ON ESTIMATING THE AMOUNT OF LEARNING MATERIALS A Case Study

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Abstract: E-learning has been studied as the means to apply digital computers to educational purposes. Although the benefits of information and communication technology are obvious in several cases, there still exists a lack of convincing measures for the value of using computers in education. This reflects the general difficulty in evaluating investments on information systems, known as the "IT investment paradox" that has not been solved so far. In this paper we approach the problem by estimating the amount of teaching and learning material in a target organisation, a university faculty. As expected, the volume of learning material dominates the communication of the faculty forming about 95% of all communication volume and 78% to 82% of communication when measured with other metrics. Also the use of alternative communication forms used in the target organisation was analysed quantitatively. The study also indicates, that communication forms dominating the volume of communication are likely to be highly organisation-specific.

1. INTRODUCTION

Computer aided learning, e-learning, distance education, and multiple other terms have been introduced to study the means to apply digital computers to educational purposes. Enterprises are adopting technology to aid learning to an increasing extent. Companies announce that they will gain multi million savings by using e-learning applications. Why big companies like Cisco, IBM, Motorola, Oracle, Toyota, Home Depot, and McDonald's (Pack, 2002) are putting effort to elearning? How they measure the financial benefit what they get from e-learning? For example, 24'000 employee Cisco announces at their web pages that they have reduced their internal training certification costs from an estimated \$1.4 million to just \$16,000 using e-learning technology (Cisco, 2001).

So far there is a few research results (Pack, 2002) concerning the methods applicable for measuring the organizations potentials for e-learning. How do you measure profit in use of e-learning? From the company's point of view there must be demand for accountability, a demand for the vendors to demonstrate that a system will produce a return for the company quickly (Pack, 2002). Organizations wish to measure the profit what they are getting from e-learning by measuring the

competitive advantages and how fast they are in the business.

Other, non-financial values witch could indicate the benefits could be the greater degree of communication and closeness among students and instructors/mentors (Knight, Ridley, &Davies, 1998; Waschull, 1997). E-learning can be more rigorous in terms of time and thought required (Ridley, 1998). E-learning promotes and succeeds in motivating learning beyond the course, plus learners tend to be more likely to change their work practices (Rutenberg & Ruttenberg, 2000). E-learning can provide not only a cost-effective method for meeting the training needs of employees, but also an innovative way to strengthen relationships with suppliers and clients, to reach new markets, and even to build a new profit center (Pack, 2002). Waschull (1997) also points out that e-learning is too dependent upon student initiative. E-learning can increase the risk of social isolation and increase the potential for academic dishonesty (Waschull, 1997). There's a lot of confusion on the buyer's side (Pack, 2002)

E-learning is economical to organizations to invest if it offers growth in total sales or productivity. From the customers viewpoint elearning is profitable if it can offer better quality or more value for the customer. From the viewpoint of internal processes of organization, e-learning is more profitable if it will increase innovation or enable flexibility in working operations. From communal

point of view e-learning can increase cultural compatibility, social interaction and mutual fairness.

When quality is considered, the main question arising is, can e-learning improve organizations quality? Quality could mean pedagogically better solutions, better content, better quality of education, more choice options in content, or less routines in mentors work. Human resources work coordination can be facilitated, learning can be more flexible, time management more efficient, and finally, better services produced for organizations external interest groups. For example Cisco was able to gain ISO 9001 compliance in a five-week period using a video on demand e-learning solution (Cisco, 2001). More good examples are needed for answering this question adequately.

E-learning requires investments and investment decisions must satisfy the criteria of profitability based on improvement of support for critical processes that will produce measurable benefits for the organization. Organizations that use e-learning can reduce administrative cost of education as well as investments to office buildings and special equipments. Re-use of learning materials can reduce cost in long run. Further benefits can include lower per cent of drop out, higher portion of international content, use of broader net of experts, outsourcing part of the cost of education, vanishing the boundaries of training and working, and better investment for development of the learning support due to lower costs. For further about benefits of elearning, see (Campbell, K. 2000, Fallah, M & Ubell, R. 2000, Feuerstein, R. 1980, Fitzpatrick, R. 2001, Sonner, B. 1999, and Tucker, S. 2001).

While estimating the potential economical benefits of e-learning we face the same problems as with information systems investment evaluation in general - what to measure and how? Various approaches and methods have been proposed for information systems investment evaluation in general (Berghout & Renkema, 2001). But the researchers commonly agree that the "IT investment paradox" has not been solved yet - the justification and evaluation of IT investments is not yet based on reliable measures, that would clearly state the benefits of the investment prior the decision (van Grembergen, 2002). This statement is valid also in the domain of estimating benefits for e-learning.

In this paper we approach the problem with a fresh method. Rather than approaching the problem from the viewpoint of technology, economical benefits, or perceived values of the users, we measure the amount of communication related with learning in existing learning organizations. Especially, the goal of this paper is to estimate the potential for e-learning by quantifying the amount of learning material and related communication in a

target organization. As most of the costs related to training are related with labour costs and the labour costs are highly related with the time spent on communicating, the costs related to learning can be estimated based on the amount of communication. By this means we aim at providing quantitative data for the evaluation of e-learning potential.

This paper is organized as follows. Section 2 reviews shortly theoretical background of the approach and represents the method used for the analysis. Section 3 describes a case study in a faculty of a university where we measured the amount of teaching material used as well as other communication of the organisation. The relevancy of the results is discussed in the end of section 3. Section 4 summarizes the results, draws the conclusions and proposes paths for further research.

2. THEORETICAL BACKGROUND

2.1 Genres of Organizational Communication and Genre Identification

Genre theory has gained ground as a practical means to observe communication in organizations. Yates and Orlikowski (1992) defined the concept of a genre of organizational communication as a typified and recurrent communicative action that can be identified by its communicative purpose(s) and, to some extent, by its form(s). A genre can be more or less widely recognized and enacted among people within the community (Yates, Orlikowski, and Okamura, 1999). Examples of communication genres include an order confirmation, customer feedback, weekly sales summary, annual report, and a project meeting. Each organization has a repertoire of genres that can be identified with it at a certain moment of analysis (Orlikowski and Yates, 1994). A set of genres can also interrelate in a wider communicative process thus forming systems of genre (Bazerman, 1994) called also a genre system.

Empirical efforts to identify organizational genre repertoires have reported hundreds of genres that can be found in organizations, denoting that this approach would provide a detailed, yet comprehensive and comprehensible, view on organizational communication (Karjalainen et. al. 2000, Päivärinta et. al. 2001). At least one generic method to identify and analyse genre repertoires has been established and applied to a number of

organizational contexts, "A Genre-Based Method for Information Systems Planning" (Päivärinta et. al. 2001). The generic method incorporates the following basic concepts:

- Information resource of an organization intended to be analysed; this domain is structured by means of the internal PUI entities (see below) and genres identified.
- Stakeholders having interests to participate in the analysis.
- PUI entities producing or using information subsumed in the information resource (PUI = Producer or User of Information), including both external organizations and the internal entities of the organization. Depending on the organization the PUI entities can instantiate as business processes, departments, functions, organization structures, roles, or even individual human beings.
- Genres, as defined above.
- Properties of the identified genres defining the metadata gathered about the genres from the stakeholders for the analysis.

The steps in this method are the following:

- 1. Identify stakeholders of the analysis.
- 2. Identify PUI entities.
- 3. Identify and name genres.
- 4. Refine the properties / metadata needed.

5. Gather metadata about the genre properties from participants.

6. Analyse the genre-based metadata.

In step 1 the parts of the organization and the persons needed for data collection are identified. Typically, group meetings are conducted to identify PUI entities in step 2. The genres are identified among these PUI entities in step 3 as a named collection of information send in between PUI entities within the organization or in between a PUI entity in the organization and an external PUI entity. In step 4 the properties to be identified for further analysis are refined. The properties needed for our purposes are defined in the following sections. Also the metadata collection in step 5 and the analysis in step 6 - as tailored for our research purposes - are described in more detail below. For further details of the overall identification process of genre repertoires, see the original method description (Päivärinta et. al. 2001).

2.2 Categories of Organizational Communication Forms

Genre theory introduces the concept of genre to structure organizational communication, and

declares that certain media can be characteristic for certain genres (Yates and Orlikowski, 1992). In literary there are at least two taxonomies related with our need for classify genres according to their characteristics media for e-learning implementations. Yoshioka et. al. (2001) proposed the use of taxonomic categories on the dimensions for genres and genre systems reflecting the communicative questions why, what, how, when, where, and how (5W1H). Out of these, the question "How" addresses the form of a genre/genre system referring to observable features including structural elements, medium, and linguistic features, but does not provide a taxonomy for the features of media matching the needs of this study. In their study Zmud et. al. (1990) categorize communication into 14 communication channels within 5 categories: face-to-face, group, written, traditional communication technologies, computer-mediated communication technologies.

Tyrväinen (2003) proposed a categorization for analysing organizational communication forms that emphasises the ability of computers to interpret and process information. This taxonomy divides the information flows first into communication using medium and not, divides communication using medium further to stored and non-stored, divides the stored information further into digital and nondigital information, and further elaborates the digital communication forms in according to the increasing ability of computers to interpret the procedural semantics of the encoding and structure of the contents. The ten categories of communication forms from the least applicable to the most applicable to computerization (in bold) and their position in the taxonomy are as follows (Tyrväinen 2003):

- Material exchanged.
- Human-to-human, same time and place, including
 - 1-to-1 face-to-face verbal communication.
 - Group Meetings.
- Communication using medium
 - Mediated / Semi-Transient communication, such as VOX messages and videoconferencing.
 - Communication using stored medium
 - Analogue, such as paper and VHS tapes.
 - Digital communication
 - Digital Image, such as fax and bitmaps.
 Encoded, such as ASCII text and mail
 - messages.
 - Semi-Structured, such as Lotus Notes applications.
 - Structured, such as XML data.
 - Formal, e.g. data in databases.

The applicability of mobile content standards for organizational communication was estimated by matching the characteristics of the standards against the categories.

This taxonomy would enable qualitative analysis of organizational communication in a very detailed level. However, for our purposes of analysing learning material and communication it is even in a bit too elaborate. Thus we adopt it but adapt it by reducing the number of categories to match the requirements of our study, as represented in the case study. The categories used here are:

- Undocumented, matching the four categories of communication forms that are not using stored medium, i.e. from category Material to category Mediated/Semi-Transient.
- Paper, containing documents manipulated in paper format, matching the category of Analogue
- Digital document, containing information produced by office tools, matching the categories of Digital image and Encoded.
- Information system (IS) matching the categories of Semi-Structured, Structured and Formal communication forms.

2.3 Metrics and Calculation Process

Tyrväinen (2003) proposes also a metrics and a calculation process for quantifying organizational communication. The process makes use of the generic genre identification process (Päivärinta et. al. 2001). For further details of the metrics and calculation process see (Tyrväinen and Päivärinta 2003).

The inputs of the calculation are the properties gathered from each communication genre during the metadata gathering phase. These are:

- Category or categories of communication forms used by the genre.
- Number of unique instances (UI) per time. Unique instances refers to the distinct instances of a genre communicated excluding duplicates, e.g. a single mail message sent to several recipients or a broadcast is considered to be a single unique instance.
- Copies or instances per UI, which refers to the average number of copies delivered to distinct receivers of the UI.
- Size of instances. The average amount of information per instance of a genre measured in "Pages" that refers to amount of information equal to a view of the size of a visual letter / A4 page.

The calculation process manages the metadata of communication genres in a detailed level and in

summary levels in three orthogonal dimensions. The dimensions are:

- 1. **Genres**, i.e. calculations per one genre or summaries of all genres.
- 2. **Communication forms**, i.e. calculations per one category of communication forms, per a group of categories of communication forms (such as Stored or Digital communication forms only), or per all communication forms.
- 3. **Measurement units** are further composed out of 3 dimensions:
 - **UI or Copies**, i.e. are all copies of genre instances calculated.
 - Instances or Pages, i.e. counting items or measuring volumes.
 - Absolute or proportional, i.e. absolute or percentage values.

We make use of this calculation process as follows: For each element - i.e. for each combination of a genre and a category - we calculate four values. They are the four absolute measurement units:

- annual number of UI and
- annual number of copies as well as
- annual UI volume and
- annual volume measured in Pages.

The results are summed up per each category of communication forms. For our purposes we make summary calculations for the four groups of communication forms represented in the case study. This produces four absolute measurement values for each category, as well as four values summing up all communication of the target organization.

3. A CASE STUDY

3.1 The Target Organization and the Research Process

Target organization of the case study was a Faculty of Information Technology in a Finnish university. The faculty involves ca. 1400 full-time major subject students and near 200 employees. The information flows of the Faculty were analysed with the genre-based method in Fall 2001 as a part of an overall process improvement project. During this project the stakeholders, PUI entities and genres were named and identified. Over twenty persons participated the identification sessions in five groups in according to the method and selected persons complemented the resulting genre lists later on with individually. A total over 300 genres were named and identified during steps 1 to 3 of the method presented in Section 2. After these steps the results

were organized in according to main processes, complemented with document templates, and used for construction of a process guide for employees.

The steps 4 to 6 of the method were executed during year 2002. In addition to the metrics data this process included collection of metadata related to long-term preservation of digital information. Thus metadata related to preservation times, media, and roles related to preservation of each genre were defined as additional metadata in step 4 and collected in step 5. However, analysis of these results is out of the scope of this paper. As the emphasis of the study was not on the organizational processes themselves but on their results, the number of the analysed genres was reduced by leaving out the intermediary genres prior to the metadata collection in step 5.

Four persons working in the faculty participated in the metadata collection for the 143 genres in step 5. Although all genres identified in step 3 were not included, relevant metadata for the aims of research on long-term preservation and this study was collected including the estimated numbers of unique instances (UI) per time, copies or instances per UI, and sizes of instances as presented in section 2.3. After this data collection we had a full dataset of the 143 genres. In phase 6 these genres were divided into four categories based on distinct organizational functions. These categories were as follows:

- Studying and Teaching (ST) category involves 41 genres related to studying and teaching. Learning materials, lectures, and exam questions are part of the category. Emphasis in this study will be on this category as it includes genres related to learning materials.
- Post-graduate studies and research projects (PGS) category includes 26 genres that are related to post-graduate studies and research projects. Typical genres of the category include project plan, admission to post-graduate student and scientific publication.
- Financial and Personnel Management (FPM) involves 30 genres related to faculty's financial and personnel management. Typical genres of the group are, for example, travel cost claim and salary sheet.
- Student Administration (SA) contains 45 genres that are related to target organization's student administration. Admission test result, curricula structure, and information booklet for foreign students are typical genres of the category.

3.2 Overall Results

Table 1 represents number of annual unique instances, annual UI volume in pages, amount of copies and annual total volume in pages for the 143 analysed genres of the target organization. There were a total of 102'443 unique instances and annual total volume of about 5'977'044 pages. Note that the average number of pages per instance and average number of copies per instance are both a bit more than 2 when measured per genre, but specific genres (such as represented in Table 2) with both high number of pages, high number of copies, and high number of instances make the total annual volume high.

Table 1. Total annual information volumes.

	Estimated Organization's Total
Annual Unique Instances	102 443
Annual UI Volume / Pages	226 502
Annual Copies	234 460
Annual Volume / Pages	5 977 044

Figure 1 represents distribution of annual unique instances of all the 143 genres, measured in pages. From Figure 1 we can see, that the two main media for short-term communication were paper and verbal (undocumented) communication. Digital documents were used mainly for communication stored for over a year but less than five years while about half of the long-term storage of data was stored in digital documents and the other hand in databases and other information systems. Somewhat surprisingly, the volume of paper documents used for long-term preservation of data was not very high.

Figure 2 represents distribution of total annual volumes at four functional organizational categories presented in section 3.1. Interestingly, if not surprisingly, as the mission of the target organization is research and teaching, 80 % of its annual UI and over 90 % of annual total volume is related to studying and teaching. Thus the 41 genres related with teaching are dominating the communication of the faculty. All the other communication including over 100 other genres forms only 20 % of the total annual unique instances and only 5 % of the copy pages. The teaching genres have on an average much higher number of pages per genre and number of copies per instance than the other genres as the material is distributed to the students.



Figure 1. Distribution of annual unique volume measured in pages for all the 143 genres, grouped by the categories of communication forms and the preservation time of the genre.

3.3 Studying and Teaching Genres

Based on previously presented numbers we analysed further the information volumes related to studying and teaching. It appears that relatively small number of genres in this category contains over half of the information resources of the target organization. Table 2 represents three genres of the target organization with highest annual volume. Over 220 courses are arranged annual with about 80 pages per course producing 16'000 unique pages of material distributed on paper, www, and digital formats, to approximately 60 students in each course, producing an annual material flow close to a million pages. Each of the a bit over corresponding to estimated 1000 lectures information exchange of about 30 pages each in verbal form produce a total communication volume equivalent to close to 2 million annual pages when summed up cross the average 60 students per lecture.

As the studying and teaching genres form about 80 % of all the unique pages, the results in Figure 1 are, to a large extent, applicable also to these genres. The verbal lectures form majority of the undocumented communication stored for less than a year and the lecture material form the bulk of the temporal paper material and the digital material stored for a year to five years.

Table 2. Three genres with most volume, in thousands.

Genre	Annual Unique Instances / 1000	Annual UI Volume / 1000 Pages	Annual Copies / 1000	Annual Volume / 1000 Pages
Lecture material	0,2	16	12	960
Lectures	1	30	60	1800
Filled exam papers	16	64	16	64

To verify the figures, we compared the resulting volumes with the available figures related with consumption of paper. This is not very easy, as the genres, such as lecture material, are partially communicated with paper, partially communicated using digital document formats (office documents, web pages or alike), and partially printed on paper after being communicated on a digital document format.



Figure 2. Distribution of annual information volumes per functional categories.

First, out of the total communication equivalent to close to 6 million pages, we subtracted:

- the volumes of genres not communicated on paper (but included genres communicated to students in digital forms that may be printed to paper), i.e. about 1,57 million pages, and
- the volumes of genres known to be communicated with specific paper formats, i.e. exam papers (64'000 pages), printed lecture notes (0,8 million pages), and alike.

The resulting bit over 3,5 million pages were thus either communicated in a digital document format (office documents, web pages, e-learning environments) or printed later on paper. By taking into account the number of pages printed by all the students and staff (1,26 million), the number of paper sheets delivered to the premises within a year for printers and copy machines (1,67 million), and estimating the proportion of one and double side print-outs and copies (54 % and 30 %, respectively), we end up with a figure of 61 % of the digital documents to be printed to paper for reading.

Figure 3 represents the communication volume of all the genres per communication forms. Altogether, a bit over half of all the communication volume was delivered on paper. Digital documents and undocumented material formed the other half while the volume of information in information systems was very small (0,4 %) due to the small average number of copies per unique instance and small size of the instances. If we exclude the undocumented communication forms, paper dominated with 69% of all stored communication.



Figure 3. Distribution of annual information volumes per categories of communication forms.

3.4 Discussion

In this case study we have made use of quantitative, non-financial metrics and a genre-based measurement process in dividing the communication of the target organization into a level of detail sufficient for qualitative and quantitative analysis. The data was collected bottom up using the processes of the organization as the baseline for the analysis. We ended up with total annual information volumes presented in Table 1. If we divide the

number of annual copy volume (5,98 million) with the number of all employees and the number of working days per year, we end up with about 74 pages per day per person. (Note, that this figure is based on the 143 genres and excludes over 150 intermediate genres.) The same way, the number of unique pages per person day is 4,6. Are these figures realistic?

Landauer (1986) estimated that people take in and remember only about a byte in a second. But they read about 3 to 5 words per second i.e. about 600 KBytes or 300 Pages per day during office hours. Thus about 70 Pages per day seems to feasible. In another study (Tyrväinen, 2003) in an independent unit of a multinational high-tech corporation the amount of communication was estimated to be about 92 pages per day per employee, including also the intermediate genres in total over 700 genres identified.

Further, if we calculate the daily figures for the 70 lecturers and 1400 students for the studying and teaching genres only, the results are as follows:

- 5 daily unique instances per lecturer
- 11 daily unique pages per lecturer
- 1 daily copy per student
- 18 daily copy pages per student

Note also that the daily copy volume per lecturer would be about 370 - exceeding human capacity to read written information. This communication on the organization boundary is more or less like publishing activity where the communication is simply one-sided one-to-many activity from the lecturers to the students. Here the number of unique pages reflects the information sent while the copies reflect the information received by multiple students.

In this case study we end up with an estimate, that 61% of digital documents of the organization would be printed on paper. According to McNurlin, B. and Spraque, R. 2001 Xplorer International has estimated that this percentage was 90% in 1998, but will decline to 40% in 2005. Thus our result seems to be reasonable. Further, in this case 51% of all communication and 69% of all stored communication was on paper form. A recent case study reported in the private sector (Tyrväinen, P. and Päivärinta, T. 2003) reports a change of the comparable figure - percentage of paper from organization's annual stored volume - to go down from about 60% to 40% due to adoption of new information systems in between 1999 and 2001.

We verified the findings of this case study also by interviewing representatives of two other large organizations that are in the middle of the process of adopting an e-learning environment. The representative of an industrial organization interviewed stated that about 70% of the material to be used in the e-learning environment already exists in a form or another – not necessary in digital format, but only about 30% of it was usable as such. I.e. 70% of the existing material will have to be reprocessed. The representative of the government organization stated that they estimated they had over 70% of the learning material already in digital form for the utilization in the e-learning environment, but only 10-30% of it could be utilized as such. The rest required re-work. To sum up, only 7-21% of existing learning material of these two organizations was available for the use in the e-learning environments.

4. SUMMARY, CONCLUSIONS AND FUTURE WORK

In this paper we described a case study on estimating the amount of learning materials in a faculty of a university. 95% of all the communication volume in the target organisation was related with studying and teaching. We identified the relation of learning material and labour cost (time) in form of daily information units processed per a lecturer and a student.

acknowledge that the We amount of communication is only a vague measure for quantity of learning excluding main qualitative factors. However, it enables us to grasp the phenomena with a simple and useful tool. Assuming that the daily information units processed correlate with the technologies used, the figures would be different for alternative e-learning approaches. Having these figures available, we would have the means to quantify the potential impact of technology adoption in the target organization by comparing the "productivity" of alternative approaches with the scale of daily information units processed with the costs of the approaches including labour, travel, information systems, and other costs - in line with the information systems investment evaluation approaches making also use of non-financial measures (Berghout, and Renkema, 2001, van Grembergen, 2000).

Paper and lectures are still being the major communication forms in the target organization. Simple calculations on costs of paper copying and delivery vs. digital material delivery can be performed based on the figures presented here and based on case-specific costs and benefits. From this viewpoint the statements on high potential for elearning seem to be justified in most cases. However, it should be noticed, that both in this case of a university faculty and in the study reported by Tyrväinen (2003) majority of communication volume depends on few genres or genre systems

specific to the organisation. Thus further studies in multiple organisations in distinct domains and settings are needed to clarify the amount of learning material in general and the daily information processing volumes of each approach separately.

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