months on average to develop. In terms of project duration the majority of project timescales were less than 6 months. Project durations ranged from one month to 36 months. The average duration for projects was 8.8 months. This figure is significantly smaller than the average project duration of a year or greater, as presented by Sumner & Sitek [1986]. The average of 8.8 months is indicative of the decreasing amount of time acceptable for development projects.

Types of Systems

Most of the projects surveyed were e-commerce (33%). These data would correspond to the amount of media attention and industry attention that the area of e-commerce has received in recent years. Perhaps a more interesting figure is that of application

development (25%), which came in second in the list of projects being currently developed. Application development would be the more traditional type of development conducted by organisations, such as payroll systems, staff records or business specific applications. The fact that a relatively new type of development, such as e-commerce has overtaken the more traditional form of development projects, is an indicator of the sweeping changes the Internet has brought to the area of information systems in the past decade.

Table 1. Breakdown of Development Projects

Types of development projects:	%
Application development (payroll systems etc.)	25
Business Process Re-engineering (BPR)	5
Data Warehouse	17
E-Commerce	33
Internet Site	7
Telecommunications	9
Other Projects	4

Development Lifecycle

Survey findings would indicate a general move towards prototyping as the most prevalent development lifecycle characteristic. Prototyping can be a useful tool for accelerating the development process with a working version of the system much earlier in development than with traditional types of development life cycles. In addition, using prototypes can improve the relationship with end-users, as development is a process of iteration in which they are included.

Table 2. Utilisation of Lifecycle Elements (by project)

Life Cycle Element:	Number of Projects which utilised Life Cycle Element
RAD	25
Prototypes	49
Mini-Projects	36
End-User Involvement	66
Distinct Phases	80

From Table 2, the frequency with which certain elements of the development lifecycle occurred among respondents can be seen. Within ISD, the most common feature of the development lifecycle is that of 'Distinct Phases of Development'. This figure (80 out of 102 projects) would indicate the presence of the more traditional type of development lifecycle (much like the Waterfall Model), which includes distinct phases of development, one phase beginning after the ending of another phase. There was a relatively small figure for the presence of RAD in development life cycles. This is a surprising figure considering the emphasis that is placed on the need for speedy development. RAD can reduce development time significantly and thus save money and man-hours. Also, although the figure for end-user development is high at 66, this is not ideal. Historically, it has been proven that end-user involvement is crucial to the success of the development project. Out of 102 projects, only 57 stated that end-users had a substantial part to play in development. This figure is cause for concern. Over a third (35%) of respondent organisations use structure their developments into mini-projects, which run simultaneously. The benefit of such an environment would be the completion of development projects more swiftly.

The Use of Methods Within Development

Out of the 102 respondents surveyed, 63 utilised a method for their development project, whilst, 28 stated that no method was used in the development. These figures mean that over 62 % of respondents use some kind of method to aid the development process. The fact that the majority of development projects use some kind of method is not surprising. However the fact that a substantial number of respondents (27%) do not use a method is noteworthy. This might imply that whilst methods are suited to some development projects, not every situation requires a method. Or if every development scenario does require a method,

the fact that nearly a third of respondents do not use a method could imply that there is no appropriate method available or that there is some other valid reason for non-adoption of ISD method.

Table 3. Development Projects which Utilised a Method

Method Usage	%
Percentage of organisations which utilise a method	62
Percentage of organisations which do not utilise a method	27
Percentage of organisations do not know whether a method is used	11

The majority of large organisations (71%) use some type of method whilst 44% of small organisations utilise a method. These figures would indicate that ISD methods are most frequently adopted by large organisations and that methods are most beneficial to large ISD projects. This theory is one, which is supported by the survey respondents who comment that in their opinion methods are best suited to projects that are large scale and have a large development team. In addition, there is a marked preference amongst method users for in-house methods. In-house methods make up 66% of all methods used in ISD, whilst only 32% of respondents use commercial methods. One of the major reasons given for using in-house methods by respondents is that they are specifically designed for their particular respondent organisations.

Modification of Methods

A significant number of respondents modify their ISD method. Over 74% of all respondents modify the method to suit the individual development project. In addition, the majority of in-house methods are modified (81%), as are commercial methods with 65% being modified for development projects. To analyse this finding further, the figures were broken down into those respondents who utilised a commercial method and respondents who used an in-house method, to investigate whether there was a difference in levels of modification depending on method type. The investigation found that out of the 20 respondents that used a commercial method, 65% were modified for the development project whilst only 30% of respondents stated that the method was applied exactly. This worked out at nearly 2/3 of commercial methods being modified for use. In comparison with these figures, were those derived for in-house methods. Of the 42 respondents who used an in-house method, 81% modified the method to use in specific development projects, whilst only 14% were applied exactly. The fact that the modification of method was higher for in-house could indicate that in-house methods by their very definition are more ad-hoc in structure, which makes modification not only easier but also the norm in the course of development.

Table 4. Breakdown of Method Usage (by Organisation Size)

Method Type:	Commercial Method	In-house Method
Projects	20	42
<i>Modified</i>	<i>13</i>	<i>34</i>
<i>Applied Exactly</i>	<i>6</i>	<i>6</i>
<i>Don't Know</i>	<i>1</i>	<i>2</i>

Benefits and Drawbacks of Methods

The use of a method as a project management aide was rated as the greatest benefit of using a method (37%) by survey respondents. This result could be partly due to the majority of respondents being project managers, whose main tasks are concerned with budgets, schedules and deadlines. A developer in the same project might see the benefits of using a method in a different light. The quality control element of a method was also rated highly (28%) by respondents and this coupled with the 'project management' benefit would indicate a preoccupation on the part of respondents with attaining greater control over the develop process without a lose of quality in the overall system developed.

Respondents felt that the greatest drawback (32%) of using an ISD method was the danger of the development team 'following the method' rather than the objective of completing the project. This can be particularly detrimental in a project where the method is not a good-fit to begin with, as projects will quickly get behind schedule and go over budget. Methods prolonging the

development process and producing high amounts of documentation were both rated as equally disadvantageous to the development process (23%). All of these drawbacks have at their root the basic effect of making a development project take too long to complete the information system. This would indicate a concern with the amount of time development takes in general and the need to speed up the process.

Conclusions

The nature of ISD has changed significantly in recent years. In fact to compare the development environment of 2002 to development a few years ago, shows significant changes to not only the type of development, but also the development team, life cycle structure and method usage. ISD is greatly influenced by the need for speedier development projects. This preoccupation with speed can be seen in the type of development projects conducted, the development logistics and the greater flexibility within development practices (in particular lifecycles and methods).

The types of development projects conducted have increased in recent years, largely thanks to the arrival of the Internet. The majority of developments being conducted at present in Ireland are e-commerce based or Internet site developments. These types of projects greatly differ from traditional application development. All of these projects differ in objectives as well as logistics. The fact that the majority of development projects are within the area of e-commerce is a cause for concern, as it is largely an unknown quantity. There are only a handful of case studies to work from and experts in the field are still formulating procedures for development of such systems.

From the point of view of development project logistics, the timescales and staff numbers of projects are decreasing continuously. As the sophistication of development tools and experience of personnel increases, the need for longer timescales and greater staff numbers decreases. The average number of staff required for a development project was 11 within this research study and the average timescale was less than 9 months which is significantly less than in previous studies [Sumner & Sitek, 1986; Wetherbe *et al*, 1984].

In terms of development life cycles, there is greater variation within individual development projects. The typical development life cycle does not bear a close resemblance to the traditional systems development life cycle of the 1970s. It is much shorter with many phases being conducted concurrently to speed up the development process. In addition, the average development life cycle will include a large degree of prototyping.

In terms of method usage there is a greater flexibility visible within organisations developing information systems. This flexibility means that methods are not static, they change and evolve as the development situation warrants alterations. This increased flexibility means that a development team can have greater 'turnaround' ability when changes are required or the direction of the development is changed. In most cases, project managers and development teams like to leave the whole development process as 'emergent' as possible, meaning that they anticipate that changes will have to be made due to circumstances that are not known at the beginning of the development project.

The current development environment suggests a new era of self-awareness when it comes to ISD and methods. Practitioners are developing a greater knowledge of development types, lifecycles and associated methods and this knowledge accommodates a better judgement when it comes to what will be most effective within individual development situations.

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