Evaluating the Costs and Benefits of End-User Development

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ABSTRACT
This paper describes a cost benefit modelling approach to introducing EUD technology. Costs are incurred in configuring and learning the technology then in developing and debugging applications. These are set against the perceived and actual benefits of producing better applications that fit end user requirements. The approach is illustrated with a case study of a web Content Management System.

Categories and Subject Descriptors
D2.1 Requirements and Specifications, Methodologies

General Terms
Design, Theory

Keywords
End user development, cost benefit analysis

1. INTRODUCTION
In spite of some advances in end-user development (EUD) since the concept was launched in the early 1980s [3], EUD products are not commonplace. In our previous work we proposed a framework for classifying EUD tools and approaches [4], [7] and assessing the probable success of introducing EUD technology into a particular user/organisation context. This paper describes development of that framework with a cost-benefit analysis and its application to a case study of the introduction of a web content management system in the University of Manchester. The following section outlines the cost-benefit analysis technique while section 3 briefly describes the case study.

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2. COST-BENEFIT MODELLING EUD
EUD essentially out-sources development effort to the end user. Hence one element of the cost is the additional design time expended. Another cost is learning. This is a critical cost in EUD because end users are busy people for whom programming is not their primary task. They only tolerate development activity as a means towards the end that they wish to achieve; for instance, creating a simulation, experimenting with a design, building a prototype. Learning to use an EUD environment is an up-front cost that has to be motivated with a perceived reward in improved efficiency or empowered work practice. Cost of errors is a significant penalty for EUD users both in operation and learning. Cost of EUD to the user can be assessed in terms of the time taken to learn to use the EUD product and possibly its language, the requirements or specification effort entailed in refining general ideas into specific instructions, the programming effort, followed by time for testing and correcting from errors. The trade-offs between effort and reward can be summarised as a set of motivating principles for EUD:

The aim for all design is to achieve an optimal fit between the product and the requirements of the customer population, with minimal cost. Generally, the better the fit between users' needs and application functionality, the greater the users' satisfaction; however, product fit will be a function of the generality/specialisation dimension of an application. This can be summarised in the principle of user motivation:

- *The user motivation to accept an EUD technology will be inversely proportional to product complexity and variability in the user population.*

The consequences of this law are that EUD will consume more effort with a heterogeneous user population, because getting the right fit for each sub-group of individuals becomes progressively more challenging and expensive. The second consequence is that larger scale and more complex applications will be more difficult to develop; people have a larger learning burden with complex products. The second follows on from the first principle, in that general technologies may not motivate us to expend development effort because the utility they deliver is less than a perceived reward from satisfying our specific requirements:

- *User motivation to customise and learn EUD software will be proportional to the perceived utility of the software delivering usable and useful applications.*

People will devote considerable effort to learning how to use a product even if it is poorly designed, so long as they are motivated. Motivation will depend critically on perceived utility and then the actual utility payoff. For work-related applications we are likely to spend time customising and developing software only if we are confident that it will empower our work, save time on the job and raise productivity. Development effort can range from customisation of products by setting parameters, style sheets and user profiles, to designing customised reports, to full development of functionality by programming. The following cost-benefit analysis framework enables the potential impact of different EUD technologies to be assessed. Costs of adopting a specific EUD technology are summarised as:

C^{tech} = actual cost of the software plus effort necessary to install it

C^{learn} = time taken to understand the appropriate language or tool

C^{dev} = effort necessary to develop applications using the EUD technology

C^{test} = time taken to test and debug the designed system.

The total EUD acquisition and development cost is therefore:

$$C^{tot} = C^{tech} + C^{learn} + C^{dev} + C^{test}$$

The technology and learning costs are incurred once during acquisition, whereas development and debugging costs occur for each application. These can either be measured for each application or estimated from a benchmark application. The benefits set against the costs are:

B^{funct} = the extent of functionality which using the technology can deliver

B^{flex} = flexibility to respond to new requirements; ease of maintenance or application development

B^{usab} = usability of applications produced

B^{qual} = overall quality of the applications produced.

The total benefits are therefore:

$$B^{tot} = B^{funct} + B^{flex} + B^{usab} + B^{qual}$$

However, benefits have two manifestations, perceived and actual. Before the technology is acquired or during the early stages of adoption, benefits are perceived based on advertising by the technology vendors, demonstrations, site visits or word of mouth reputation of the technology concerned. At this stage learning and acquisition costs are realised so it is important that the perceived benefits outweigh the costs during the learning period. Once the technology is put into use benefits become transformed through experience into actual benefits, which if the experience is positive will be more motivating than perceived benefits. In use, therefore, development and debugging costs have to be sufficiently low so as not to outweigh the benefits. The relationships of costs and benefits over time are summarised in Figure 1.

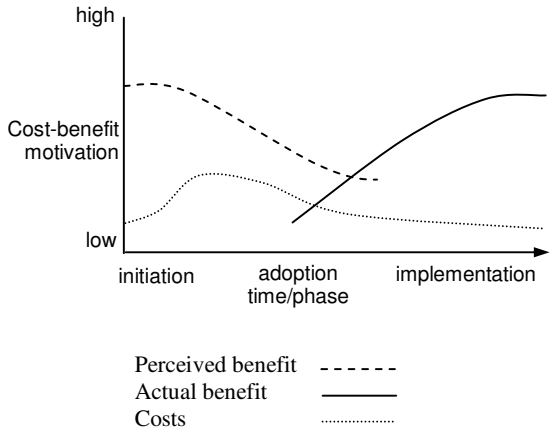

Figure 1. Time line of costs and benefits during technology acquisition

Cost and benefits may be estimated or based on histories of development effort. These simple calculations and projections over time can be used to compare different EUD technologies and assess potential risks of rejection at different phases of introduction. For example, in the learning phase success depends on a high level of perceived benefit and reducing learning costs, whereas in the usage phase, actual benefits need to exceed development and debugging effort. We treat perceived benefit which comes from subjective impressions prior to use independently from actual benefit derived from experience. Once product use is underway perceived benefits inevitably fall as some expectations are not realised, although the shape of this decline will vary by product and promotion activities. Actual benefits are realised once the user has progressed though the initial learning phase. The key balance is to keep user motivation, derived from perceived and later actual benefits, higher than the costs incurring through learning and use. More training might be given to reduce costs and increase actual benefit, hence improving success in the early phase, while better support and help desks may be the answer in later phases.

3. CASE STUDY

The University of Manchester introduced a content management system (CMS) for its website in 2004. The selected CMS provided three layers of programmability which end users could have access to.

- Content authoring within templates controlled by a centrally imposed style guide
- Template configuration within the limits of the central corporate style
- Programming of interactive applications within the CMS framework using standard web development tools such as Director, JAVAscript etc.

Prior to the introduction of the CMS end users had access to a variety of web-enabled applications throughout the university. The majority of schools and departments had progressed no further than development of static web pages with Frontpage and native HMTL; however, approximately 10-15% of the web stakeholders had introduced more adventurous interactive sites

which were integrated with backend databases and included interactive facilities, multimedia and animation. The School of Informatics was in the latter category with a dynamic site, incorporating a video slideshow walkthrough of the School, video and audio resources and interactive database searching.

The corporate motivations for introducing the CMS were a consistent house style, improved functionality across the university, reducing costs of content authoring and updating, better usability and overall quality of the website. In reality these benefits have not been realised because of clash of a interests between the university and end users ultimately responsible for the website delivery. The costs and perceived benefits of existing technology (Director, Javascript) and the CMS are summarised in Tables 1 and 2. These ratings on a 1= poor to 5 = excellent scale for benefits and 1= low to 5 = very high for costs were collected by interviews with School of Informatics staff involved in website development and content authoring. Costs were informal estimates based on anticipated development effort and the 'value for money' expected based on the price of the software. Benefits were more difficult to estimate since these variables were intangible qualities, so staff were asked to rated the expected benefits against their view of an ideal technology. Respondents were asked to calibrate their judgements so an ideal technology would score 20, offset against a worse case cost of 20.

Table 1. Perceived costs and benefits of web based EUD technology prior to introduction of the CMS

Costs	rating	Benefits	rating
Technology	3	Functionality	4
Learning	4	Flexibility	5
Developing	3	Usability	4
Debugging	3	Website quality	4
	13		17

Previous technology did have some real monetary cost in site licences, mainly for Microsoft .NET products, there were also considerable learning costs in gaining skills in JAVAscript, Director (Lingo and Flash scripting), and SQL web server integration. These technologies also imposed considerable development and debugging costs since they are essentially programming languages. Some of this cost could be avoided by using EUD tools such as Dreamweaver, but this reduces the potential benefits of increasing functionality and flexibility in responding to requirements. Although the costs were considerable, they were outweighed by the benefits of improved functionality, usability, flexibility of modification and overall perceived quality of the site.

Table 2. Perceived costs and benefits after introduction of the CMS

Costs	rating	Benefits	rating
Technology	0	Functionality	3
Learning	5	Flexibility	2
Developing	4	Usability	2
Debugging	4	Website quality	2
	13		9

The CMS system incurred considerable costs (see Table 2) even though it was claimed to reduce EUD problems. In this case costs and benefits were based on actual experience so respondent were reminded of their initial ratings and asked whether they wished to revise them. No acquisition costs have been given since those costs were borne by the University; however, learning how to develop dynamic sites with the CMS scripting language was even more difficult than learning standard web scripting languages; furthermore, integration of existing JAVAscript and database applications into the CMS proved an additional learning burden. The costs extended to development and debugging where end users were faced with many more integration problems than they had previously encountered. Unfortunately the CMS benefits did not outweigh the costs. Functionality and usability were rated poorly for two reasons. First was the imposition of a corporate style guide which limited the designers' and users' freedom to improve the website. Secondly the technical complexity of the CMS made it more difficult to deliver improved functionality and usability even when there were no corporate style constraints. These assessments had a consequent effect on judgements of flexibility to implement new requirements and overall quality. The above assessment was made primarily from the 'expert' end-user viewpoint; however, the result for content authoring end users was the same. Complexity of the CMS increased the learning burden and this was exacerbated by a poor training programme and technical difficulties with the CMS itself. Not surprisingly introduction of the system attracted widespread resistance and at the time of writing it is still not clear whether the CMS investment will be continued.

The lessons which should be drawn from this case study are that introduction of EUD tools needs to carefully consider the socio-economic costs imposed on end users, in particular the learning burden of new technology and programming languages. Training is critical to reducing those costs, as is technical support to help users with development and debugging. On the benefits side, imposition of corporate styles can destroy perceived benefits of EUD by hindering the ability to respond to local needs. The clash of interests between the various stakeholder groups is summarised in Table 3.

Table 3. Perceived gains and losses of the different stakeholder groups

Stakeholder group	gains	losses
University owners	Consistent style	----
University IT services	Control, consistent updating of content, improved security	----
Departmental webmasters/developers	?? reduced costs from updating	Control, flexibility
Individual website developers	?? reduced costs from updating	Control, flexibility

The University stakeholders (Central managers and IT services) perceived only gains from their point of view in improve security, and a consistent style for projecting the University's image. These

benefits were assumed to hold for actual end users in Departments and research groups who owned web sites. They also argued that the CMS would reduce updating and maintenance costs since this should be effected automatically. While this might be true for content author end users it was less of a benefit for end users who developed web sites. In contrast they perceived only loss from the style content imposed by the CMS which reduced their flexibility to respond to local needs. Introducing the CMS failed to understand End users perspective and this led to considerable resistance to introducing the technology. This was exacerbated by poor provision of training and end users support by the vendor and the University project team, as well as technical problems with the software itself.

4. CONCLUSIONS

The method followed in this case study was relatively informal with ordinal ratings being collected by interviewing users and technical staff. More systematic data collection techniques could be adopted, for instance using actual costs of equipment and people costs from workload estimates. Similarly benefits could be estimated more precisely, from anticipated work load savings; however, several variables are difficult to quantify (e.g. flexibility, web site quality). Intangible benefits of this nature can be included into a comprehensive valuation of system costs and benefits using approaches such as the Inclusive Value Manger [5]; however, we believe that simpler metrics are more practical.

While considerable progress has been made in EUD technology [2], [6], few attempts have been made to assess the acceptability of these technologies. The framework presented in this paper is a first step in this direction. Our analysis indicates the important of connecting user motivation to the perceived reward of using EUD tools. User motivation requires considerable research since it will vary by the domain, and by how it is delivered through promotion, training, or functionality embedded in the tool (e.g. wizards, tutors, reuse faculties). The balance between cost and benefit suggests a graded exposure to complexity. Training and user support are critical success factor for introducing End user technology, as well as thorough analysis of the costs and benefits for all stakeholders {4} One suggestion we will follow in future work is to use Carroll's minimal manual approach [1] that exposes users to simple examples and a limited functionality first, to establish confidence and reduce errors. However further research is necessary to understand users motivations toward adopting new technologies and how costs and rewards are perceived.

5. REFERENCES

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