e-Learning Indicators: a Multi-Dimensional Model for Planning and Evaluating e-Learning Software Solutions

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Abstract: As a number of recent studies suggest applications of networked computers in education have very inconsistent results ranging from success stories to complete failures. Literally, thousands of e-learning projects have been carried out that greatly differ in their outcomes. Until now, however, there is no systematic or a standardized way of planning, comparing and evaluating e-learning projects, their outcomes, and their effectiveness. Therefore, the main objective of this research was an investigation of possible approaches to systematic planning, development and evaluation of e-learning initiatives and their corresponding e-learning projects. The result of this work is a multidimensional model of e-learning Indicators that are defined as the important concepts and factors that are used to communicate information about the level of e-learning and used to make management decisions when planning e-learning strategy. The lack of knowledge of the learner audience as well as of the factors influencing that audience and e-learning projects overall results in failing to provide satisfactory support in the decision making process. In order to address this issue, an approach dealing with e-learning indicators is proposed. Having a standardised guide of e-learning indicators accepted by the scientific community enables comparison and evaluation of different initiatives regarding e-learning in a standardised manner. The proposed E-learning Indicators Methodology enables successful planning, comparison and evaluation of different e-learning projects. It represents an empirical methodology that gives concrete results expressed through numbers that could be analysed and later used to compare and conclude its e-learning efficiency. A practical value of this approach was analyzed in the realized comparative analyses of two different institutions using different LMS tools: Angel and Moodle focusing on comparison and evaluation of e-learning indicators of these two e-learning projects. With the application of this methodology in e-learning projects it is more likely to achieve better results and higher efficiency as well as higher Return on Investment-ROI.

Keywords: e-learning indicators, evaluation of effectiveness, learning outcomes

1. Introduction

e-Learning indicators are defined as the important concepts and factors that are used to communicate information about the level of e-learning and used to make management decisions when planning e-learning strategy for an institution or University according to the study of Fetaji et al (2007). The purpose was to raise the awareness of the factors and concepts influencing e-learning in order to enhance learning and identify the nature of obstacles being faced by e-learners. What is proposed is this methodology approach to develop any e-learning initiative. Because there are too many factors, personalizations and specifics related to each situation and circumstances it is considered that would be wrong offering one size solution for all.

It is of great importance to have standardised guides of e-learning indicators accepted by the scientific community to be able to compare and to evaluate the different initiatives regarding e-learning in a standardised manner.

In order to define and assess the e-learning indicators the data have been gathered from interviews with e-learning specialists, 2 focus groups (one student and one instructors), web based survey of academic staff and students and literature review of similar previous research work found at (Brusilovski, 1996). The web based survey was realised through questionnaire that was developed in three cycles. In the first cycle the questions were developed based on the e-learning indicators. For most of the e-learning indicators there was just one question to cover it, while for some 2 questions. At the beginning developed were more questions but after thorough consultations with survey experts shortened and come up with 23 questions. In the second cycle the developed survey questionnaire was tested on a 2 different focus groups. One group consisted of students and the other group was from instructors. After analyses of the survey data they were presented to the focus groups and confronted them with how much they agreed and considered these results as realistic and accurate. The initial response was that although the survey captures in substantial level the real situation there were a lot of discussions especially on the student focus group regarding the appropriateness of the
survey questions. In discussion with both of the focus groups most of the questions were changed according to the discussions and proposals of the group. In the third cycle both of the focus groups had filled in the new survey and after the survey data were given to them both of the focus groups agreed that it really gave an accurate clear picture of the participants.

The survey was designed following the rule of thumb for all communications: Audience + Purpose = Design. This survey was divided into 18 (eighteen) sections to cover all the e-learning indicators previously defined and had 23 (twenty three) questions in total. It was communicated to the participants and provided as a link in the message board of the e-service system of the University.

As e-learning indicators they were defined as: (1) learner education background; (2) computing skills level (3) type of learners, (4) their learning style and multiple intelligence, (5) obstacles they face in e-learning (e-learning barriers), (6) attention, (7) content (suitability, format preferences), (8) instructional design, (9) organizational specifics, (10) preferences of e-learning logistics; (11) preferences of e-learning design; (12) technical capabilities available to respondents; (13) collaboration; (14) accessibility available to respondents; (15) motivation, (16) attitudes and interest; and (17) performance-self-efficacy (the learner sense their effectiveness in e-learning environment); (18) learning outcomes. Recommendations as to the defined e-learning indicators for starting points when developing e-learning initiatives and based on the measurements of these e-learning indicators to tailor the specifics of e-learning. Each e-learning initiative should measure the provided indicators and based on them to design and build their e-learning sustainability.

2. Research method

From the results of the secondary research based on the literature review a grounded theory was developed as a systematic methodology to formulate a theory, either substantive or formal, about improving and enhancing e-learning by addressing the deficiencies from the findings and in this manner to contribute in enhancing e-learning effectiveness. In order to achieve this, the following research objectives have tried to be addressed:

- Review key authoritative literature on e-learning trends, e-learning standards, technologies and e-learning systems provided as e-learning solutions, and evaluation of e-learning effectiveness in order to provide a thorough understanding of e-learning in general and associated knowledge dissemination.
- Discuss the advantages and disadvantages of different approaches to e-learning solutions.
- Analyses different e-learning environments and solutions
- Asses, measure and evaluate concepts and factors influencing e-learning defined as e-learning indicators
- Design, develop and conduct experiments in order to assess the best modelling approach to developing e-learning software solutions
- Connect e-learning indicators with each e-learning software solution approach and learning theory and design
- Analyse and discuss the data gathered from the experiments
- Conclude and deliver recommendations for enhanced learning and future improvements.

The research method used was qualitative research and comparative analyses of factors influencing e-learning as well as an in-depth literature review of e-learning in general. The secondary research consisted of e-learning trends, e-learning technologies and solutions, e-learning standards, learning theories, concepts and factors that influence e-learning. Then grounded theory research was realised through exploratory research to determine the best research design and then constructive research was undertaken to build the software solution followed by empirical research to describe accurately the interaction between the learners and the system being observed. The data for this research was gathered from research interviews with e-learning specialists and participants, focus group and a web based survey as well as printed hard copy survey of academic staff and students.

Key variables and themes that have been studied are: students needs analyses, usage environment feasibility analyses, e-learning indicators, e-content and learning processes issues, feasibility analyses of authoring issues, assessment of e-learning effectiveness, and discussion of the purpose and evaluation of results of the research and proposed recommendations for e-content and e-learning
processes issues, applications specifics and requirements in correlation with the environment and
situation of the Communication Sciences and Technologies Faculty at south East European
University, accessibility and learning specifics based on learners needs, deployment, testing and
evaluation of the solution.

Interviewed and realised direct observation of students as program implementation case study for the
three subjects: Advanced Elective course “Object Oriented Programming in Java” and the two core
courses “Software Engineering” and “Algorithms and Data Structures”. There implemented the
solutions proposed under the part of the research study on e-content issues and e-learning
processes.

What was developed was a novel e-learning indicators-(ELI) model to be used for developing
information retrieval courseware’s by concentrating on previously assessed e-learning indicators.
Secondly, the research conveyed the need for close correlation of software development and e-
learning pedagogy. It is recommended that technology should adapt to theories of learning and e-
learning indicators assessed earlier. This process modelling based on e-learning indicators should be
used as guidelines in similar developments.

A pilot study was conducted on e-learning interactive courseware applying network analyses method
in order to find the critical activities and assess the risks. The main focus and aim of research was set
on software development proposed and based upon the e-learning indicators and the design of the
courseware in compliance with theories of learning and didactical pedagogical approach. For the
assessment of e-learning effectiveness proposed a methodology, called ELUAT (E-learning Usability
Attributes Testing), for which developed an inspection technique the Predefined Evaluation Tasks
(PET), which describe the activities to be performed during inspection in the form of a predefined
tasks, measuring previously assessed usability attributes.

3. Data collection from the experiments

Depending on each of the Software Lifecycle used for the e-learning software solutions developed in
particular for the given experiment used is the ELUAT methodology and PET testing as described
thoroughly at Fetaji et al (2007). Questionnaires, surveys, focus groups, usability testing and other
software testing groups were used. Groups of students filled out different surveys discussing e-
learning indicators, barriers to distance education and usability surveys of e-learning software
solutions modelled and developed. The return rate for the surveys for each experiment was different
and the highest was for distance education with 64.89 %, (The distance education program at the
moment has 81 undergraduate full time students, and 13 part time students, or in totals 94 students)
while for the e-learning indicators the response rate was 9.7 % (There were in total 701 student
surveys filled. The University at the moment of the research survey has 6.386 undergraduate and 188
postgraduate full time students, and 643 part time students, or in total 7217 students). The majority of
the participants (63.8%) have used the e-learning software solutions discussed. Ten percent of the
participants took fewer than all of the courses mentioned previously since Object Oriented
Programming in Java was an elective subject. Large amounts of data was collected and used from
the literature reviews and inputs from other related projects.

4. Data analysis

Several statistical procedures were conducted for data analysis. First, the zero-order correlations
were computed among all variables. The aim of this operation was to have an initial test of whether
there were relationships among the variables. The interaction of technology with teaching or social
presence was considered if including those items would increase the power of the regression model
substantially. The standard multiprogression procedures were conducted with course subjective
satisfaction through the perceived learning outcome, learning engagement assessed through time to
learn and time of performance as dependent variables. All assumptions of normality, usability, of
residuals were checked in those regression analyses. In order to handle those data the triangulation
technique from Dumas and Redish (1999) was used, were we look at all data at the same time to see
how the different data supports each other.
5. e-Learning indicators

5.1 e-Learning indicators definition

E-learning indicators have been defined with help of different focus groups, realised literature review and a web based survey of academic staff and students in the framework of South East European University as well as revised closely with experts in the field during participation in several research projects.

5.2 e-Learning indicators analyses and specification

(1) Learner education background together with his cultural background is set as indicator since it is a direct factor that is associated and impacts e-learning. According to Gatling et al., (2005), students today come from a variety of cultural backgrounds and educational experiences outside of the traditional classroom. How do students construct meaning from prior knowledge and connect it with the new experiences? Based on this facts and interviews with e-learning specialist it was set it as important indicator.

(2) Computing skills level of the learner is set as indicator since it directly influences the way e-learning is conducted with the use of Information and communication technologies (ICT) and use of computers and the computing skills requirements are essential in learning. “As we move toward the 21st century, anyone who is not “computer literate” will find themselves at a disadvantage when competing in the job market.” (Johnson, Gatling, Hill, 1997).

The indicator (3) type of learners they are depends primarily on the balance in the two dimensions of the Learning Style scale model formulated by Richard M. Felder and Linda K. Silverman of North Carolina State University according to Felder & Soloman (n.d) based on four dimensions (active/reflective, sensing/intuitive, visual/verbal, and sequential/global). According to Felder & Soloman (n.d) “students preferentially take in and process information in different ways: by seeing and hearing, reflecting and acting, reasoning logically and intuitively, analyzing and visualizing, steadily and in fits and starts. Teaching methods also vary. Some instructors lecture, others demonstrate or lead students to self-discovery; some focus on principles and others on applications; some emphasize memory and others understanding. Active learners tend to retain and understand information best by doing something active with it, discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first. Sensing learners tend to like learning facts; intuitive learners often prefer discovering possibilities and relationships. Visual learners remember best what they see: pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of word, written and spoken explanations. Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly getting it”. Therefore assessing and knowing the learning audience is crucial in order to know whom to support and there is an extensive need for this input data in order for the e-learning initiative to be successful and effective. Then after the measurements the learners are divided into groups so called “collectives” were personalisation is offered to the specifics of the collective majority (in Universities these are the departmental levels) primarily based on learning style categorization and type of learner they are according Felder-Silverman model for learning style categorization (Felder, 1993).

The importance of the type of learner and (4) their learning style and multiple intelligence is for the both sides: instructor and student. For instructors it is of importance since it reflects the preferences of Learning style in their teaching and delivery style to students. We advise to tend to use each learning style to teach also in a delivery type suited to other types of learners and truing to bring it closer and generalize to include all the types using visualization and verbal communications, as well as other communication tools. According to Tomas Armstrong (n.d.) Multiple Intelligences are eight different ways to demonstrate intellectual ability. 1) Linguistic intelligence (“word smart”), 2) Logical-mathematical intelligence (“number/reasoning smart”); 3) Spatial intelligence (“picture smart”); 4) Bodily-Kinesthetic intelligence (“body smart”); 5) Musical intelligence (“music smart”); 6) Interpersonal intelligence (“people smart”); 7) Intrapersonal intelligence (“self smart”); 8) Naturalist intelligence (“nature smart”). Again assessing the audience and having this input data is very important e-learning indicator in planning and developing e-learning initiative.
The indicator (5) obstacles they face in e-learning (e-learning barriers) is set as important based on interviews and speaking with e-learning specialists. Each e-learning project has different barriers and they are specified as learner input and depend from a situation.

Assessing what the learner audience faces as barrier is crucial in achieving effective e-learning. Indicator (6) attention is set as very important. Attention cues when the learners begin to feel some mental workload, Ueno, M. (2004).

Indicator (7) e-content (suitability, format preferences), e-learning content (e-content) considered as vehicle of the e-learning process and knowledge construction. The quality of the virtual learning environment is mainly depending on the quality of the presented e-learning content. Fetaji, B. (2006).

Indicator (8) Instructional design has gained significant prominence in e-learning for a number of compelling reasons. One of them is the possibility for instructional design to systematically address the need for creating and evaluating students’ learning experience as well as learning outcome. The other is instructional design can help faculty to focus on using the appropriate format and tools for the appropriate learning objectives. Fetaji, B. (2006).

Indicator (9) organizational specifics - every institution has its specific business processes that influences and impacts e-learning, Galotta et. al. (2004)

(10) preferences of e-learning logistics - targeted at learners of different experience levels and organizational background/hierarchy, based on the ELA model-the European Logistics Association (ELA), (Zsifkovits, 2003). The following 7 (seven) variables have been set as priority in determining viable learning environment and its e-learning logistics: 1) Interoperability; 2) Pricing; 3) Performance; 4) Content development; 5) Communication tools; 6) Student Involvement Tools; 7) Evolving technology.

(11) indicator preferences of e-learning design; designing instruction that acknowledges that students differ in their learning preferences and abilities and that instruction needs to be flexible to address these differences, (Kumar 2006).

The next indicators (12) technical capabilities available to respondents (13) collaboration; (14) accessibility available to respondents, areas defined as important indicators in discussions with e-learning specialist and experts. They represent the essential influencing factors on e-learning mentioned in different studies such as (Coleman, B., Neuhauser, J. & Fisher, M. 2004).

(15) Motivation is essential to learning and performances, particularly in e-learning environments where learners must take an active role in their learning by being self directed (Lee, 2000).

(16) Attitudes and interest. A review of studies on attitudes toward learning and using information technology in education has revealed that most studies have shown that students’ attitudes toward technology are critical, (Liu, et. al. 2004);

(17) performance: self-efficacy (the learner sense their effectiveness in e-learning environment); Self-efficacy refers to people beliefs about their capabilities to perform a task successfully at designated levels, (Bandura, 1997).

(18) According to Jenkins, A. and (Unwin, 1996) learning outcomes are defined as statements of what is expected that a student will be able to do as a result of a learning activity. Learning outcomes are usually expressed as knowledge transfer, skills, or attitudes (Unwin, 1996). Therefore, it is a very important indicator in planning, designing and evaluating e-learning.

5.3 e-Learning indicators assessment, measurement and evaluation

In order to investigate e-learning indicators in planning e-learning projects and evaluating e-learning projects a comparison of two e-learning projects using the e-learning indicators methodology was realised. The two e-learning project realised were using two different Learning Management systems: Angel LMS and Moodle and were used in different institutions and had different participants. ANGEL LMS is the learning management system of CyberLearning Labs, today known as Angel Learning (www.angellearning.com). It evolved from research conducted in mid-1990s in the CyberLab of

www.ejel.org 5
Indiana University-Purdue University. Later the Indiana University Research and Technology Corporation (IURTC), an independent corporation affiliated with Indiana University, created the CyberLearning Labs today known as Angel company in mid-2000. This research was realized under the South East European University “E-Learning Framework” research project were the author of this research was also the initiator and principal investigator as well as project coordinator.

In order to investigate e-learning indicators in planning phase of e-learning projects a case study was initiated in order to assesse, measure and evaluate e-learning indicators a web based survey has been used. The survey was designed following the rule of thumb for all communications: Audience + Purpose = Design. The survey was divided into 18 (eighteen) sections to cover all the e-learning indicators previously defined.

It was communicated to the participants and provided as survey in Angel LMS. It was offered to two different department from two different Universities. One using angel LMs as e-learning platform and the other using Moodle as learning platform.

For the first e-learning project there were in total 701 student surveys filled. The answer rate was 30.48%. There were 701 filled survey, and the total number of students in using Angel platform was 2300. The data was collected using Angel Learning Management System and further analyzed in Excel. The second e-learning project that is using Moodle as e-learning platform was focused on computer Science Faculty and in total 44 surveys were filled and the answer rate was 9.78%.

5.4 Survey analyses and results

5.4.1 Analyses of indicator: Self efficacy in e-learning

The survey questions are given in Appendix A.

Please rate your self efficacy in e-learning. How effective and efficient you are?

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5.4.2 ANGEL LMS - Findings for indicator: Self efficacy in e-learning

Most of the respondents, 43.7% have rated them self’s as good their efficacy in e-learning. While 24.1 % have rated them self’s as very good.

On the other hand 1% of them were not satisfied with the e-learning environment and their efficicy and have rated them self’s as bad, 4.7 % not so good, and 26.5% rated them self’s as OK, meaning they are partially satisfied with the e-learning system and their effectiveness in it.

![Figure 1: Self efficacy in e-learning](www.ejel.org)
5.4.3 Moodle LMS- Findings for indicator: Self efficacy in e-learning

Most of the respondents, 33.17%, have rated them self's as good their efficacy in e-learning. While 26.54 % have rated them self's as very good.
On the other hand 1.12% of them were not satisfied with the e-learning environment and their efficacy and have rated them self's as bad, 9.7 % not so good, and 29.47% rated them self's as OK, meaning they are partially satisfied with the e-learning system and their effectiveness in it.

![Self Efficacy in e-learning](image)

**Figure 2**: Self efficacy in e-learning

5.4.4 Discussion of the findings for indicator: Self efficacy in e-learning

As Bandura (1997) defined it, self-efficacy refers to people beliefs about their capabilities whether or not they can perform successfully at designated levels using the e-learning environment. From the analyses of the findings it indicates that there is an increase in student's achievement after their engagement in an e-learning environment. Overall 94.3% of the students in Angel and 89.18 % of students in MOODLE are satisfied with their self-efficacy and have shown progress moving in the new e-learning environment from the traditional classroom. However there are 5.7 % of the students (ANGEL) and 10.82 % (MOODLE) that are not satisfied with their achievement. The main reason among others for this result is identified in the usability issues of the two offered e-learning systems. Other reasons will be discussed in conclusions. However in general students rated their self efficacy as better in using ANGEL compared to MOODLE.

5.4.5 Analyses of indicator: Type of learner

What type of learner you are? (Please Circle one option:  a) or b) for each row)

**a) ACTIVE** or **b) REFLECTIVE Learner**

(Explanations: Active learners tend to retain and understand information best by doing something active with it--discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.)

5.4.6 ANGEL LMS - Findings for indicator: Type of learner

![Type of Learner](image)

**Figure 3**: Findings for indicator: Type of learner
On the whole, 72.61% of respondents rated themselves as Active learners while the others 29.24% as Reflective learners.

5.4.7 MOODLE - Findings for indicator: Type of learner

![Type of Learner](image)

Figure 4: Findings for indicator: Type of learner

On the whole, 54.28% of respondents rated themselves as Active learners while the others 45.72% as Reflective learners.

5.4.8 Discussion of the findings for indicator: Type of learner

The indicator (3) type of learners they are depends primarily on the balance in the two dimensions of the Learning Style scale model formulated by Richard M. Felder and Linda K. Silverman according to Felder & Soloman (n.d). The findings indicate that students in using ANGEL are primarily of the Active type of learner 72.61% in comparison to 29.24% Reflective type of a learner. The students in using MOODLE are primarily of type reflective learners 54.28% in comparison to 45.72%. These findings indicate that the structure and curriculum of the studies should change and embrace this type of learner more by preferring and choosing a hands on approach in comparison to the theoretical approach for the learners using ANGEL and the opposite for the learners using MOODLE were learners should be provided more reading materials and solved examples so they can reflect this and learn by doing this.

5.4.9 Analyses of indicator: Type of learner

a) SENSING or b) INTUITIVE Learner

(Explanations: Sensing learners tend to like learning facts; intuitive learners often prefer discovering possibilities and relationships.)

5.4.10 ANGEL LMS - Findings for indicator: Type of learner

![Type of Learner](image)

Figure 5: Findings for indicator: Type of learner
On the whole, 62.62% of respondents rated themselves as Sensing learners while the others 37.37% as Intuitive learners.

5.4.11 MOODLE - Findings for indicator: Type of learner

On the whole, 43.91% of respondents rated themselves as Sensing learners while the others 56.09% as Intuitive learners.

5.4.12 Discussion of the findings for indicator: Type of learner

The findings indicate that ANGEL LMS students are primarily of type sensing and they tend to learn by learning facts 62.62%. The minority group of the students are of type intuitive learners 37.37% and they prefer discovering possibilities and relationships for themselves. These findings suggest that the content created and used in the e-learning environment should be concentrated around facts and detailed descriptions rather than on living this to students to discover for themselves. MOODLE students are primarily of type Intuitive 56.09% compared to the sensing group with 56.09%. For the students of this type the recommendations are to provide more information and case studies for students in order to intuitively learn and find the answers.

5.4.13 Analyses of Indicator: Type of learner

a) VISUAL or b) VERBAL LEARNER

(Explanations: Visual learners remember best what they see—pictures, diagrams, flow charts, timelines, films, and demonstrations. Verbal learners get more out of words-written and spoken explanations.)

5.4.14 ANGEL LMS - Findings for indicator: Type of learner

On the whole, 59.34% of respondents rated themselves as Visual learners while the others 40.66% as Verbal learners.
5.4.15 MOODLE - Findings for indicator: Type of learner

On the whole, 51.42% of respondents rated themselves as Visual learners while the others 49.58% as Verbal learners.

5.4.16 Discussion of the findings for indicator: Type of learner

The findings indicate that ANGEL students are 59.34% while MOODLE 51.42% primarily of type Visual learners and they tend to learn by pictures, diagrams, flow charts, timelines, films, and demonstrations. The other group of the students is of type verbal learners Angel 40.66% and MOODLE 49.58% and they prefer to learn out of words, written and spoken. This findings suggests that the e-content created and used in the e-learning environment should contain more multimedia elements like pictures, diagrams, flow charts and demonstrations rather than just text explanations.

5.4.17 Analyses of indicator: Type of Learner

a) SEQUENTIAL or b) GLOBAL LEARNER

(Explanations: Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it.")

5.4.18 ANGEL LMS - Findings for indicator

On the whole, 61.63% of respondents rated themselves as Sequential learners while the others 38.37% as Global learners.
5.4.19 MOODLE - Findings for indicator

![Chart showing Type of Learner: Sequential, 47.17% and Global, 52.83%](image)

**Figure 10**: Findings for indicator

On the whole, 52.83% of respondents rated them self's as Sequential learners while the others 47.17% as Global learners.

5.4.20 Discussion of the findings

The findings indicate that 61.63% Angel students and 47.17% Moodle students are primarily of type Sequential learners and they tend to learn in linear steps, with each step following logically from the previous one. The other group of the students are of type Global learners 38.37% Angel students and 52.83% Moodle students and they prefer to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it.". This findings suggests that the e-content created and used in the e-learning environment should present the subject sequentially and then progressing step by step to the global and general issues for Angel environment students while for the Moodle environment students the content provided should contain information that provides global picture of the content.

5.4.21 Analyses of indicator: Learning style and intelligence

1) Linguistic ("word smart", sensitivity and ability to spoken and written language)
2) Logical-mathematical ("number/reasoning smart", analyze problems logically, investigate issues scientifically)
3) Spatial ("picture smart", potential to recognize and use the patterns of wide space)
4) Bodily-Kinesthetic ("body smart", mental abilities to coordinate bodily movements)
5) Musical ("music smart", skill in the performance, composition, and appreciation of musical patterns)
6) Interpersonal ("people smart", capacity to understand the intentions, motivations and desires of other people)
7) Intrapersonal ("self smart", capacity to understand oneself, to appreciate one's feelings, fears and motivations)
8) Naturalist ("nature smart", recognize, categorize certain features of the environment)

5.4.22 ANGEL LMS - Findings for indicator

![Chart showing Learning Style distribution](image)

**Figure 11**: Findings for indicator
5.4.23 MOODLE - Findings for indicator

![Learning Style Pie Chart]

**Learning Style**
- Linguistic: 11.85%
- Logical-mathematical: 36.55%
- Spatial: 17.84%
- Bodily-Kinesthetic: 4.63%
- Musical: 2.42%
- Naturalist: 5.80%
- Linguistic: 5.16%
- Intrapersonal: 11.85%
- Interpersonal: 15.75%

**Figure 12:** Findings for indicator

5.4.24 Discussion of the findings

The findings indicate that Angel and Moodle students are more or less with a balanced and similar learning style and intelligence were slightly prevails the Logical-mathematical, and linguistic style and intelligence preferences.

5.4.25 Analyses of indicator: Obstacles - borders

Please define the obstacles you face in e-learning?

5.4.26 ANGEL LMS - Findings for indicator

![Obstacles - borders Pie Chart]

**Obstacles - borders**
- Computer skills: 12.86%
- Location based: 10.46%
- Instructional design: 12.66%
- Computer access: 9.65%
- Personal: 12.97%
- Organisational: 9.75%
- Internet connection: 13.29%
- Content suitability: 9.65%

**Figure 13:** Findings for indicator

5.4.27 MOODLE - Findings for indicator

![Obstacles - borders Pie Chart]

**Obstacles - borders**
- Computer skills: 6.83%
- Location based: 9.04%
- Instructional design: 3.29%
- Computer access: 24.85%
- Personal: 14.49%
- Organisational: 14.98%
- Content suitability: 24.85%
- Internet connection: 13.39%

**Figure 14:** Findings for indicator
5.4.28 Discussion of the findings

The findings indicate that there are a lot of obstacles and barriers to e-learning and they are rated as follows in percentage: Angel: Based on these findings the internet connection and e-content not suited to learners learning style are rated as the biggest obstacles and barriers to enhanced learning.

Moodle: Based on the findings content suitability, personal issues and learning style are rated as the biggest obstacles to enhanced learning.

5.4.29 Analyses of indicator: Attention

What captures best your attention in ANGEL that helps you learn best?

5.4.30 ANGEL LMS - Findings for indicator

![Graph showing ANGEL LMS attention](image)

**Figure 15**: Findings for indicator

The findings indicate that e-learning attention is based on different factors and they are rated as follows in percentage: 39.31% rated that their attention on Lessons; 11.40% rated that their attention on Calendar; 13.43% rated that their attention on Forum; 5.85% rated that their attention on Chat; 6.00% rated that their attention on Surveys; 14.70% rated that their attention on email feature; 9.30% rated that their attention on other factors.

5.4.31 MOODLE - Findings for indicator

![Graph showing MOODLE attention](image)

**Figure 16**: Findings for indicator

The findings indicate that e-learning attention is based on different factors and they are rated as follows in percentage: 89.31% rated that their attention on Lessons; 0.14% rated that their attention on Calendar; 7.37% rated that their attention on Forum; 0.62% rated that their attention on Chat; 0.23% rated that their attention on Surveys; 1.03% rated that their attention on email feature; 1.30% rated that their attention on other factors.

5.4.32 Analyses of indicator: Content format

If you could choose different formats for the same content which one do you think is best to convey knowledge and to learn from?
5.4.33 ANGEL LMS - Findings for indicator

![Chart showing content format preferences for ANGEL LMS]

Figure 17: Findings for indicator

5.4.34 MOODLE - Findings for indicator

![Chart showing content format preferences for MOODLE]

Figure 18: Findings for indicator

5.4.35 Discussion of the findings

Most of the respondents, in both of the environments prefer mostly a combination of all media in representing the course e-content. Then the preferences are for Text as their representation of learning e-content, then respondents prefer Video as their e-content, Graphics and animation representation of their learning e-content. This data highlights the importance of the e-learning content and its format of representation which should be provided in different formats and most desirably as combination of all the media. The structure and interactivity should also be embedded in the content as well and provide clear summary and outcomes for the e-content.

5.4.36 Analyses of indicator: Optimal course to learn

When is your optimal time to learn, what do you prefer?

- a self-paced e-learning course completed independently
- an e-learning course facilitated by an instructor who requires completed assignments and discussions with peers
- a real-time e-learning course conducted online with a facilitator and participants in different locations
5.4.37 ANGEL LMS - Findings for indicator: Optimal course to learn

Most of the respondents, 53% prefer a real-time (synchronous) class conducted by a facilitator and participants in different locations. 12%, prefer an asynchronous e-learning course facilitated by an instructor who requires completed work and participation in discussions. Only 35% prefer a self-paced course. This data highlights the importance of a facilitator who can structure interaction and provide assistance and accountability.

5.4.38 MOODLE - Findings for Indicator: Optimal course to learn

Most of the respondents 55% prefer a self-paced course. Then, 34% prefer a real-time (synchronous) class conducted by a facilitator and participants in different locations. 11%, prefer an asynchronous e-learning course facilitated by an instructor who requires completed work and participation in discussions. This data highlights the importance of having a self-paced course were the focus will be in the e-content since the content is the main vehicle into learning.

5.4.39 Analyses of indicator: Optimal time to learn

When is the best time for you for a real-time online classes or online discussion with your instructor or colleague student?
5.4.40 ANGEL LMS - Findings for indicator

Figure 21: Findings for indicator

In Angel: Most of the respondents, 26%, prefer Evenings/night for online classes or online discussion. 23% prefer Weekdays Monday to Friday, 22% prefer afternoons, 16% prefer Weekends Saturday and Sunday, and 13% prefer morning for online classes and online discussions. This data suggests that e-learning most preferred efficient time is during evenings in the weekdays, second option is at least to be in the afternoon and very few learners desire to learn during weekdays. In Moodle: Most of the students 43% prefer weekdays as optimal time to learn. Then afternoon is the second choice with 30% and morning with 17% while evenings/nights with 10%.

5.4.42 Analyses of indicator: Online positives

If you study at home or workplace, how much do you agree with the following statements?

Figure 23: Findings for indicator
5.4.44 MOODLE - Findings for indicator

Figure 24: Findings for indicator

5.4.45 Discussion of the findings

Angel: Most of the respondents, 26% prefer online learning because they can learn at their own peace. 21% prefer online working in groups, 15 % need teachers/instructors to help, 14% prefer online because they can work at times suited to their schedule, 12% prefer things explained in sequence, 7% prefer online because they can repeat difficult bits, 5 % prefer online because they have more time for reflection.

Moodle: Most of the respondents, 25% prefer online learning because they have more time for reflection. 23% because they can repeat difficult bias, 19 % prefer learning in their own pace, 11% prefer working at times suited to their schedule, 09 % prefer things explained in sequence, 4% prefer working in groups.

This data highlights the importance of the factors that drove the learners decision for choosing e-learning compared to traditional classroom. The most preferred positive option of e-learning for student learners are the facts that they can learn on their own peace, at times suited to their schedule, they can repeat difficult bias and they have more time for reflection.

5.4.46 Analyses of indicator: Learning preferences

Do you prefer to study ALONE or as part of a TEAM?

5.4.47 ANGEL LMS - Findings for indicator

Figure 25: Findings for indicator
5.4.48 MOODLE - Findings for indicator

![E-Learning preferences chart](image)

**Figure 26**: Findings for indicator

5.4.49 Discussion of the findings

In Angel: Most of the respondents, 50.92% prefer working alone and learn at their own peace. 49.08% prefer team work. The preferences of the student learners are almost divided the same in favor of working alone or in team. In Moodle: Most of the respondents 74.92% prefer working alone, while 26.08% prefer working in team. Based on the findings we concluded that this is not such an issue for them and it is not influencing the learning process substantially.

5.4.50 Analyses of indicator: Communication preferences

As Learner how do you usually work with fellow students on your course and share ideas with him/her? 1) Face to Face; 2) Telephone; 3) Email 4) chat room; 5) Moderated discussion forum

5.4.51 ANGEL LMS - Findings for indicator

![E-Learning preferences chart](image)

**Figure 27**: Findings for indicator

5.4.52 MOODLE - Findings for indicator

![E-Learning preferences chart](image)

**Figure 28**: Findings for indicator
5.4.53 Discussion of the findings

Most of the respondents, similarly in both cases Angel and Moodle prefer Face to Face communication with their colleges. Then they prefer telephone communication to exchange ideas with their colleges, and then prefer email communication, afterwards prefer Discussion forum to communicate with their colleges, and at the end prefer chat rooms for communication.

5.4.54 Analyses of indicator: Technology usage extending learning

To what extent have your skills and learning improved by your personal use of technology outside the University?

5.4.55 ANGEL LMS - Findings for indicator:

![Technology usage chart for ANGEL LMS](image1)

Figure 29: Findings for indicator

5.4.56 MOODLE - Findings for indicator

![Technology usage chart for MOODLE](image2)

Figure 30: Findings for indicator

5.4.57 Discussion of the findings

Most of the respondents, for both Angel and Moodle feel that they have improved their skills using technology and they have classified this as good. Most of the respondents classified their improvement as OK, then fewer respondents classified their improvement as Very Good, while on the other side although few there are some respondents that classified their improvement as Not so good, while fewer as Not at all. This data highlights the importance of technology usage in improving student learner's skills and learning. The learning system usage influenced and improved student learning.

5.4.58 Analyses of indicator: Access to e-learning material

Describe your access to e-learning material?
5.4.59 ANGEL LMS - Findings for indicator: Access to e-learning material

![Figure 31: Findings for indicator: Access to e-learning material](image1)

5.4.60 MOODLE - Findings for indicator: Access to e-learning material

![Figure 32: Findings for indicator: Access to e-learning material](image2)

5.4.61 Discussion of the findings for indicator

Most of the respondents, for both Angel and Moodle prefer using their own home connection to internet, then the largest group have no home connection and use the University facility for connecting online, then use their home connection around 2/3 of the time and 1/3 the University facilities to connect to internet, then few of the respondents use their home connection around 1/3 of the time and 2/3 of the time they use the University facility, and smallest group although do have home connection they always use the University facility to connect to internet.

This data highlights the importance of the factors that drove the learner's decision for choosing e-learning compared to traditional classroom. The most preferred positive option of e-learning for student learners are the facts that they can learn on their own peace, at times suited to their schedule, they can repeat difficult bias and they have more time for reflection.

5.4.62 Analyses of indicator: Online positives

How often do you visit course contents on ANGEL??
5.4.63 ANGEL LMS - Findings for indicator: Online positives

![Figure 33: Findings for indicator: Online positives](image)

5.4.64 MOODLE - Findings for indicator: Online positives - Question 22

![Figure 34: Findings for indicator: Online positives - Question 22](image)

5.4.65 Discussion of the findings

Most of the respondents, in Angel (65 %), Moodle (71.09%) access content in LMS on Daily basis, Angel (20.35 %), Moodle (18.63%) of the respondents access the content each 2 or 3 days, Angel 5.71 % Moodle 4.71% of the respondents access the content on Weekly basis, while on the other hand Angel 5.85 %; Moodle 5.39% of the respondents access the content Rarely, Angel 1.31 %; Moodle 0.21% access it hardly ever, and Angel 1.31 %; Moodle 0% never access content in LMS.

5.4.66 Analyses of indicator: Learning outcomes

What is the impact of this e-learning system regarding learning outcomes?

9) Knowledge transfer and understanding; 2) Intellectual (thinking) skills; 3) Practical skills; 4) Transferable skills
5.4.67 ANGEL Findings for indicator:

![Pie chart showing ANGEL findings for indicator]

Figure 35: Findings for indicator

5.4.68 Moodle Findings for indicator

![Pie chart showing Moodle findings for indicator]

Figure 36: Findings for indicator

5.4.69 Discussion of the findings

Most of the respondents, Angel 44% and Moodle 39% declared that knowledge transfer was the most important outcome, 31% in Angel and 38% in Moodle the respondents declared that intellectual thinking skills were the most important outcome, Angel 24% and Moodle 25% of the respondents think that practical skills were the most important outcome, while only 11% in Angel and 8% in Moodle the respondents declared most important the transferable skills.

It is a conclusion that both e-learning projects using Angel and Moodle have been rated very similarly regarding the learning outcomes.

6. Discussion and conclusion on e-learning Indicators

Many current e-learning initiatives follow the "one-size-fits-all" approach just offering some type of LMS to learners. Typically, this approach is related to lack of knowledge of the learner audience or factors influencing that audience and e-learning project overall and therefore fail to provide satisfactory support in the decision making process.

In order to address this issue, an approach dealing with e-learning indicators is proposed, assessed, measured and evaluated. The proposed e-learning Indicators Methodology enables successful planning, comparison and evaluation of different e-learning projects. Above is given a comparative analysis of two different institutions using Angel and Moodle and focusing on comparison and evaluation of e-learning indicators of these two e-learning projects. e-Learning indicators methodology represents an empirical methodology that gives concrete results expressed through numbers that can be analysed and later used to compare and compare e-learning efficiency. With the application of this methodology in e-learning projects it is more likely to achieve better results and higher efficiency as well as higher Return on Investment ROI.
We recommend using the defined e-learning indicators as the starting point when developing e-learning initiatives and tailor the specifics of e-learning based on the measurements of these e-learning indicators. Each e-learning initiative is unique and involves specifics that can not be taken under consideration in general in the form of one solution suits all. On the contrary each e-learning initiative should measure the provided indicators to design and build their own e-learning based on them.

All available evidence points toward growing enrolments and provision albeit from a low starting point. The opinion is that future quality development in e-learning has to be oriented at the learner’s needs and the specific situation that needs to be measured and evaluated using e-learning indicators.

Regarding the comparative analysis of two distinct e-learning projects: Angel and Moodle the fact is that after analyzing both of the systems, some main problems that these two systems contain, and some suggestions how these problems could be solved or recovered are given below:

It can be concluded from the data described above, that Moodle really has a large number of options that it offers and when these tools come involved into the course they attract the student’s attention from his aim. This problem is not faced in ANGEL system, which has a cleaner interface with high usability. As a solution for such a problem, our recommendation is to simplify course pages in the Moodle system, and in this way make it more aesthetic, efficient and attractive. Of course, some necessary tools would have a proper place in a smaller and well readable format.

Another problem of Moodle is that it has a difficult file management. The solution to this problem is allowing managing files and according to the latest news, the professional team of Moodle is currently working on this issue.

ANGEL is not considered to have any problems with the templates and design, but it does not contain a glossary which the Moodle has, and it operates perfectly. I would necessarily put such an item in order to increase its functionality and effectiveness since Moodle is evidence how much it is useful for the learners. Another problem that ANGEL faces is that it does not target a UNIX based system. All of the above mentioned important issues and problems are the most important and essential ones that student, instructors and other roles mostly care about. That is why their improvements are important as much as their existence. All of the other tools such as surveys, quizzes, language supports and different options are very functional and efficient in both systems and these items are definitely the ones that I would not change in any of them.

7. Appendix A

SURVEY

1. What Faculty and department you are coming from? (Please write below)

2. Are you an undergraduate or a graduate student?
   - undergraduate student
   - graduate student

3. Please select the year of studies you are?
   - I (first)
   - II (second)
   - III (third)
   - IV (fourth)
4. Are you a full time student or part time student?
   - Full Time student
   - Part Time student

5. Please define your computer skills?
   - Inexperienced
   - Beginner
   - Ok
   - Good
   - Expert

6. Please rate your self efficacy in e-learning. How effective and efficient you are?
   - Bad
   - Not so good
   - OK
   - Good
   - Very good

7. What type of learner you are? (Explanations: Active learners tend to retain and understand information best by doing something active with it--discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.)
   - ACTIVE
   - REFLECTIVE LEARNER

8. What type of learner you are? (Explanations: Sensing learners tend to like learning facts; Intuitive learners often prefer discovering possibilities and relationships.)
   - SENSING
   - INTUITIVE LEARNER

9. What type of learner you are? (Explanations: Visual learners remember best what they see--pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of words--written and spoken explanations. Everyone learns more when information is presented both visually and verbally.)
   - VISUAL
   - VERBAL LEARNER

10. What type of learner you are? (Explanations: Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then
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suddenly "getting it.")

☐ SEQUENTIAL Learner

☐ GLOBAL Learner

11. Please select your learning style below. (You may select more than one)

☐ 1) Linguistic ("word smart", sensitivity and ability to spoken and written language):

☐ 2) Logical-mathematical ("number/reasoning smart", analyze problems logically, investigate issues scientifically)

☐ 3) Spatial ("picture smart", potential to recognize and use the patterns of wide space)

☐ 4) Bodily-Kinesthetic ("body smart", mental abilities to coordinate bodily movements)

☐ 5) Musical ("music smart", skill in the performance, composition, and appreciation of musical patterns)

☐ 6) Interpersonal ("people smart", capacity to understand the intentions, motivations and desires of other people)

☐ 7) Intrapersonal ("self smart", capacity to understand oneself, to appreciate one's feelings, fears and motivations)

☐ 8) Naturalist ("nature smart", recognize, categorize certain features of the environment)

12. Please define the obstacles you face in e-learning?

☐ Computer skills

☐ Learning Style

☐ Content suitability

☐ Computer access

☐ Internet connection

☐ Instructional design (material)

☐ personal

☐ organizational

☐ location based

13. What captures best your attention in ANGEL that helps you learn best? (you can select one or more options)

☐ Lessons

☐ Calendar

☐ Forum

☐ Chat

☐ Surveys

☐ email feature
14. If you could choose different formats for the same content which one do you think is best to convey knowledge and to learn from?
- Text
- Animation
- Graphic
- Video
- combination of all

15. When is your optimal time to learn, what do you prefer?
- a self-paced e-learning course completed independently
- an e-learning course facilitated by an instructor who requires
- a real-time e-learning course conducted online with a facilitator

16. When is the best time for you for a real-time online classes or online discussion with your instructor or college student?
- (Morning)
- (Afternoon)
- (evenings/nights)
- (Weekdays: Monday - Friday)
- (Weekends: Saturday -Sunday)

17. If you study at home or workplace, how much do you agree with the following statements?
- More able to learn at own pace than in class
- Able to work at times suited to me
- Can repeat difficult bits
- Allows more time for reflection
- Like to have teacher to help me
- Like to have things explained in sequence
- Prefer working in groups

18. Do you prefer to study ALONE or as part of a TEAM?
- Alone
- as part of the team

19. As Learner how do you usually work with fellow students on your course and share ideas with
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him/her?
- Face to Face
- Telephone
- Email
- chat room
- Moderated discussion forum

20. To what extent have your skills improved by your personal use of technology outside the University?
- Not at all
- Not so good
- Ok
- Good
- Very Good

21. Describe your access to e-learning material?
- I nearly always use my home connection
- I use my home connection about 2/3rds of the time and University facility about 1/3rd of the time
- Use home connection 2/3rd of the time and University facility about 1/3rds of the time
- I have no home connection to internet, always use University facilities
- I do have home connection to internet but always use University facilities

22. How often do you visit course contents on ANGEL?
- Daily:
- Every 2/3 days
- Weekly
- Rarely
- Hardly ever
- Never

23. Please write your comment how to help you improve learning by using ANGEL? THANK YOU FOR PARTICIPATING

www.ejel.org 27 ISSN 1479-4403
Check Spelling

Thank you for participating in this survey.

References


Towards a Fusion of Formal and Informal Learning Environments: the Impact of the Read/Write Web

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Abstract: The read/write web, or Web 2.0, offers ways for users to personalise their online existence, and to develop their own critical identities though their control of a range of tools. Exerting control enables those users to forge new contexts, profiles and content through which to represent themselves, based upon the user-centred, participative, social networking affordances of specific technologies. In turn these technologies enable learners to integrate their own contexts, profiles and content, in order to develop informal associations or communities of inquiry. Within educational contexts these tools enable spaces for learners to extend their own formal learning into more informal places though the fusion of web-based tools into a task-oriented personal learning environment. Where students are empowered to make decisions about the tools that support their personal approaches to learning, they are able develop further control over their learning experiences and move towards their own subject-based mastery. Critically, they are able to define with whom to share their personal approaches, and how they can best connect the informal learning that occurs across their life to their formal, academic work. The personal definition or fusion of tools and tasks is afforded through individual control over the learning environment. The flowering of personal learning aims, mediated by technologies and rules of engagement, occurs within task-specific loops where learners can interpret and process epistemological signals. In turn, where those loops are located within broader, personalised environments students can make contextual sense of their learning and extend their own educational opportunities. Moreover, they can extend their own academic decision-making through application in other contexts, and as a result manage their own academic uncertainties. This is evidenced through a thematic study of the voices of both learners and tutors, which highlights how the read/write web can be used proactively by educators, using specific tasks to enable learners to fuse their informal and formal learning spaces, and thereby enhance their decision-making confidence. The structuring of learning spaces that enable users and social networks to manage their educational processes is enhanced by read/write web approaches and tools, and in this paper is defined through a Fused Learner Integration model.

Keywords: learner; personal learning environment; formal learning; informal learning; read/write web; Web 2.0; thematic analysis

1. Introduction

The impact of the read/write web, or Web 2.0 as it is commonly known, on learner engagement within higher education is a central focus of current e-learning research (Ebner, Holzinger and Maurer, 2007; Conole et al., 2006; Mason and Rennie, 2007; Mayes, 2006). In particular, pedagogues have been re-thinking the implications of the read/write web in extending environments for situated, informal education, and for addressing the blurring of the boundaries between personal, social spaces and formal learning contexts (JISC, 2007).

In part, this blurring of spaces has been catalysed by the structures and affordances of user-centred technologies and their ability to be mashed (Webmashup.com, 2007) or modded (El-Nasr & Smith, 2006). The open nature and availability of key source code, wedded to the participative models that exist for re-working both content and presentation, enable dynamic, hybridised and derivative knowledge development. The ability for users to work with a variety of networks to mash-up, modify or recreate both content and applications extends their self-presentation and knowledge (Franklin and van Harmelen, 2007).

There is scope for extending this analysis to develop fused models of learning. Here users engage with both the signals and the connections that are made by-way-of real-time and synchronous engagements in the physical and virtual worlds (Ibrahim, 2008). This is connected to nascent work on both mixed reality (Mixed Reality Lab, 2008; MXR, 2008), where real-world and computer-generated information are merged to present new visualisations or simulations, and augmented reality (Hainich, 2006), where live visual streams are enhanced by computer-generated information. Critically, it is the fusion of information sources in the real and virtual worlds, primarily with or for users in similar contexts that affords new connections between formal and informal settings. Moreover, where fused,
networked spaces are co-owned and developed, they enable users to engage varied perspectives and approaches (Barnett and Coate, 2007).

Empowering learners to design and deploy fused, formal and informal educational spaces not only extends the power of situated, individual, educational outcomes, but can also positively extend their personal learning experiences. This is impacted by: the contextual control available to users to manage uncertainty; the rules that underpin access and participation; the feedback and signals received from associations within those contexts; and the development of personal literacies. This thesis is framed by the outcomes of a thematic study of the voices of both learners and tutors, in order to argue that the read/write web should be used proactively by educators to enable learners to fuse their situated, informal and formal educational spaces, and thereby enhance the production of educational outputs.

2. Users, networks and the read/write web

The affordances of web-based applications are such that tools can be embedded within the curriculum at low cost in order to connect people and information. These tools are often known as Web 2.0 applications (O'Reilly, 2005), but they are also usefully referred to as read/write web applications. The use of the term ‘read/write’ emphasises an approach rather than a toolset and stresses the marriage of broadcast and interactive tools within a personalisable environment.

These applications afford opportunities for: social networking, using software like Facebook and Ning.com; social bookmarking, using tools like del.icio.us and Ma.gnolia; user-generated content, using blog and wiki software; virtual representation in worlds like Second Life; the syndication of content including multimedia; and innovative approaches to content and application-handling, including mash-ups and aggregation. Their impact has prompted practitioners to re-evaluate curriculum delivery, if not yet its design, and Sharpe (2006, p. 16) has highlighted that:

This shift creates an era of opportunity for education. At the heart of education and learning lie the encounters that an individual has with people, places and things, and the opportunity each encounter presents for interaction, challenge and growth. As digital technology pervades everything around us, we can enrich each encounter to harness the global resources of the information world and of learning communities, to make it more appropriate in that moment to that individual.

These connections are catalysed by the interplay between applications, content and people. They produce signals and feedback between users within broader associational or friendship networks, and help to shape on-line beliefs, identities and, importantly, decision-making and agency (Hall, 2008). Anderson (2007) has highlighted six key areas in which these connections between applications and users are made real: user-generated content; the power of the crowd; data on an epic scale; an architecture that supports participation; network effects; and openness in content and computer code. The openness and malleability of use of these tools empowers users to express themselves to others, and to take part in shared activities, in a variety of contexts.

The ways in which the structures of these technologies allow their application and their content to be repurposed enables socially-constructed, dynamic, hybridised and derivative knowledge to be developed. The processes of producing mash-ups and modifications to applications can be seen in both technical and cognitive terms (El-Nasr & Smith, 2006; Webmashup.com, 2007). Through the control of code that is open source or open standards, and through the integration of media presented in multiple applications, individuals have the opportunity to rethink the spaces and places in which they represent themselves (Hodgson and Reynolds, 2005; Franklin and van Harmelen, 2007). Through the reframing of individual and collective tools and artefacts an understanding of the world and a view of difference can be generated.

There are still many issues for read/write web participants to consider, around: identity presentation and formation; engagement, agency and marginalisation; privacy and security; and developing technological confidence. Anderson (2007, p. 53) pinpoints ‘the need to explore further the informal, social aspects of the learning that takes place and the many issues concerning participation. We cannot, for example, assume everyone is happy working in the “self-publish” mode.’ However, our engagement with read/write web tools and experiences forms part of an agenda for educational change, through the development of new spaces and contexts for enriching formal education through informal activities (Goodfellow and Lea, 2007; HEA, 2008).
3. Informal and formal education: the affordances of the read/write web

A critical space for individual learning development to occur is a formal learning environment. Eraut (2000, p. 12) defines such contexts as consisting of: a prescribed learning framework or schedule; specified learning tasks; facilitation by a professional educator; and formal accreditation, based upon external specifications. Where the rules that underpin activity in these places are framed by tutors and learners, they can enhance levels of personalisation and ownership, underpinned by personal self-reliance. In terms of technologies, institutionalised formal learning is defined by a standard toolkit, like a virtual learning environment that interoperates with institutional administrative databases, for instance student record systems. In this way, individual and group interactions and assessments can be captured, monitored and assured. The key here is that personalisation is achieved through accredited frameworks delivered in professional settings (DIUS, 2008).

The concept of informal education is contested although many would use the following terms in its description: education "owned" and "directed" by the learner; independent study; non-formally timetabled education; education using non-institutional technologies; and engaging learning that takes place away from traditional, educational contexts. The interface between traditional and non-traditional contexts or spaces has come more sharply into focus through the use of emergent read/write web and mobile technologies, which emphasise learning linked to ownership, context, personalisation and differentiated tasks (HEA, 2008). Critically, these tasks and spaces have different rules from traditional academic contexts, even if they are less structured and more open (Barnett, 2008). With users operating in multiple spaces, there are widespread affordances for personal validation, the formation of new allegiances, freeing access to varied resources, and achieving self-reliance through critical action across the boundaries of networks. Moreover, these networks and contexts are at once virtual and real.

In defining an approach to informal education Leadbeater (2000, p. 112) has argued that:

Schools and universities should become more like hubs of learning, within the community, capable of extending into the community... More learning needs to be done at home, in offices and kitchens, in the contexts where knowledge is deployed to solve problems and add value to people's lives

The development of added value occurs through self-education, and through both membership of formal educational classes and associations with informal, external networks of people (McGiveney, 1999). Increasingly, it is the critical ability that an individual learner develops in fusing their formal and informal learning, which lever educational gains (Joseph Rowntree Foundation, 2007). This personal fusion is supported by trusted peers or practitioners and enables users to seek out appropriate personal connections between spaces, so that signals can be passed between networks, to inform action.

This provokes strategic and operational issues for higher education providers about:

- curriculum design, delivery and assessment;
- enhancing personal, technological access and participation;
- the development and ownership of personalised learning environments (PLE);
- the impact on institutional strategies for learning and teaching, estates, IT, staff development and library services; and
- the impact on staff-student and student-student relationships.

In developing strategies to manage these issues, education providers and practitioners need to address issues around control of the learning environments that they support, and enabling connections to be forged and fused with informal learning spaces.

4. Fused learning spaces

Developing the connections between formal and informal networks and spaces moves us towards an acceptance of a personalisation and ownership of the learning process that coalesces within a range of spaces, networks and applications. In this way, there is the hope that learners can develop agile agency in deploying new learning or literacies, within new contexts, and as a result enhance their outcomes. This is driven by the motivation and engagement of the learner within what can be termed fused spaces.
Fused, personal environments consist of a ‘diverse range of possible technologies and applications’ in both virtual and real worlds (Ibrahim, 2008, p.1), which are interconnected and enable proactive, personalised actions to be taken. They emerge from fused media, which ‘can facilitate context-aware, situation-aware, multi-scale, proa ctive, and sign/signal-action dynamics in real time’ (Fused Media Lab, 2008). Such actions are driven by closed-loop models where action is impacted by contextual, environmental triggers and a dynamic understanding of human behaviour. The connections that are fused between triggers, environment and behaviours enable signals to be passed between a user and a socio-technical system. By making sense of these signals, systems and users can learn from new experiences, better predict future outcomes and make better decisions.

In a read/write web world, this approach appears blurred by a mashing of identities and networks, within and across a multitude of spaces for sending and receiving signals. However, for specific tasks or outcomes, users make sense of their collected, personal spaces and networks, in order to perform closed-loop operations that are closely linked to real-time tasks. Ibrahim (2008, p.2) notes that these operations in both physical and virtual contexts ‘can best be described as the fusion of worlds’. In extending these closed-loop, task-based strategies one can pick out the key elements of Ibrahim’s fused framework that impact upon networks or spaces for personal, learning development, namely:

- A defined “focus aspect”, like a personal aim or need;
- The provision of personalised signals and feedback mechanisms through interactive, social media that enable users to regulate their actions and development;
- Personal mastery over new resources, networks or literacies, which promote certainty; and
- Social or networked rules or frameworks that enable the robust management of uncertainty, whilst enabling a dynamic engagement with change.

In the fusing process, open applications and networks are connected technologically and cognitively by the individual to provide a place for action and identity formation. The most important element is the impact of feedback and signals that are passed between an individual and both their preferred media forms and their networks (Boekaerts et al., 2005). The feedback loops that occur empower users to construct ways of acting (Nicol and Macfarlane-Dick, 2006; Vygotsky, 1978), and thereby to confront and control their uncertainty about working within academic cultures, or engaging with academic tasks, or evaluating and creating academic content. Where such uncertainties are controlled or made certain, this activity positively reinforces a user’s actions or decision-making processes (Barnett, 2008).

This fusion of educational spaces is itself impacted by the role of technologies. There is increasing evidence that e-learning is rarely seen as separate or special by learners and that academically they are deploying a mix of personal and institutional technologies over which they have more choice, access and control (JISC, 2007). The JISC LXP project (2007) argued that there is an increasing complexity and blurring of boundaries between the formal and informal use of technologies. In turn this facilitates advanced networking and the development of new critical literacies. As Jeffs and Smith (1990) note, separate learning environments are viewed in different ways, depending upon the information and people who operate within them, and the relationships that are formed between those ‘resources’ and a particular user.

In the fusing process, open applications and networks are connected physically and cognitively by the individual to provide augmented places for action and identity formation (Mixed Reality Lab, 2008). This does not produce a simulated reality; rather it enables the user to engage with real uncertainties, through participation with tasks and feedback loops. For instance, students on placement might experience enhanced project work using mobile devices and social networks. Equally, networks of users might fuse hardware, media and content to produce shared stories. The most important element is the impact of feedback and signals that are passed between an individual and both their preferred, mixed media forms and their social networks. These have the potential to augment ubiquitous, experiential learning (Educause, 2005), and empower users to construct ways of acting (Vygotsky, 1978), and thereby to confront and control uncertainty. Where uncertainty is controlled or made certain, it positively reinforces a user’s actions or decision-making processes (Bandura, 1977). The ways in which a user can fuse informal and formal personal resources, networks and literacies underpins their assemblage of a meaningful PLE.
5. Assemblage of fused personal learning environments

The Ravensbourne Learner Integration project (JISC, 2008a) argues that a PLE is ‘a learning environment that is assembled through learner choice’. It encompasses the personalised aggregation of tools, networks and content from a range of formal and informal places. This aggregation can exist in several places or be presented in one space, depending upon the nature of the personal tasks to be undertaken, or the specific aim to be achieved. In this way the learning context, and both the learning that takes place and the artefacts that are produced within it, are owned and controlled by the individual student, rather than the institution. The read/write web underpins this approach by dint of its user-centred, participative and networked affordances (Anderson, 2007).

The interactions between an individual and their environment lead to reciprocal determinism, ensuring that both individual and environment are changed. In this model, learning is a combination of watching, thinking and trying (Kolb and Fry, 1975). When a person succeeds in a task s/he becomes more confident and more willing to take on new operations. The situated nature of this practice is highlighted by Tennant (1999, p. 170), who stresses how expert knowledge and skill can be gained from everyday social experiences at work, and in community or family, and how personal mastery can be forged through goal-directed behaviour with appropriate feedback. Given the growing impact of read/write web technologies on educational processes, it is important to evaluate the personal impact of social tools in a range of formal and informal settings, in order to develop a critical understanding of how PLEs are assembled and fused in specific domains.

The PLE offers us a complex view of learning environments based upon differentiated user needs (JISC, 2008b). The Ravensbourne Learner Integration project (JISC, 2008a) has developed an assemblage model that focuses upon the individual’s transition from private to public learning in the context of social software and communities of practice.

The Learner Integration model is important because it highlights the links between: personal mastery in specific domains; social learning in communities or associations of practice; and social media and technologies. It highlights how self-education and critical literacy are enhanced through active...
participation with user-centred media and within groups that make sense to the individual. This frames a constructivist paradigm where learners can situate themselves, in order to make and record actions, to reflect on those actions, to share decisions and thoughts with others, and to represent aspects of their identity within validated networks.

Defined environments for learning are unique to each learner based on their learning aims. Moreover, they are fused from specific formal and informal associations using social media, where meaningful, rule-based signals can be processed into action. Therefore, the context surrounding the Learner Integration model is enhanced through Ibrahim’s (2008) fused framework. By integrating and making explicit the elements that focus upon the development of the learner’s focus aim, her/his signal processing and network rules, Ibrahim’s (2008) fourth theme relating to personal ways of managing uncertainty and anxiety can be addressed. Thus, it is possible to refine the technological, social and cognitive links made by the individual in overcoming uncertainty and developing mastery. This accords with the view of Illich (1971, pp. 77-8) that the key question is not ‘what should someone learn?’ but ‘what kinds of things and people might learners want to be in contact with in order to learn?’

For Illich education was owned by the individual in becoming a self-aware actor, and he also argued (1977, p. 31) that the questions individuals are empowered to ask coupled to the socio-technical tools available to them, supports personal emancipation. The read/write web affords tools for encouraging individuals to associate with each other in contexts that support doing, questioning and re-conceptualising (Siemens, 2008). Linking the four strands of the fused learning spaces framework into the Learner Integration model scaffolds an adaptive, environmentally-flexible toolset that furthers participation through personally-focused activity.

Figure 2: e-Learning in context, a Fused Learner Integration model

Individual students can develop their own approaches to conceptual mastery, and in the process of successfully modelling their learning they are able to overcome academic uncertainty. Such modelling is underpinned by their proximity to formal and informal associations, which are personally meaningful in enabling a learning aim or focus aspect to be achieved (Siemens, 2008). In turn the rules and
frameworks that are negotiated within these networks, associations and communities frame a fused learning space for making environmental sense of signals and feedback. Therefore, evaluating the personal, fused spaces in which users operate and produce is critical in understanding how the read/write web offers opportunities to extend learning opportunities in higher education.

6. A note on context and evaluation

The discussion that follows pivots around the impact on the development of fused personal learning environments of deploying read/write technologies within one UK university. The evaluation is designed to analyse conversations about emergent curriculum approaches, in order to examine how the tools provided are being embedded, and to align that view with student expectations. It focuses upon the triangulation of two data sources.

- Student evaluations: in-depth interviews and on-line focus groups with 129 students at all levels, including postgraduate, in all five University faculties between 2005-08; and
- Staff evaluations: in-depth interviews with 11 staff before, during and after they introduced read/write technologies into their curricula.

The evaluator did not focus conversations upon the implications of the read/write web for developing PLEs. Rather, the approach engaged with understanding the systematic implementation of e-learning innovations and their impact on learning and teaching, in order to support the critical, reflective, accountable, self-evaluative and participative improvement of practice (Zuber-Skerritt 1992, pp. 14-17). Thematic content analysis was used in order to unpick and capture the emergent themes from the interviews. The interviews were conducted and the coding scheme was framed and tested by the same evaluator in order to maintain an internal consistency of approach. The coding scheme was iterated over time using two separate samples of ten interviews, and tested by a peer working in a clinical psychology context (Boyatzis, 1998; Joffe and Yardley, 2004). Thus, this latitudinal evaluation examines what students say about the impact of the read/write web on their learning experiences, in order to provide a pragmatic description of their expectations for the use of those tools and approaches in the curriculum (Reason and Bradbury, 2001). This accords with the view of Reason (2003, 106) that the ‘fundamental strategy of action research is to ‘open communicative space’ and help the emergence of ‘communities of inquiry’.’ This approach becomes rigorous through consensual participation. As Elliott (2007, p. 159) has noted: ‘the democratic process of enquiry determines... which descriptions of the human environment, natural as well social, best enable human beings effectively to interact with it to satisfy their needs and desires.’ (Elliott, 2007, p. 161).

7. Emergent outcomes

Table 1: Themes from interviews and focus groups with students in 2005-08 on their experiences of e-learning in the curriculum (129 interviewees)

<table>
<thead>
<tr>
<th>Outcomes 1: personal ways of managing uncertainty through contextual control [aligned with the Tools of the Fused Learner Integration model]</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A focus on personal boundaries for an environment: use of terms like ‘involvement’, ‘conversations’ and ‘agreement’</td>
<td>45</td>
</tr>
<tr>
<td>A focus on personal control of tools: discussion of terms like open access technologies, variance of use and shared communication</td>
<td>71</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcomes 2: networked rules for access and participation [aligned with the Rules of the Fused Learner Integration model]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A focus on dialogue between networks of learners-as-peers, and learners-with-tutors</td>
<td>39</td>
</tr>
<tr>
<td>A focus on aspects of access and participation between networks of learners-as-peers, and learners-with-tutors</td>
<td>62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcomes 3: interpreting signals through associations [aligned with the Personal signal processing of the Fused Learner Integration model]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A focus on the impact of collaboration through technologies on specific academic tasks</td>
<td>44</td>
</tr>
<tr>
<td>A focus upon feedback on specific academic tasks, supported by technologies</td>
<td>49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcomes 4: towards a focus aim of critical literacy [aligned with the Focus aim and Personal mastery of the Fused Learner Integration model]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A focus on personal domain-specific learning outcomes</td>
<td>65</td>
</tr>
<tr>
<td>A focus on personal ontological outcomes</td>
<td>32</td>
</tr>
</tbody>
</table>
The conversations with students and staff about the read/write web were designed to test assumptions about the personalised use of these tools. However, only a subset of interviews developed in directions whereby a dialogue could open up and be classified in terms of the Learner Integration model or the developmental aspects of the fused model. As such, appropriate themes emerged from the categorisation of what students and staff themselves said about its broader influence on their learning and teaching. This categorisation of conversations with students pivoted around their discussion or use of specific terms or foci that can be interpreted to signify particular themes. Those which are captured in Table 1 are those with the highest frequency.

In the scoping discussion that follows, each of these themes is linked to the perceptions of eleven staff as elicited from detailed conversations with them about innovation in the curriculum. It should be noted that the evaluator found no differences on these themes: across subject areas; between distance and local learners, or between undergraduates and postgraduates.

8. Outcomes 1: personal ways of managing uncertainty through contextual control

A focus on who sets the boundaries for a learning context is linked to who controls the types of tools that can be used therein. The control of the connections between formal and informal education is a personal enabler. One level two student noted that ‘staff define the use of technologies and students expect to be told what to do.’ The programme tutor believed that this was because ‘they don’t come in with enough ideas, but I would like this to change over time, that they talk to each other, in MSN etc. and share thoughts and values.’ However, for those students who raised issues around control and ownership, a passive view was not the norm, for instance a distance learning student argued that ‘I feel like we are penalised by being forced to attend [face-to-face] sessions rather than building our own independence and autonomy and authority in the workplace.’ A level three undergraduate concurred arguing that ‘an integrated system is the way forward – something that allows the academic and social functionality to be personalised… I think it is important to apply real-life tools to education.’

In part student expectations for more control of their learning environment are shaped by their agency and confidence in relation to the tasks and tools at hand. A first-year student argued that ‘I’d like spaces to work together with people I know. I don’t want to make a fool of myself with people I don’t know’. Understanding the point of a tool contextualised by a learning task requires facilitated deliberation amongst a cohort, which enables students to find ‘the right place’ for the use of web-based tools. A third-year student had a mature view on this issue and stated ‘I like personalised tools, web media, animations, YouTube and that, and I like feeds that connect them like my Firefox toolbar that has good navigation based upon my thought processes and preferences.’

Personal contextual preferences also impacted upon views of staff engagement in student-led spaces. One learner commented that ‘Teachers can join Facebook, and if we ran a group maybe they could just see a small portion of your page, rather than all of your personal and professional life.’ For some staff, student control of the use of non-institutional, read/write tools, and their subsequent impact on formal learning was problematic. One felt that ‘many staff feel threatened and challenged by technological innovation that widens student aspirations’. A second tutor added perceptively that ‘the students have discovered and use web-based [tools] – they are migrating themselves into industry toolsets. We need to adapt.’ This adaptive view was also held by a student representative who argued that ‘this normally explicit division between the academic and the social spaces could easily become blurred with use of Web 2.0, and therefore learners must understand where boundaries should be placed to ring-fence both the personal and academic experience these tools offer.’

9. Outcomes 2: networked rules for access and participation

The critical theme of negotiated rules for access and participation within curriculum groups emerged from the student interviews. One learner ‘liked the fact that group pages were only seen by us and no-one else, and I can find out what the other group members are contributing to the work. We can then decide who to send information to’. For some students access and participation stemmed from the personal efficacy of tools that could be used both formally and informally. A level one learner highlighted that subscription was a critical means of access to the curriculum: ‘not everyone will have iPhones and video or audio, but most text, and can subscribe to stuff. That way I could get critical announcements and reminders’. This places value upon a curriculum that connects individual ways of working to a personal ability to access adaptive tools and strategies.
For some cohorts of students, the use of tools outside the control of the teaching team was critical in building a rationale for access and participation. One postgraduate argued that ‘we built the community between us and now I am less apprehensive about getting feedback. It removed the fear of isolation’. This was echoed by a second postgraduate: ‘we need social engagement and debates about practice. In the end we set up our own MSN chat room to move to total ownership of our learning.’ Both students felt that the differences between group members were overcome by a shared participation in a defined learning context.

This proactive strategy for connecting learning contexts using different read/write tools was not uniform. One level two tutor argued that this mindset takes time to emerge and that these read/write tools would affect ‘participation in the formation of their own project [group] identity, [and] it will be interesting to see how this affects their overall sociability’. This type of participation, within a context that respects the differences between students and fosters a space for personal action, was echoed by a separate lecturer:

The Web2.0 software is ‘owned’ and editable by them, and they can see what each other have done and all are free to comment... what staff say has to be encouraging and of value, emotionally, technically, educationally, within a set of guidelines that promote active interest.

The level of active interest, facilitated by local environmental control and participation, is spurred by personal proximity to relevant networks and associations.

10. Outcomes 3: interpreting signals through associations

Most curriculum interactions are fixed within institutionalised spaces. However, for some students external associations with validated others hold most value. One level two student drew these matters together:

I use Web 2.0 technologies because it is an interest thing. I am able to say ‘I found this and what do you think?’ It is a process of self-validation, to have opinions outside [the University]. I want an external view, a wider opinion on my work. This is not what people are taught, but outside experience is important in practice.

For a sub-set of students the ability to manage their work through dialogue with non-institutional networks is critical in their own reflexive assessment of personal progress. A second, level two learner noted that ‘I don’t want a closed view. Making my work more abstract is important – my identity is defined externally and I like to go off on my own and work with others. I like [our use of read/write tools] as it is an extension of my way of working.’ This sense of shared, open validation was important for one programme team: ‘We encourage students to share their resources with others via wikis, del.icio.us, and other open applications’. This demonstrates a mastery over the intended curriculum outcomes and develops trust and validity in the production of personal and social assets. Thus, a complex set of approaches exists in the fusion of informal and formal learning contexts enhanced by the interpretation of signals. A distance learner using synchronous classrooms noted how they ‘are a good community building tool with opportunities for us to learn in teams, allowing you to gather knowledge and experience and ideas quickly and share it.’ However, a level one student highlighted that the extension of personal skills in virtual worlds, like Second Life, was forged out of shared interests between wider groups of people. He noted that

the first thing we did was explore places that looked good and where people had already solved the problems we had. We talked to them about this about how they had solved problems. They talked to us because we were using the same language, and they could get something from us.

One of his peers went on to argue that this impacted his creativity: ‘I can understand the programming but it is the creative side that has changed, because I have had to work outside our normal group.’

This demonstrates the strength of associations based upon common interests in promoting mastery and conceptual understanding, through signal processing and trusted feedback. These associations are underpinned by personal control over the deployment of read/write technologies. A student in a different cohort noted that ‘We all have MySpace sites – they are more interactive and I can get to know people or even get constructive feedback from strangers. If someone has an opinion it’s great; it’s simple and I get to re-think my space.’ For one tutor this crystallised around the value of ‘exposure...
to the use of technologies in a variety of creative and discursive ways... the students do understand the tools and know about the issues.'

11. Outcomes 4: towards a focus aim of critical literacy

Developing association and participation, in negotiated informal and formal educational spaces, can enhance critical literacy. One learner highlighted how she valued 'the ability to hear other people's views and have the opportunity to express mine' but that 'I would like to see more collaboration between lecturers and students in order to make learning more interesting.' The process of sharing and modelling practice helped students manage curriculum anxieties, as one second-level lecturer highlighted:

*The Web 2.0 software is ‘owned’ and editable by them, and they can see what each other have done and all are free to comment... what staff say has to be encouraging and of value, emotionally, technically, educationally, within a set of guidelines that promote active interest.*

The level of active interest, facilitated by local environmental control and participation, spurs critical thinking, and the development of collaborative strategies for managing uncertainty. Situated support was seen as vital in enabling learners to enhance their educational experiences. A first-year student argued 'I accept that we need to move to total ownership of our learning but we still expect a graduated level of support throughout.' A peer agreed and highlighted that in developing critical literacy in a particular subject area ‘our ownership of blogging tasks means that we have to get used to tagging and linking and thinking like this'. A level two tutor concurred with the use of these tools for personal ownership, arguing that ‘the better students had a quality and depth of notes that went beyond a set text to produce more original thinking that was linked to a topic of personal interest. They took time to personalise their case studies'.

A separate postgraduate student highlighted the value in extending their academic writing of blogging: ‘There is a much more relaxed feel about writing a blog, it’s much more natural and still has the potential to raise one’s writing ability.’ This learner went on to argue that informal, reflective writing enhanced her critical engagement in structured teaching sessions: ‘You have to read and discover and discuss these in the tutorials and so the blog complements and summarises points.’ For this learner, the experience of discovery through read/write web tools helped to fuse formal and informal educational literacies and enhance her subject-specific mastery over time. This longer-term approach was reiterated by a level three student: ‘I like the idea of constantly updating [the blog], so you have to think about it and develop personal ideas over time'

However, for some students simply having access to a personalised technological space is an issue in developing critical literacy. One first-year student noted that ‘next year we will have broadband in the flat – it was the first thing we organised. Last year we didn’t have broadband and I was [disappointed]. It is a necessity when you are at university, especially as the library is [busy] at assessment times’. These issues of technological access and marginalisation mean that universities cannot presume that all of their students are able to enhance their learning in a wide range of informal and formal educational networks. Managing the impact of technological uncertainty and anxiety on curriculum disenfranchisement is critical for higher education.

12. Conclusion

The read/write web offers ways for users to personalise their online existence, and to develop their own critical identities. User centred, participative, social networking tools enable learners to create informal associations or communities of practice, in which to develop their own subject-based mastery. By fusing web-based tools into a task-oriented PLE, students gain control over their learning experiences. Moreover, they are able to define who they share those experiences with, and to connect their informal educational lives to their formal, institutional work. This fusion is a product of control in four key areas.

- A defined “focus aspect”, like a personal aim or need;
- The provision of personalised signals and feedback mechanisms through interactive, social media that enable users to regulate their actions and development;
- Personal mastery over new resources, networks or literacies, which promote certainty; and
• Social or networked rules or frameworks that enable the robust management of uncertainty, whilst enabling a dynamic engagement with change.

The structuring of personal learning spaces that enable users or social networks to manage these four areas is enhanced by read/write web approaches and tools, and can be modeled through an extension of the Ravensbourne Learner Integration model. This Fused Learner Integration model highlights the impact of personal aims, tools and rules, within closed, task-specific loops that enable signal processing to take place. In this way, one can begin to see how students can make contextual sense of their learning, develop their own approaches to mastery and extend their own learning opportunities. By utilizing these applications and their ways of working, formal and informal educational spaces can be fused, in order positively to extend participation and the development of critical literacy. As a student representative highlighted 'It is important for the learner to have control over the tools they use and to make informed choices about how to use them.’ The contextual control available to learners in personalising their own learning environments, their modes of access and participation within multiple networks, and the associations that are made in those contexts enable those learners to overcome uncertainty. In this way, the read/write web can proactively shape the means for the production of educational outputs through its affordances for the creation of fused learning spaces.

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An e-Class in Action: Experiences with ICT-intensive Teaching and Learning of Discrete Dynamical Models at Secondary School

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Abstract: In 2007, a small team of university and secondary school teachers jointly developed and piloted an e-class for 4th and 5th grade students (age: 16-17yrs) at both pre-university and general vocational level. The goal was to develop and try out innovative ways of teaching mathematics that would enable schools to offer optional courses for small numbers of students. The e-class can be summarized as web-supported instruction in a blended learning approach. The instructional material consisted of the chapter on discrete dynamical models from a brand-new mathematics textbook, supplemented by investigative activities. Students could build and simulate dynamical models with the computer learning environment Coach. Instructions for learning to work with software were given through screen casts created by the teacher to gear with students’ needs and made available in the Sakai-based virtual learning environment. Students got weekly on-line assignments, which they submitted digitally. At home they could get assistance from peers and the teacher in a chat room. We discuss some of the e-ingredients of the e-class and their potential for teaching and learning mathematics and science in terms of principled design approaches to multimedia learning and pedagogical arrangements. We report the experiences of the participants of the project and present the future plans based on this work.

Keywords: e-learning, blended learning, multimedia learning, e-learning implementation, screen casts, secondary mathematics education, discrete dynamic models

1. Background

The design and implementation of an e-class and the future plans regarding this form of blended teaching and learning cannot been seen apart from curriculum reforms and changes in the Dutch education system that took place in secondary education in the Netherlands in the last two decades and from the reforms still under way (For details about the Dutch education system we refer to documents of the Ministry of Education, www.minocw.nl). In particular the implementation in 1998 of the so-called 'Second Stage', that is, the upper secondary education, had a strong influence because it introduced many new concepts for education and it introduced new national curricula. Until 1998 students had been free to pick their own combination of examination subjects. This free choice was replaced by a selection of one of four fixed subject combinations. These four subject combinations, called 'profiles', are: (1) Nature & Health, (2) Nature & Technology, (3) Economics & Society, and (4) Culture & Society. The first two profiles form the category of ‘Nature Profiles’; the last two profiles are categorized as ‘Society Profiles’. The Second Stage was adapted in 2003 (reduction of study load was one of the issues) and renewed in 2007 (introduction of new study programs). All profiles consist of a common core of subjects plus a number of specialized subjects and an optional component. The common core of subjects provides knowledge and skills of general educational value. The specialized subjects in the profile determine for which higher education studies a student can apply. In the optional part, individual accents can be laid. To enable individual learning paths in a certain profile, school examinations have been introduced next to the nationwide, written examination. In this educational setting, students are required to carry out some practical investigation tasks and one rather large, cross-disciplinary research or design assignment, called the ‘Profielwerkstuk’ [Profile Project].

Table 1 shows the curriculum and study load of the Nature & Technology profile in pre-university secondary education as of August 2007, when the ‘New Second Stage’ got implemented. This profile prepares for a university study in exact sciences and engineering.

Not only the education system and the list of curriculum subjects changed in the last decades, but also the educational goals, subject matter, teaching materials, and teaching methods underwent significant changes. This holds especially in mathematics and science education. For the context of
describing the e-class project, we can restrict the discussion to the newly introduced subjects ‘Mathematics D’ and ‘Nature, Life and Technology’ (henceforth abbreviated as NLT, but also called ‘Advanced Science Mathematics and Technology’ by the Steering Committee on their web site http://betavak-nlt.nl/English/)

Table 1: Curriculum and study load of the Nature and Technology profile in pre-university secondary education.

<table>
<thead>
<tr>
<th>part of the study programme</th>
<th>Subject</th>
<th>study load hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>common to all profiles</td>
<td>Dutch</td>
<td>480</td>
</tr>
<tr>
<td></td>
<td>English</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>2ⁿᵈ foreign language (German or French)</td>
<td>480 (600)</td>
</tr>
<tr>
<td></td>
<td>(or a classical language at a Gymnasium)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Studies</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Culture and Arts (or Classical Culture)</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>General Science</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Physical Education and Sports</td>
<td>160</td>
</tr>
<tr>
<td>compulsory part</td>
<td>Mathematics B</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
<td>480</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>440</td>
</tr>
<tr>
<td></td>
<td>Profile project</td>
<td>80</td>
</tr>
<tr>
<td>one subject to choose from</td>
<td>Mathematics D</td>
<td>440</td>
</tr>
<tr>
<td></td>
<td>Informatics</td>
<td>440</td>
</tr>
<tr>
<td></td>
<td>Nature, Life and Technology</td>
<td>440</td>
</tr>
<tr>
<td></td>
<td>Biology</td>
<td>480</td>
</tr>
<tr>
<td>free part</td>
<td>at least one subject to choose freely from</td>
<td>440</td>
</tr>
<tr>
<td></td>
<td>all school subjects with an examination</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(optionally, depending on the school)</td>
<td>(400)</td>
</tr>
<tr>
<td></td>
<td>a subject of free choice</td>
<td></td>
</tr>
</tbody>
</table>

The optional ‘Mathematics D’ is only offered to students in the Nature & Technology profile and aims at deepening of understanding mathematics and at extension of mathematical knowledge and skills through separate modules. Statistics and probability theory, dynamical systems, or a topic like complex numbers are examples of extensions. The deepening comes to the surface in topics taken from a scientific or technical context such as cryptography, graph theory and discrete mathematics, optimisation, and the mathematics of traffic. ‘Nature, Life and Technology’ (NLT) is a new, integrated science subject offered to students in both nature profiles that aims to create coherence in the different subjects of the sciences and to make the natural sciences and technology more attractive. It is based on a modular structure with domains such as communication and navigation, health and healthcare, biomedical technology and biotechnology, earth and climate, stellar information and processes, and biophysics, biochemistry and bioinformatics. Examples of modules have titles like ‘forensic evidence’, ‘sports records’, ‘partying and no hangover’, ‘zero-energy greenhouse’, ‘aerosols and clean air’, ‘MP3-player’, ‘pharmacology’, and ‘dynamic modelling’.

The lists of possible contents of ‘Mathematics D’ and NLT illustrate that these optional subjects aim to tackle the problem that (1) exact sciences have little attraction for students because the school subjects are not challenging and seem disconnected with new developments in society, mathematics, science and technology, and (2) that, as a consequence of this lack of appeal, too few students choose a follow-up study or profession in these fields.

The implementation of the new curricula has to contend with difficulties of a rather short preparatory period, a lack of modern and advanced equipment at secondary schools, and a shortage of qualified teachers who have enough scientific baggage for teaching the new mathematics and science subjects. To tackle these problems in the region of Amsterdam an initiative, called the ‘its academy’ (www.itsacademy.nl), was started in 2007. Within this framework, staff members from about forty secondary schools and four higher education institutes jointly design and implement the new offer of curriculum materials. Because of the real danger that not enough students would choose Mathematics D or NLT, and consequently teaching can only be done cost-effectively within a cluster of schools, the potential of e-learning in conjunction with classroom activities at cluster level and practical work in the its-labs at the higher education institutes has been examined. Table 2 shows the percentages of schools offering these new optional subjects and the percentages of students selecting these subjects in the study year 2007/2008 (Tweede Fase Adviespunt 2008). These figures must be read within the perspective that the percentage of students choosing a nature profile
increased recently to 22% and 26% for the Nature & Technology and Nature & Health profile, respectively.

In May and June 2007, a pilot study of e-classes Mathematics D with a study load of 40 study hours was carried out. About three hundred students from 4th and 5th grade (age 15-17) at both pre-university and general vocational level, from fifteen classes at four schools, participated. Only a minority of the students belonged to the envisioned group of motivated and mathematically competent students who would choose the optional Mathematics D subject in their Nature and Technology profile. However, because we thought that the new style of teaching and learning would also be relevant for mathematics courses at other levels of education, we tested the new approach with a diverse group of students to get experiences from many directions. The mathematics subject was number sequences, recursive formulas and discrete dynamical models. It was taught from a chapter in a brand-new book appearing in the largest mathematics textbook series in the Netherlands and supplemented by investigative activities on quantitative pharmacokinetics and alcohol metabolism (Heck 2007; for lesson materials, see www.science.uva.nl/~heck/research/alcohol), approximation of roots, and bouncing balls (Heck et al 2008). We discuss some of the e-ingredients of the e-class and their potential for teaching and learning mathematics and science in terms of principled design approaches to multimedia learning and pedagogical arrangements. We report the experiences of the participants of the project and present the future plans based on this work.

Table 2: Percentages of schools offering and students selecting the new subjects in 2007

<table>
<thead>
<tr>
<th>subject</th>
<th>schools chosen (average)</th>
<th>male</th>
<th>female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics D</td>
<td>71% 7%</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>NLT</td>
<td>38% 8%</td>
<td>10%</td>
<td>6%</td>
</tr>
</tbody>
</table>

2. What does an e-class look like?

Harm Houwing is an experienced mathematics teacher at the municipal comprehensive school in Schagen, North Holland, and he is also author of the mathematics textbook series ‘Getal en Ruimte’ concerning Mathematics B (for senior secondary education) and Mathematics D. In collaboration with six teachers from Bonhoeffercollege (Castricum), Bertrand Russell College (Krommenie) and Goois Lyceum (Bussum), and three staff members from the University of Amsterdam and the Free University Amsterdam, he designed and implemented an e-class for his 4th grade pre-university students (age: 16yrs) on the subject of discrete dynamical models. We use this course to exemplify what the e-class concept is.

One of the ideas behind the set-up of an e-class was to develop a rich electronic learning environment equipped with study guides, digitised lesson materials, software for learning and doing mathematics and science, video instructions, animations, (self-)assessments, chat functionality for students and teachers, and so on. Central is the blended approach, here considered as a combination of online learning and face-to-face education at school, in which various methods of delivery of instruction are used in such way that schools where there are only few students who choose Mathematics D (or some other optional course) are still able to offer the course effectively as a partner in a cluster of schools. Actually, the broader definition of (Heinze and Proctor 2004) for blended learning in higher education – “learning that is facilitated by the effective combination of different modes of delivery, models of teaching and styles of learning, and founded on transparent communication amongst all parties involved with a course.” – seems to us more applicable to the e-class setting. We will adopt this definition, acknowledging that there is no universally accepted definition of blended learning (Whitelock and Jelfs 2003; Bonk and Graham 2006) and that there are some serious doubts about its conceptual integrity (Oliver and Trigwell 2005). In the rest of this article we look into the different modes of delivery, models of teaching, and styles of learning.

The set-up of the pilot course given by Harm Houwing was both simple and complex. Students received a preprint of the chapter on discrete dynamical models from the brand-new textbook for Mathematics D to work with. The PDF-version of this chapter and the study guide, which informs the students about their weekly assignments, were put online in the Sakai-based virtual learning environment (VLE) to which all students of his class had access. Students learned to work with number sequences and recursive formulas, and they learned to build and simulate discrete dynamical models with the computer working environment Coach (Heck et al 2009; see also www.cma.science.uva.nl), the modelling and data video version of which they had received to work with at home. Instructions for learning to use this software and other programs like Excel and the
graphing calculator were mainly given by means of screen casts that were created by the teacher and were made available in the VLE. A screen cast, a term coined by Udell (2004, 2005), is “a digital movie in which the setting is partly or wholly a computer screen and in which audio narration describes or explains the story on the on-screen action.” In this way, students did not need to get separate instructions on tool use or find their ways through long manuals. Students were requested to hand in their answers to some of the online assignments through the request-and-delivery system for exercises inside the VLE: this homework could be a Word document, an Excel sheet, a Coach result file, or whatever appropriate digital document. Students got partial credit for their homework. For personal transfer of documents between a student and the teacher (for example, to get dedicated help or advice on a task, or for the simple reasons that homework could not be delivered within the scheduled timeframe), the drop box facility of the VLE was convenient. Students used the chat facility of the e-class to keep in touch with their peers and the teacher during the course: they could discuss exercises, ask each other for further information or explanation, and so on. And last but not least, students could still meet the teacher at school and ask questions, discuss homework, and so forth. Weekly meetings between teacher and students were scheduled. After all, face-to-face contact in education remains highly valued! The course ended with a written test and a computer-based assessment. Thus, the assessment of the students is in accordance with the way they had studied the subject contents.

The complexity of the e-class setting lies in the well-known fact that mere use of ICT in education does not lead to good quality of learning. The major challenge for a long time is how to find the right mix for a blended learning arrangement with regard to content, knowledge construction, communication within a regular curriculum setting (Laurillard 2002; Kerres and de Witt 2003; John and Wheeler, 2008) that leads to meaningful learning, and how to initiate, sustain, and structure interaction and enhance its quality (Hannafin 1989). In the design of the pilot e-class we have based our decisions mainly on the teachers’ experiences, research-based design principles of multimedia learning (for a collection of papers see Mayer 2005), and principles of learning sciences for the design of pedagogical arrangements (for a collection of papers see Sawyer 2006). Below we exemplify this in the description of the virtual learning environment and some of the e-ingredients.

Figure 1 shows the opening screen of an e-class after logging in. It is kept as simple as possible so that navigation through the instructional environment is easy. On the left-hand side is the list of facilities; from top to bottom they are the link to the home page of the course, the study guide, the agenda, the archive of announcement, the documents related to the course (also Coach files and tutorial video clips to work with), a discussion forum, the list of assignments, the list of grades, the drop box, the chat room, e-mail, and a quick link to the web site of the school. The midsection of the home page is used for general information and on the right-hand side a student can see the most recent announcements and chat lines.

![Figure 1: Opening screen of an e-class session](image-url)
The study guide is very explicit about what the students are expected to do in a particular week and if there are assignments for which they should send in their answers. In the screen shot shown in Figure 2, a student is informed that (s)he is supposed to practice with Coach 6: the advice is to watch the screen cast on modelling inside the Coach environment the elimination of a medicine from the human body and hereafter try to make a computer exercise. Later on (s)he must watch the movie on predator-prey models and learn a bit more about computer modelling of such mathematical systems. The student is referred to exercise 81 of the textbook and the corresponding modelling activity file on the web. The translation of this exercise in Figure 3 shows that it is a rather standard mathematical exercise on population dynamics. Once the student has finished these preparatory tasks, (s)he can form or join a small group of peers and carry out part of the practical investigative task on clearance of drugs and alcohol from the human body. The teacher’s strategy was not to make a study guide for the entire course in advance, but to prepare it only one week ahead so that he could anticipate the progress or study load of his students in the current week. This allowed him for example to create a screen cast related to difficulties that a large group of students actually had during the week, to give some additional explanations, and to prepare extra tasks. It is a form of just-in-time teaching. Besides, it is for the teacher one of the available communication channels to interact with his students, to motivate them, and show interest in their needs.

Figure 2: A sample page of the study guide
In a closed wildlife park lives a population of foxes. This population of foxes is divided into three age classes, namely:

- $Y$: young animals (0-5 years old)
- $A$: adult animals (5-10 years old)
- $O$: old animals (older than 10 years)

The chance that a young animal matures equals 0.68.
The chance that an adult animal gets old equals 0.30.
The chance that an old animal 5 years later is still alive equals 0.20.
Adult and old animals give birth to 90 fox cubs per 100 animals.
In 2006 there were 2500 young, 1200 adult, and 500 old foxes in the park.

a. Convert the data into system of difference equations.
b. Plot the graphs of $Y$, $A$, and $O$ in one diagram for the coming 50 years.

Because the number of foxes decreases, it is decided to enlarge the number of breeding places so that the birth rate will increase.
c. Investigate how large the minimum birthrate must be so that the population of foxes in the park does not become extinct in the long run.

When you set the step size in Coach6 equal to 0.2 you compute the annual population.
d. Plot in this case the graphs of $Y$, $A$, and $O$ in one diagram.
e. Investigate what happens with the number of animals when you take a very small step size.

What is in this model a realistic step size? Please explain your answer.

Figure 3: Fragment of the textbook with a Coach exercise on a population model

Another communication channel in the e-class is the chat room in which students help and motivate each other. At the beginning of the e-class it was made clear that this kind of collaboration was greatly appreciated and that idle chatting would not be tolerated. The main idea was that students working at home could overcome difficulties through discussions with their peers and the teacher in the chat room. The following snapshot of a chat session (translated and made anonymous) illustrates how such discussions went and were hardly off topic. At the same time it shows when students were (still) working in the e-class. In the session below, most of the talking was about using the Coach software. To understand what went on this chat session it is important to realize the students could always see on their screen who was present in the chat room and that they knew that they could be monitored. The teacher regularly participated in the discussion and often learned about the students’ difficulties or their ease with the subject contents from the chat sessions.

---

T (17:50 CEST) hi L, do you get the third of a??:
T (17:50 CEST) of the coach exercise..:P
L (18:28 CEST) No, havn’t started with it yet sorry
L (18:28 CEST) I must first get that other
L (19:36 CEST) I always get ”time not specified" ???
L (19:40 CEST) Has someone else this too?
L (19:42 CEST) T come to msnmnn!
J1 (20:01 CEST) Does anyone know how to do the Coach task (of skating) b
J1 (20:01 CEST) so, how to compute the final score?
L (20:04 CEST) That is where I am too... and I also do not get it
L (20:04 CEST) I placed behind the outflow arrow a state box and at the outflow arrow 1.01*... but that does not work well :P
L (20:05 CEST) Oh no thatis another! The last of a thus that I do not get
J2 (20:11 CEST) I also do not get it at all L!
J2 (20:11 CEST) did you finish 10 and 14?
J1 (20:13 CEST) there you must add an inflowline 0.01.
J1 (20:16 CEST) because you miss that, say, thus you must do 0.01*speed (or whatever name you have used)
A (22:15 CEST) hey H
A (22:15 CEST) do you like the energy week
H (22:25 CEST) Hey A, that goes smoothly now:D
H (22:29 CEST) Did you really understand the coach task?
A (22:31 CEST) mwoah
A (22:31 CEST) it was not that easy
A (22:31 CEST) but my dad helped me a bit
H (22:32 CEST) Question: have you done b and c following the method of Houwing, ie letting something flow away, or so?
L (22:51 CEST) whaaa finally done :O
T (23:02 CEST) L...how should you do b of that coach task?
T (23:03 CEST) should you make a new model orso?
J2 (23:07 CEST) yeah
J2 (23:07 CEST) I am finally done
J2 (23:07 CEST) sweet dreams!!!!!!!

**Figure 4:** Fragment of a chat session between students in the evening

You may wonder about what kind of learning activities the students have been chatting. To give you an idea and to illustrate at the same time the use of screen casts, we show a predator-prey model that is implemented in the graphical modelling tool of Coach 6 and explained in a video clip. Of course, in written form, there is no way to demonstrate a movie, but the screen shot in Figure 5 shows a sample screen of the movie that is used to explain how to build and explore a simple predator-prey model through the graphical modelling tool of Coach, which is similar to the stock-flow approach of a system-dynamics-based modelling tool like STELLA. Students can watch the movie (also through a simple movie player that works on any PC) or go step-by-step through it while trying to make a similar exercise. The movie could also be used as a digital answer to the exercise made available to the students in the e-class after they have worked on the problem themselves.
Figure 5: Sample screen from a movie delivered thought the e-class and explaining Coach in the context of a mathematical model of a predator-prey system

3. Screen casting in the e-class

Besides the chat facility, which effectively supported the communication in the e-class, screen casting was the killer application appreciated by all students. This asks for a description of how the screen casts, i.e., the video clips containing a computer instruction captured for the teacher’s screen and a voice recording of the explanation that the teacher gives, were created and applied in the e-class. The success of our form of screen casting can be underpinned by research-based principles of multimedia learning.

For the creation of an instruction movie one needs the following equipment: a personal computer, standard headphones, a microphone, and screen capture software. The choice of the microphone and the recording software is most crucial for the quality of the created movie. One needs a high-quality microphone with enough noise reduction: we used the Samson C01U USB condenser microphone, [www.samsontech.com](http://www.samsontech.com), because it matches this criterion and is not too expensive. The choice of the screen capture software is large: Adobe Captivate, BB Flashback, Camtasia Studio, and so on. Ease of use and the quality (sound and image), format, and file size of the created movies are important issues. We are happy with BB Flashback, [www.bbsoftware.co.uk](http://www.bbsoftware.co.uk), in the sense that it is simple to use, not expensive, and creates small Flash movies of DVD quality. To give you an idea: a recording of a session that lasts 5 minutes leads to a Flash movie with a file size of about 1MB (depending on the compression used), which means that it can be quickly downloaded from the VLE to the computer of the student or teacher at home.

The aims of screen casting are simple: to allow students to

- see and hear the thinking and explanation of a teacher when doing a task;
- watch whenever and as many times they want;
- go step by step through an instruction;
- look at the whole process and not only at the final result of an activity.

The main benefits of the screen casts in the e-class are that they support student learning outside the classroom, function in case of software instruction better than user manuals or help pages, and help the teacher in the sense that (s)he can make optimal use of the face-to-face contact time with students. As Garner (2008) suggested, use of screen casts for feedback to student assignments and for answering student questions in areas of conceptual difficulty is also a strong option for learning support, the value of which should not be underestimated.

Teachers often think that it is difficult and time-consuming to make good screen casts, but as Fahlberg et al (2007) already pointed out this is not true. It is in fact more a matter of getting classroom experience in teaching with a computer, mouse, and possibly tablet technology than of getting familiar with technology. In addition, it can be from pedagogic point of view wise not to make movies of perfect software use, but to show students the real use of computer programs (with sometimes some idiosyncratic actions of users). In this way, the standards of tool use are not set immediately too high for students, they do not get the impression from clean and elegant teachers’ solutions that they themselves should be able in a straightforward fashion to work in a similar sophisticated manner, and there is space left for them to recommend improvements. One should also keep in mind that the movies have an instructional purpose and therefore must be professional, but not perfect, and that they must capture the actual process as naturally and authentically as possible (no artificial planning/scripting).

When it comes to movies in which mathematics or science concepts and methods are explained, then of course the standards of the content must be kept high. But also in such cases, once a teacher notices that students have some difficulty, say with a calculation, (s)he can quickly generate a screen cast to demonstrate a task or give an explanation, and then give another exercise to try. This concept of ICT support of learning has been applied consistently in the new ‘Getal & Ruimte’ textbook series: screen casts of mathematical exercises, which are supposed to be made with the help of software such as GeoGebra ([www.geogebra.org](http://www.geogebra.org)), Coach, or Java applets for learning and practicing school
algebra (Heck et al. 2007), have been created and the students can use them to learn and practice mathematics. Figure 6 exemplifies this idea: on the left-hand size a screen cast with explanation of how to solve stepwise an equation containing roots, and on the right-hand side a screen shot of an environment in which student can practice at various levels. It is our experience (see also Heck et al 2007) and of others (e.g., Bennedsen and Caspersen 2005; Fahlberg-Stojanovska and Stojanovska 2007) that screen-cast-based exercises encourage students and provide them the necessary scaffolds to carry out mathematical tasks and to practice skills.

**Figure 6:** A screen cast (left) on solving equations and a screen shot (right) of an exercise

Cognitive theories of multimedia learning (for a collection of papers see Mayer 2005) provide in our opinion a theoretical underpinning of the success of the screen casting in the e-class. Let us first linger upon the instructional design principles (cf. Mayer 2002; Sweller 2003) with regard to screen casts explaining the use of Coach, GeoGebra, the homework delivery system of the VLE, and so on. In comparison with written user manuals, screen casts as demonstration or tutorials of software packages reduce cognitive load because of the

- **multimedia effect:** a combination of verbal and pictorial material usually helps learners.
- **modality principle:** textual information is preferably presented in spoken language. Appropriate use of voice narration is consistent with Paivio’s (1986) dual coding theory.
- **split-attention effect** (aka ‘spatial contiguity and temporal contiguity principle’): Ciernak et al (2009) explain against the background of cognitive load theory why people learn better when words and pictures are physically and temporally integrated. In accordance with this, it is a clear advance when a student can listen to an explanation of tool use while watching at the same time what is going on at the computer screen, and does not need to split visual attention between viewing the computer screen and reading a tutorial.
- **personalisation, voice, and image principles:** people learn better when words of a multimedia presentation are in conversational style rather than formal textbook style and when the words are spoken in a standard-accented human voice; but people do not necessarily learn better when the speaker’s image is on the screen (this may distract students). A screen cast does not need to be streamlined: it is beneficial if students see in a screen cast an example of real tool use, including mistakes that are later corrected, searches in the menus for an appropriate item, user’s hesitations, and so on. This could be referred to as the tool-use fidelity of the screen casts, i.e., the alignment between the tool-use shown in the video clip and the way people work use the tools in real, practical work.
- **self-regulation principle:** video support works better when learners can replay fragments of the video clips as many timed as needed, that they can halt the video clip in order to think or try things out, and have full control over the items to look at in the screen casts.
- **redundancy and coherence principle:** people learn better when irrelevant or redundant information is not presented. ‘Less is more’ is a good slogan for screen cast design.
- **worked-out example effect:** learning from worked-out examples is effective for initial skill acquisition. This principle is robust (Schwonke et al 2009) and works well in a first learning phase, when focus is more on gaining understanding than on meeting performance demands. Students typically prefer this style of learning, but it can become detrimental when learners are already
more experienced and know how to perform the task (the so-called expertise-reversal effect, Kalyuga et al 2003).

The above principles are also applicable for the design of screen casts that deal with content, say mathematical tasks such as problem solving and algebraic manipulation. In a worked-out example one can pay attention to the problem formulation, chosen strategies, intermediate solution steps, checking of solutions, and so on. Hilbert et al (2008) give in this case the advice to gradually fade the support provided as learners make progress and acquire more knowledge and skills, and to include self-explanation prompts (like question 81e shown in Figure 3) in order to help students become self-reliant, competent, and self-confident. One can also improve learning with multimedia by paying attention to common mistakes and alternative conceptions (Muller et al 2008).

4. Experiences with the e-class in the pilot project

How did the students experience the e-class? Our data come from

- evaluation reports of the students;
- interviews with students;
- a questionnaire at the end of the study year: 175 students responded from 3 schools; 88 male and 87 female students at pre-university level; 53 students were in the Nature & Technology stream.

The data obtained from the questionnaire are summarized in table 3.

Analysing the results of the questionnaire, the interviews with students, and the students’ evaluation reports, we conclude that most of the students appreciated that they could

- work with and learn from screen casts;
- consult their peers and the teacher in the chat room;
- plan more or less their working hours;
- learn a lot, in a mixed and attractive approach;
- build and simulate graphical models of Coach 6; they liked the software once they got more familiar with it through the screen casts and by helping each other.

Table 3; Summary of the results of the student questionnaires

<table>
<thead>
<tr>
<th>property</th>
<th>much lower (%)</th>
<th>lower (%)</th>
<th>normal (%)</th>
<th>higher (%)</th>
<th>much higher (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>difficulty level</td>
<td>0</td>
<td>1</td>
<td>24</td>
<td>48</td>
<td>27</td>
</tr>
<tr>
<td>amount of homework</td>
<td>0</td>
<td>2</td>
<td>19</td>
<td>27</td>
<td>52</td>
</tr>
<tr>
<td>quality of lesson material</td>
<td>4</td>
<td>12</td>
<td>63</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>ability to study independently</td>
<td>3</td>
<td>24</td>
<td>43</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>usefulness of the course</td>
<td>12</td>
<td>13</td>
<td>49</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>clarity of explanations</td>
<td>12</td>
<td>33</td>
<td>42</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>variety between texts and task</td>
<td>3</td>
<td>7</td>
<td>70</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>perceived teacher’s enthusiasm</td>
<td>20</td>
<td>12</td>
<td>48</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>preparedness for university study</td>
<td>16</td>
<td>21</td>
<td>51</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Many students who were sure that they would choose a higher education study in technology or exact sciences thought that the e-class prepared them better for their future study than traditional lessons. The following fragment of a student report illustrates these conclusions:

“The e-class is really of our time and because it is based on the idea of ‘blackboard’ it will be useful later at the university; then you already know how such system works. I think that the e-class can go far because the explanation that you get through the videos is sort of individual guidance, which works of course better than explanation to the whole class. The instructions had been recorded very clearly and in case you did not get the idea yet, you could rewind the movie; I found this a great advantage.”
On the other hand, I found that the e-class was sometimes difficult; in particular at the beginning it was not very clear how the program was set up. Especially at the beginning I ask my dad for help because I found the Coach 6 exercises at a tougher level than we were used to. Also I spend whole evenings working on the tasks, whereas I usually do less mathematics at home.”

A positive interpretation of the last paragraph is that this student found the course challenging. In fact the student was right saying that the course was more demanding and took more time than usual. About one quarter of the students found the course too difficult, and about half of the students found it difficult, but manageable. About half of the students brought up that they had much more homework than usual. Some students reported that they worked weekly on the entire Sunday afternoon and evening to meet the deadlines for the online assignments. Many students characterized the final computer assignment as difficult, although the result less mathematical competencies below average complained more about the difficulty level and the amount of homework, perhaps because the weekly assignments painfully revealed their difficulties and weaknesses. At the same time this is important information for the teacher to make use of in the preparation of his/her lessons.

The teachers in the design team had actually been too optimistic about the amount of work for the students. But honestly, it must be taken into account that the course was not given exclusively to the prospective Mathematics D students. There was in the pilot project a strong correlation between the mathematical skills level of the students and their appreciation of the e-class (more able students liked the e-class more). We expect that students who are not so good in mathematics will not choose Mathematics D as optional subject. Experiences in the last and current study year with students who have chosen this subject indicate that the level and amount of work in the e-class was in fact not as bad as it looked initially.

But students were not the only ones who had been busy in the e-class of the pilot project: the same holds for the participating teachers. Especially, the weekly grading of homework handed in by the students was time-consuming and stressful. On the other hand, monitoring of work progress was also a stimulus for the students to do their homework: postponing behaviour was penalized. Also, teachers had to regularly log into the VLE to check if everything was going well and if their students needed a helping hand. Teachers received more emails than usual from their students that needed to be answered. On the one hand this is a positive sign that the communication between students and teachers in the e-class was functioning well, but on the other hand the complaints of the teachers about the workload in the e-class must be taken serious: a teaching assistant, perhaps a bachelor student from a university, seems to be a solution. What is interesting to note is that almost all teachers, regardless of the work it took, looked back at the pilot project as a successful enterprise, with great prospects. The majority of the participating teachers continued to run an e-class in the following years, sometimes in a less labour-intensive setting. A quotation:

“A selling point of the e-class is in my opinion that the student can be busy with the subject matter in different ways. It is extremely varied, with individual and group work, instruction movies, project work, and so forth. Besides, working with a VLE and a computer working environment like Coach are good preparatory activities for continuing education at university or higher vocational level, where this way of teaching and learning is commonplace.”

5. Future directions

In the e-class of the pilot project we had not encountered one of the main disadvantages of online learning that is often brought up, namely, the lack of social contact. The main reason lay in our opinion in the blended approach: face-to-face teaching and learning at school was combined with web-supported instruction outside the classroom and at home. This seemed to work well. It also matches the so-called study house concept, in which students are held more self-responsible for their learning, and it even seems to work better than traditional instruction in the classroom because students can work in the e-class in an individual way that suits their learning style best.

The success of the pilot project has resulted in a large project for the academy, within the framework of the Nationwide Programme for e-Learning (www.surffoundation.nl) for the years 2008-2010, in which sixteen e-classes are designed and implemented in clusters of schools in the region of Amsterdam, in a joint effort of about forty teachers of secondary schools and higher education
institutes. All developed e-classes will be field tested in several schools, thoroughly evaluated, improved, and preferably certified by the countrywide Programme Renewal Committees in mathematics and science education. This time the modules will not be restricted to Mathematics D, but there will also be modules for the subjects Informatics and Life, and Technology. Other aims of the project, besides development and implementation of e-classes, are:

- improvement of the transfer from secondary to higher education concerning content of subject matter;
- raising of the quality of mathematics, science, and technology teaching and learning at secondary schools by teacher professional development;
- increase in the number of teachers in exact sciences and technology;
- realisation of sustained contacts between teachers of secondary and higher education;
- increase in the number of students who choose a follow-up study in exact sciences and technology.

6. References


e-Learning Success Model: an Information Systems Perspective

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Abstract: This paper reports the observations made and experience gained from developing and delivering an online quantitative methods course for Business undergraduates. Inspired by issues and challenges experienced in developing the online course, a model is advanced to address the question of how to guide the design, development, and delivery of successful e-learning initiatives based on theories of a user-centered information systems development paradigm.

The benefits of using the proposed model for e-learning success assessment is demonstrated through four cycles of action research after two action research cycles of pilot study. Findings from our empirical study confirm the value of an action research methodology for promoting e-learning success. The paper concludes with a discussion on the merits of the proposed model in furthering our understanding of how to define, assess, and promote e-learning success.

Keywords: e-learning success, e-learning assessment, action research, information systems success model

1. Introduction

The Internet has profoundly changed the way we communicate and interact with one another. Studies conducted by Pew Internet and American Life Project found that as of June 2005, 137 million Americans (or 68% of American adults) used the Internet, up from 63% one year ago (Fox, 2005). About 94 million Americans used the Internet for such daily activities as e-mailing, searching for information, getting news, checking the weather, instant messaging, and online banking, to name a few (Daily Internet Activities, 2005). The Internet has brought dramatic changes to education as well. As of 2003, 100% of public schools in the U.S. had Internet access, up from 98% in 2000. Ninety percent of public schools offered Internet courses using asynchronous computer-based instruction. Eighty-eight percent of public schools indicated plans to start or increase use of the Internet as a primary mode of instructional delivery (Waits & Lewis, 2003). The growth of distance learning is phenomenal when comparing the 1997-1998 statistics (Lewis et al., 1999) with those of 2000-2001:

- A 14% increase of the nation’s public 4-year institutions offered distance learning courses (from 78% in 1997-98 to 89% in 2000-01);
- A 123% increase in enrollments in college-level, credit-granting distance learning courses (from 1.3 million in 1997-1998 to 2.9 million in 2000-2001; with 82% of the 2.9 million at the undergraduate level in 2000-01);
- A 45% increase in the percentage of institutions using asynchronous Internet-based technologies as the most used distance learning technologies (from 60% in 1997-98 to 87% in 2000-01).

All these provide strong evidence that Internet-based technologies have transformed traditional in-class learning to a new way of learning called e-learning, defined by the Instructional Technology Council (ITC, 1998) as well as the National Center for Education Statistics (Waits and Lewis, 2003) as the process of extending learning or delivering instructional materials to remote sites via the Internet, intranet/extranet, audio, video, satellite broadcast, interactive TV, and CD-ROM.

This paper reports the lessons learned and experience gained from developing and delivering an online quantitative methods course for business undergraduates. Inspired by issues and challenges experienced in developing the online course, a model is advanced to address the question of how to guide the design, development, and delivery of successful e-learning initiatives based on theories of a user-centered information systems development paradigm. The value of the model is demonstrated through four cycles of action research after two action research cycles of pilot study. Results from this empirical study are then presented and discussed. The paper concludes with a discussion on the merits of the proposed model in furthering our understanding of how to define, evaluate, and promote e-learning success.
2. Literature review

What constitutes success in e-learning? Attempts to address this question have resulted in a large volume of anecdotal studies assessing the success of e-learning initiatives on various measures such as learning benchmarks (Pittinsky & Chase, 2000), learning styles (Byrne, 2002), learning environment (Jung et al., 2002), learning outcomes (McClelland, 2001; Motiwalo & Tello, 2000; Teh, 1999), teaching practices (Savenye, et al., 2001; Owston & Wideman, 1998) and cost-benefits (Smith, 2001; Lawhead et al., 1997). Some of these studies are guidelines or “best practices” of e-learning that are developed from case studies (Byrne, 2002; Smith, 2001; Pittinsky & Chase, 2000; Lawhead et al., 1997). The most comprehensive guidelines are Pittinsky & Chase’s 24 benchmarks in seven areas: institutional support, course development, teaching/learning, course structure, student support, faculty support, and evaluation and assessment (Pittinsky & Chase, 2000). The rest of the studies attempted to explore a variety of factors and intervening variables that might have an impact on the success of e-learning. As a result, it is difficult to understand and isolate success factors of e-learning as there is a lack of consensus of what constitutes success of e-learning.

These seemingly diverse and incoherent views of how best to evaluate e-learning are not surprising given that research in this area is at its formative stage with the recent recognition of the educational promises of Internet-based technologies. There is a need to integrate and formulate a holistic and comprehensive model for evaluating e-learning. Another shortcoming of these studies is that success measures are derived from assessing the results of the development effort only. There is also a need to broaden the viewpoint of learning success from a result to a process perspective. The primary objective of this study is to address these needs.

3. e-Learning success model

This research proposes the use of an e-learning success model to guide the design, development, and delivery of e-learning initiatives. Our e-learning success model, as shown in Figure 1, is adapted from DeLone and McLean’s information systems success model (DeLone and McLean 2003). Compiled from past literature on information systems success, six dimensions of success factors, namely, system quality, information quality, service quality, use, user satisfaction, and net benefit, are identified and incorporated into an overall success model. Not only did DeLone and McLean’s model succeed in bringing together an integrated view of information systems success, but their model also helped instill a process approach to information systems success. DeLone and McLean (2003) identified 16 empirical studies that rendered support for the associations among the six dimensions of success factors. In addition, Rai et al., (2002) conducted a confirmatory factor analysis and estimation of fit indices for the model. Their empirical evidence gave credence to the explanatory power of the model and validated the importance of using a multi-construct dependent measure of information systems success.

The validity of viewing e-learning initiatives’ development from an information systems perspective is supported by recognizing that both of these efforts are fueled by a common goal to harness new technologies to better meet the needs of their users. In addition, a similar journey has been undertaken by information systems researchers on their attempts to identify factors that contribute to information systems success. Related theories and knowledge accumulated since the early 1980’s can be beneficial in contributing to the pursuit of success in e-learning. Consequently, a second objective of this study is to examine the applicability of an information systems success model to e-learning initiatives’ development and assessment.

Our e-learning success model makes explicit the process approach to measuring and assessing success. The model also includes success metrics developed specifically for the e-learning context being investigated. The process approach posits that the overall success of e-learning initiatives depends on the attainment of success at each of the three stages of e-learning systems development: design, delivery, and outcome analysis. Success of the design stage is evaluated along three success factor dimensions: system quality, information quality, and service quality. Success of the delivery stage is evaluated along one success factor: use. Finally, success of the outcome stage is evaluated along two success dimensions: user satisfaction, and net benefits. The arrows shown in the figure depict the interdependences within the three stages of success assessment. Success of system design is essential to the success of system delivery which, in turn, affects the success of system outcome. The success of system outcome, however, has an impact on the success of...
subsequent system delivery, as indicated by the double arrow linking system delivery and outcome stages.

![Figure 1: e-learning success model](image)

### System design

**System Quality**
1. easy-to-use
2. user friendly
3. stable
4. secure
5. fast
6. responsive

**Information Quality**
1. well organized
2. effectively presented
3. of the right length
4. clearly written
5. useful
6. up-to-date

**Service Quality**
1. prompt
2. responsive
3. fair
4. knowledgeable
5. available

### System outcome

**Net Benefits**
- Positive Aspects
  1. enhanced learning
  2. empowered
  3. time savings
  4. academic success

- Negative Aspects
  1. lack of contact
  2. isolation
  3. quality concerns
  4. technology dependence

**Use**
1. PowerPoint slides
2. audio
3. script
4. discussion board
5. case studies
6. practice problems
7. Excel tutorials
8. assignments
9. practice exam.

**User Satisfaction**
1. overall satisfaction
2. enjoyable experience
3. overall success
4. recommend to others

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4. Methodology

The value of using the proposed model for e-learning success assessment is demonstrated using an action research methodology. Action research was introduced by Kurt Lewin in the 1940s to study social psychology and social changes at the University of Michigan's Research Center for Group Dynamics (Lewin, 1947). Lewin's work established the reputation of action research as a “science of practice” that is best suited for studying complex social systems by introducing changes into practice and observing the effects of these changes (Argyris et al., 1985). The fundamental contention of action research is that complex social systems cannot be reduced for meaningful study. As a result, the goal of action research is to understand the complex process rather than prescribing a universal law (Bakerville, 1999). The complex nature of learning is summed up eloquently by Meyer (2002):

*The problem with most research studies on learning is the difficulty of isolating factors so that their impact (if any) can be identified and understood, separate from the action of other factors in the environment. Unfortunately for researchers, learning is both complex and occurs in very rich environments. It is doubly difficult to unravel influences from the individual's personality, values, brain, background (family, school, friends, work), and, of course, the educational environment (classroom, teacher acts, pedagogical choices, tools).* (p.24)

Consequently, action research lends itself well as the methodology of choice to this study. Following the spirit of action research, this study adopts an iterative process involving five phases to gain understanding of how to enhance e-learning success: diagnosing, action-planning, action-taking, evaluating, and learning (Susman & Evered, 1978). The diagnosing phase identifies impediments to successful e-learning initiatives so that measures to overcome these impediments can be developed in the action-planning phase. The action-taking phase then carries out the measures developed. The evaluating phase examines resulting changes from the actions taken to assess their impact on the success of e-learning. The learning phase assimilates lessons learned and experiences gained.
towards a better understanding of e-learning success. These five phases of action research as applied to this study are illustrated in Figure 2.

Figure 2: The five phases of action research

5. First cycle of action research

The first cycle began after the approval of a proposal to develop an online quantitative methods course for business undergraduates. A major problem to successful development and delivery of this course was the lack of a full understanding of students’ needs and attitudes towards e-learning. The plan was to investigate students’ receptiveness of e-learning using a pilot study. The pilot study involved designing an e-learning module on facility location analysis. Forty-eight students from two sections of the quantitative methods course then used this module in an Internet-based environment. These students filled out a course feedback survey to evaluate the module upon its completion. Opinions gathered from the students indicated that other than the flexibility of being able to learn anywhere anytime there was little learner satisfaction with e-learning (Lee-Post, 2002).

6. Second cycle of action research

A second action research cycle was launched with a special focus on gaining students’ acceptance of e-learning. Seventy-two students from three sections of the quantitative methods course were informed at the beginning of the semester that the topic on facility location would be learned via an Internet-based distance learning environment. The values of e-learning were stressed at that time. In addition, a specific recommendation on using more examples to enhance the presentation of course materials was implemented. The same course feedback survey was administered to the students after the delivery of the revised module. Opinions gathered from these students showed that their attitudes towards e-learning had improved, indicating that getting students ready for online learning was instrumental in gaining a more positive reception of e-learning (Lee-Post, 2003). The pilot study conducted during the first two cycles of action research is akin to prototyping in information systems development. Because of the experimental and explorative nature of e-learning initiatives, the use of a prototype e-learning module is critical in deciphering students’ learning needs and how those needs can be met in an e-learning environment. Moreover, issues experienced in developing the prototype can be proactively addressed before resources are committed to further develop the remaining modules of the online course.

7. Next four cycles of action research

The next four action research cycles were conducted with the goal of investigating the usefulness of the e-learning success model. The entire quantitative methods course was offered online using Blackboard 5.0 as the platform for system delivery. The system quality dimension measures
The desirable characteristics of the Blackboard environment such as ease-of-use, user friendliness, stability, security, and responsiveness. The information quality dimension evaluates the course content on aspects such as organization, presentation, length, and clarity. The service quality measures instructor-student interactions on attributes such as promptness, responsiveness, fairness, competency, and availability. The use dimension measures the extent to which the course elements are actually used, including PowerPoint slides, audio clips, lecture scripts, discussion boards, case studies, Excel tutorials, practice problems and assignments. The user satisfaction dimension gauges opinions of the students about e-learning based on their experience with the course. The net benefits dimension captures the positive aspects of e-learning in terms of learning enhancement, empowerment, time savings, and academic achievement, as well as the negative aspects of e-learning such as lack of face-to-face contact, social isolation, quality concerns and dependence on technology. The online course was assessed by students at the end of each action research cycle using a course evaluation survey. This survey was designed and administered by the University’s Distance Learning Technology Center and consisted of thirty six questions. Questions were mapped to the six success dimensions and their ratings aggregated to form a single measure for each of the six success dimension. Table 1 lists the items in the course evaluation survey used to measure the six success dimensions of the model. Reliability of the survey was evaluated using Cronbach Alpha. Table 1 also shows the alpha values for each of the six constructs. All six constructs are showing an alpha of 0.7 or above indicating that the mapping of items from the course evaluation survey to the six success dimension is appropriate.

Table 1: Survey construct and measures

<table>
<thead>
<tr>
<th>Construct</th>
<th>Definition</th>
<th>Items in the Course Evaluation Survey</th>
</tr>
</thead>
</table>
| System Quality             | The desirable characteristics of the Blackboard environment                | 21. I was able to navigate through the course website to find what I needed to complete the course.  
22. I was able to access course materials. |
| Information Quality        | The desirable characteristics of the course content                        | 1. The instructor outlined in reasonable detail course requirements and grading procedures.  
9. The instructor organized the presentation of the course material in an effective manner.  
10. The instructor demonstrated good knowledge of the subject matter. |
| Service Quality            | The desirable characteristics of student-instructor interactions           | 5. Grading in the course was fair and consistent.  
6. Assignments were distributed fairly throughout the semester.  
7. Graded assignments, test, etc., were returned promptly.  
8. Graded assignments included helpful comments from the instructor.  
11. The instructor could be contacted for consultation.  
12. The instructor satisfactorily answered questions.  
13. The instructor facilitated student participation in course activities.  
25. Email contributed to my understanding of the course content. |
| Use                        | The extent to which the course elements are accessed                       | 24. Printed materials contributed to my understanding of the course content.  
26. Posted discussions contributed to my understanding of the course content.  
27. PowerPoint (R) slide presentations contributed to my understanding of the course content.  
28. Audio taped presentations contributed to my understanding of the course content.  
29. Video taped presentations contributed to my understanding of the course content.  
31. Course assignments contributed to my understanding of the course content. |
| User Satisfaction          | The opinions of the students on e-learning                                | 19. The overall value of this course.  
20. The overall quality of teaching by the primary instructor in this course. |
| Net Benefits               | The overall benefits of e-learning                                        | 15. The course strengthened my ability to analyze and evaluate information.  
16. The course helped me to develop the ability to solve problems.  
17. I gained an understanding of concepts and principles in this field.  
18. The course stimulated me to read further in the area. |
8. Results

Analyses of responses to the course feedback survey completed in the pilot study during the first two action research cycles revealed that students believed e-learning better enabled them to “Control where and when to learn” and “Learn materials in less time”. Consequently, each topic in the quantitative methods course was developed to ensure learning flexibility and efficiency. Using the prototype e-learning module as a blueprint, course materials in each topic were presented in various media formats: PowerPoint slides, audio clips, and lecture scripts. Students’ understanding of the course materials was demonstrated through a number of activities including discussion boards, case studies, practice problems, and assignments.

Another finding from the pilot study was that students’ indifferent attitudes towards e-learning would be a major barrier to successful development of e-learning initiatives. Recognizing that e-learning was not for everybody, students were accepted into the online course only if they were online-ready: those who earned a B or above standing in the prerequisites and responded with at least a 4 using a 5-point scale on all three readiness measures: technical competence, lifestyle aptitude, and learning preference.

The success of the online course was evaluated along six success dimensions during the last four action research cycles using a course evaluation survey. A comparison of the ratings of the six success dimensions analyzed from the survey responses is reported in Table 2. The overall rating of each success dimension is obtained by averaging all respondents’ ratings on the corresponding items of the survey. The mean of the average ratings for each success dimension is expressed as a percentage of the highest rating possible for that dimension. A target rating of 85% was sought for all six success dimensions.

Table 2: Success measures comparison

<table>
<thead>
<tr>
<th>Success Dimension</th>
<th>3rd Cycle</th>
<th>4th Cycle</th>
<th>5th Cycle</th>
<th>6th Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System design</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System quality</td>
<td>96%</td>
<td>97%</td>
<td>81%</td>
<td>95%</td>
</tr>
<tr>
<td>Information quality</td>
<td>88%</td>
<td>95%</td>
<td>80%</td>
<td>86%</td>
</tr>
<tr>
<td>Service quality</td>
<td>82%</td>
<td>92%</td>
<td>81%</td>
<td>89%</td>
</tr>
<tr>
<td><strong>System delivery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use</td>
<td>65%</td>
<td>78%</td>
<td>65%</td>
<td>89%</td>
</tr>
<tr>
<td>User satisfaction</td>
<td>85%</td>
<td>86%</td>
<td>73%</td>
<td>90%</td>
</tr>
<tr>
<td><strong>System outcome</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net benefits</td>
<td>78%</td>
<td>83%</td>
<td>67%</td>
<td>88%</td>
</tr>
</tbody>
</table>

We observed that (1) the ratings for all six dimensions were higher in cycle 4 than cycle 3; (2) the ratings for the system design dimension were highest in cycle 4; (3) the ratings for all six dimensions were lowest and below the 85% target in cycle 5; (4) the ratings for the system delivery and system outcome dimensions were highest in cycle 6; and (5) the ratings for all six dimensions reached the 85% target in cycle 6. The changes in ratings for all six dimensions were resulted from efforts made to improve the success dimensions of the online course. The usefulness of our e-learning success model in this regard will be detailed in the next section.

9. Model utility

Recall that our e-learning success model calls for a process approach to effectively design, develop, and deliver an e-learning initiative. The process approach to e-learning success is essentially a continuous improvement process seeking to raise ratings of six success dimensions including system quality, information quality, service quality, use, user satisfaction, and net benefits in three stages: system design, delivery, and outcome. The interdependences within the three stages, as shown in Figure 1, imply that attempts to improve a success rating should start with raising the three quality ratings in the design stage first and proceed to boosting the use rating in the delivery stage, then followed by improvements in the user satisfaction and net benefits ratings in the outcome stage.

The online course was first evaluated using the proposed model in cycle 3. Among the six success dimensions in cycle 3, service quality, use, and net benefits were below the target 85% rating. As a result, service quality enhancements to improve instructor-student interactions were made in cycle 4. Specifically students were reminded in the syllabus as well as the announcement page of the course website that emails would be responded to within 48 hours. The use dimension was monitored during
cycle 4 leading to a number of improvements impacting the net benefits dimension: (1) errors in the materials were corrected; (2) extra sets of practice exercises were selected to prepare students for a more difficult set of assignment problems; and (3) students were encouraged to dialog with one another through the discussion board. Consequently, cycle 4’s ratings for all six dimensions are higher than those of cycle 3, showing efforts made to improve the system design and delivery stages of the online course followed through onto the outcome stage.

Two success dimensions remained below an 85% rating at the end of cycle 4, namely use and net benefits. Accordingly, e-learning enhancements were sought to raise the use dimension after improvements in system quality and information quality were made in cycle 5. Specifically the Blackboard environment was upgraded from version 5.0 to 6.0 featuring a more secured log in procedure. A website containing practice exercises put together by the textbook publisher was added to the existing course website on Blackboard. The textbook publisher’s website provided students with immediate feedbacks via onscreen buttons such as “link to text”, “show hints”, “show answer”. When the use dimension was monitored during cycle 5, it was realized that the design changes were ineffective as students found that the more secured log in procedure for Blackboard was cumbersome. At the same time students were required to log in a second time to access practice problems from the publisher’s website. Consequently, cycle 5’s ratings were the lowest along all six dimensions when compared to those of any four action research cycles.

The poor ratings of cycle 5 signaled that an overhaul of the system design was imminent. A special training media presentation was made to familiarize students with the secure log in procedure of Blackboard. Students were no longer required to log on the publisher’s website to access practice problems. Instead students could attempt practice exercises from the course website directly. These practice exercises were graded immediately with “show answers” feedbacks. In addition, assignment problems were graded with instructor’s comments. When the use dimension was monitored, system delivery improvements were further enhanced to boost system outcome measures. One such improvement was giving students a second chance in attempting the practice exercises and assignment problems. Students could improve their grade by submitting a corrected version of the practice exercises and assignment problems in response to the feedbacks and instructor’s comments. Consequently, cycle 6’s ratings on all six dimensions were not only higher than that of cycle 5 but they also exceeded the 85% baseline.

10. Model limitations and extension

While our model is useful for instructors to measure and evaluate e-learning success, it assumes instructors are skilled system developers and enthusiastic e-learning adopters. In addition, the model’s student-centered perspective relies only on students’ e-learning experience as feedback for e-learning improvements. Consequently we extend the current model by taking into account both the instructors’ and institutional perspectives. An extended model incorporating these perspectives is shown in Figure 3.

The extended model calls for institutional supports for instructors, in particular for those who are e-learning skeptics. Some critical institutional supports include, first, a sound technical infrastructure such as campus-wide high-speed Internet access, and an institutional learning management systems like WebCT or BlackBoard should be provided. Second, ongoing instructors’ workshops should be organized to allow training and sharing of e-learning best practices. Third, e-learning developmental support in the form of technical and pedagogical aids should be established to facilitate instructors’ e-learning adoption. Fourth, technical support should be in place to address any issues that arise in e-learning delivery and access. Fifth, incentives such as grants, awards and other forms of recognition should be placed to encourage e-learning practices.

The extended model also calls for an evaluation of e-learning institutional outcomes so that the impacts of e-learning can be assessed on the institutional level as well. Specific measures for institutional outcome can be cost saving, increased enrollment, higher rankings, increased endowment, etc. Our extended model provides a more comprehensive view of e-learning success – that students, instructors, and institutions all have roles to play.
11. Observations

In summary, our study demonstrates the value of assessing e-learning success from an information systems perspective. Specifically, the following observations are made from the development and continual improvement in designing, developing and delivering the online course.

- The first step to ensure successful development and delivery of e-learning initiatives is to understand students’ learning needs and attitudes towards e-learning through pilot studies. In so doing, issues in designing and developing e-learning initiatives can be identified and addressed adequately before their actual delivery.

- A critical factor of e-learning success is the online readiness of the students. Online readiness should be assessed along four readiness measures: academic preparedness, technical competence, lifestyle aptitude, and learning preference toward e-learning.

- The overall success of an e-learning initiative is dependent on the attainment of success at each of the three stages of e-learning systems development, namely, system design, system delivery, and system outcome.

- The success of the system design stage is dependent on the attainment of three success factors: (1) system quality; (2) information quality; and (3) service quality.

- The success of the system delivery stage is dependent on the attainment of success of the system design stage and one success factor: use.

- The success of the system outcome stage is dependent on the attainment of success of the system delivery stage as well as two success factor: (1) net benefits; and (2) user satisfaction.

- An action research methodology is an impetus for success dimension improvement. Rather than attacking the research issue in its entirety at the outset, action research encourages organizing the issue into manageable cycles. Findings from these cycles then converge to a full understanding of the issue itself and how it should be addressed.

- A common interface allowing a seamless access to all course design elements is an important system design feature.

- Success metrics that are relevant to a specific e-learning context should be defined and quantified to a desirable target level of performance. For example, the user satisfaction success metric in our empirical study is defined as the students’ opinions on e-learning. It is measured by two indicators on a 4-point scale: (1) the overall value of the course; and (2) the overall quality of teaching. A target rating of 85% is deemed desirable.
Course improvements should be made by following a process approach to systematically raising the three quality ratings in the design stage first and proceed to boosting the use rating in the delivery stage, then followed by improvements in the user satisfaction, and net benefits ratings in the outcome stage.

Institutional supports are critical to promote and facilitate e-learning adoption among instructors.

Institutional outcome should be incorporated as the seventh success dimension in extending the current success model to encompass an institutional perspective.

12. Conclusion
This research moves us a step closer in harnessing the power of Internet-based technologies to enhance learning. We demonstrated the applicability of an e-learning success model to guide the design, development, and delivery of e-learning through four action research cycles. A primary contribution of this research is in furthering our understanding of how to define, assess, and promote e-learning success. To this end, success in e-learning is defined as a multi-faceted construct that can be assessed along six dimensions including system quality, information quality, service quality, use, user satisfaction, and net benefits occurring in three stages. The first stage is to attain system design success by maximizing the three quality dimensions. The second stage is to attain system delivery success by maximizing the use dimension. The final stage is to attain system outcome success by maximizing net benefits and user satisfaction dimensions. Each success dimension is quantified as a single numeric measure by aggregating the ratings of its set of attributing factors obtained via a course evaluation survey instrument. The overall success of e-learning can then be evaluated for each dimension. A low score for any success dimension signifies a deficiency in that area and efforts can be devoted accordingly to rectify the deficiency.

Although the findings of the current study are drawn from one undergraduate quantitative methods course, there is no reason to doubt that the e-learning success model proposed here cannot be applied to other disciplines and graduate level of courses as well. In addition, to broaden the current student-centered perspective, an extended e-learning success model is proposed that gives recognition to the role that students, instructors, and institution play in making e-learning a success. Future testing and validating of both the proposed and the extended model will be beneficial to the continued growth of this important research area.

References


Impact of Communication Patterns, Network Positions and Social Dynamics Factors on Learning among Students in a CSCL Environment

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Abstract: At present, it is difficult to assess the quality of learning in Computer-Supported Collaborative Learning (CSCL) environments, because standard pretest and posttest measures do not capture the differences in the learner’s ability to engage in the material, pose interesting new questions, engage others in learning and work collaboratively. This research investigates the impact of communication patterns, network positions and social dynamics factors on students’ self-perception of learning in a CSCL environment. The study involved a combination of methodologies combining questionnaires, and archiving of communication logs for data collection. Social network analysis tools were used to analyze relational data, map emergent student communication patterns and calculate centrality scores based on the electronic and face-to-face communication patterns among class members in the CSCL environment. Structural equation modeling was then performed on the hypotheses model to determine the impact of these centrality measures and the social factors on students’ perceptions of knowledge gained and their satisfaction with their performance in the course.

Keywords: Computer-Supported Collaborative Learning (CSCL), distance learning, social network analysis, social dynamics, respect, influence, structural equation modelling, path analysis, interaction, participation, motivation to participate and learn, satisfaction with performance, gaining new and conceptual knowledge

1. Introduction

Computer-mediated communication (CMC), consisting of highly interactive communication tools, including electronic mail, electronic bulletin boards, asynchronous multimedia notebooks, remote screen-sharing, and desktop video teleconferencing, is becoming increasingly common in modern classrooms, in addition to face-to-face time between the instructor and the students. It must be noted however that the increase in the use of these CMC tools has been more to facilitate online learning for distance students. For example, many university classes use WebCT® (a Computer-Supported Collaborative Learning - CSCL tool) to post topics on the discussion boards, post grades and manage student projects. Others use Blackboard® or Elluminate®. The use of these discussion boards allows students to discuss topics related to the material they are learning in class, allows them to interact with one another and the instructor asynchronously and also post, view and if required rate group projects, thus allowing for a certain level of peer involvement and assessment. As predicted by Fishman (1995), such technologies have become more integrated into education, and, therefore, it is important to understand student learning, behaviors and attitudes towards the use of these communication technologies.

While Picciano (2002) raises questions regarding the nature and extent of the interaction and its effects on student performance, he reiterates that much of the research is based on student perceptions of the quality and quantity of their interactions and how much they have learned in an online course. In his study, Picciano (2002) examines performance in an online course in relationship to student interaction and sense of presence in the course and makes an attempt to go beyond typical institutional performance measures such as grades and withdrawal rates and to examine measures specifically related to course objectives. He found that though there was support for a strong relationship between students’ perceptions and perceived learning, the relationship of actual measures of interaction and performance is mixed and inconsistent depending upon the measures and requires further study. Reffay & Chanier (2002), describe a situation of distance learning based on collaborative production occurring within groups over a significant time span. They found that social network analysis was a good candidate for application to their experiment in order to compute communication graphs.

The specific aims of this study are therefore to identify actors within the group/class that are central to the group/class and are sought by the others in the group/class for gaining knowledge or information pertaining to the course material. Social network analysis will be used to calculate the network
centrality measure will then be used to determine if this structural position gives these and other actors in the group/class respect (perceived or real) among their group and/or classmates and influence (perceived or real) in group/class projects. Path analysis (structural equation modeling) is then done to see if the respect and influence gained from network positions motivate the students to actively interact and participate further in group discussions and whether they will in turn have an effect (perceived) on the conceptual and new knowledge gained by the students, their confidence in doing well in the course (performance) and satisfaction with their performance in the course. Before going into the analysis aspects of this study, I would like to review some of the literature that has guided, and motivated this study.

2. Review of relevant literature

Many believe that online learning is the “magic” answer to the pressure of growing enrolments, decreasing income (in some cases), demands by students for more flexibility, along with the explosion in knowledge created in part by the communications revolution (Land, 2002; Race, 1998). Designers of online environments and CSCL systems have striven to make online learning more interactive through the use of tools for instructor-student and student-student interaction using both synchronous (instant messenger) and asynchronous (electronic discussion boards) communication. CSCL was founded based on the idea that classrooms could be structured on the model of professional communities of practice that collaboratively built knowledge, such as scientific theories (Scardamalia & Bereiter, 1996).

Furthermore, following the principles of Vygotsky (1930/1978), knowledge was seen to be generally constructed socially in interactions among people before it was internalized as individual knowing. Taking a cue from instructional theories, CSCL systems like Elluminate® additionally offer whiteboards, voice-over-IP (VoIP) and webcam features to increase the social presence among students in these environments.

Wellman (1997) states that an electronic group is virtually a social network, and the network structure provides for and facilitates the social interaction and enhances social presence, which in turn can lead to social learning and knowledge construction. The socio-cultural aspects that arise as a result of social interactions among members of a group of students in a CSCL environment form the basis of the social dynamics factors discussed later on in the paper. An understanding of these factors will provide insight into the design of courses and systems to support collaborative learning and the development of respect, influence and teamwork in student teams.

It was noted by Yildiz and Chang (2003) that the quality of feedback from peers and instructor in web-based courses was superior to that of face-to-face courses and onsite instructors should consider incorporating web-based asynchronous discussion to their face-to-face classes. They recommend that researchers should examine how the quantity, quality or immediacy of feedback or response from peers or the instructor in web-based courses might differ or be similar in relation to these components (participation, grades, technology and course content).

In the rest of the paper we will discuss the CSCL system, the social dynamics factors and assessment in a little more detail and also introduce the concept of social network analysis. Social network analysis is widely used in the social and behavioral sciences and focuses on relationships among social entities, like communications among group members, transactions between corporations or organizations and this focus on relationships can help reveal social network properties like centrality, prestige, cohesive subgroups, affiliation networks etc. This approach is important and relevant to classroom social behavior, because in some ways the classroom is a microcosm of the real world, where roles are sometimes assigned, while on other occasions they are adopted because of the skill sets and motivation that each individual brings to the classroom in their bid to learn, get an education and succeed in a competitive environment. During these periods of learning and interaction, students...
have the opportunity to build and develop relationships with their peers and social network analysis can be used to investigate whether these relationships help the students gain knowledge, and obtain satisfaction on their performance.

3. Communication in CSCL environments

While contemplating the physical separation of the learner and the instructor, Moore (1993), believed that this separation contributes to “psychological and communication gap” and he proposed and developed “the theory of transactional distance”, emphasizing the effect of distance on teaching as well as learning behaviors, forms of interaction, communication, instruction, and curriculum. He identified three components of distance education: dialogue, structure, and autonomy, where dialogue refers to the interaction via actions, words, or ideas between the instructor and learner or among learners. The nature and extent of dialogue depends on the course design, subject matter, medium of communication, personalities of instructor, learning styles of learners, and size of the class. Moore speculated that when everything else is controlled, chances are interaction between instructor and learners in a small class will be more frequent than in a large class (Moore & Kearsley, 1996). Moore (1993) further proposed that when similar media are used, graduate courses in social sciences and education tend to be more interactive with project work than those in sciences and mathematics that demand teacher direction.

Moore suggested that structure is determined by the educational philosophy of the instructor, academic level of the learners, course content, as well as communication media (Moore & Kearsley, 1996). While autonomy, on the other hand, is the extent to which learners have control over learning objectives, implementation procedures, resource, and evaluation (Moore, 1990:13), with the belief that learners are capable of making decisions for their learning. Moore hypothesized the tendency that “the greater the structure and the lower the dialogue in a program the more autonomy the learner has to exercise” (Moore, 1993:27).

The goals of the group (or students in the class) activity (performance, rewards), its constraints (materials, time), its medium (computer support, meetings), its division of labor (group selection, mix of skills) and its social practices (homework, native language) are given by the larger community beyond the group or class itself (Stahl, 2004). The individual, group and community all develop new skills and structures through the influence of one unit upon the other; none is fixed or independent of the others; learning takes place at each unit and between them (Stahl, 2004). So CSCL communication can be thought of as a mediated discourse, involving the knowledge of the language, symbols, metaphors, and shared meaning. The language, usually the medium of instruction, will take the shape of the course the instructor has developed, while the symbols, in face-to-face and mediated interactions will revolve around socially constructed and accepted norms of cooperation, ‘esprit de corps’, standards of behavior (online and offline) and a common goal of learning the subject matter. And collaborative discourse is situated in the shared understanding of the group members, which in turn is historically, socially and culturally situated (Stahl, 2004).

Thus a CSCL environment would have to take into account interactions among many people, mediated by various artifacts, and cater to the learning objectives of individuals and groups that will interact in this environment. The design of CSCL environments has involved the use of several learning styles like project based learning, scaffolding, situated learning in communities of practice and educational theories like the theories of constructivism, collaborative interaction and activity theory. And it was recognized early on (Scardamalia & Bereiter, 1996, Yildiz and Chang, 2003) that a CSCL environment must contain all the aspects of computer-mediated communication like electronic mail, instant messenger, teleconferencing, videoconferencing (to provide for face-to-face interactions), presentation media (electronic whiteboards), and electronic discussion boards to name a few, in order to promote easier communication and foster social interaction among the students and thereby facilitate better learning outcomes as a result of these interactions.

4. Social network analysis

Social network analysis (SNA) is a set of research procedures for identifying structures in systems, based on relations among components (Barnett, Danowski and Richards 1993; Rogers and Kincaid 1981; Wasserman and Faust 1994). To describe the underlying structure, network analysis not only examines node-level indicators such as centrality, but also the pattern of connections among nodes by examining their clustering into subgroups. In this study these emergent network maps reveal the influential actors in student groups and their use patterns of the communication technologies. They
also reveal whether these roles that students assume (intentionally or otherwise) impact learning and social dynamics in student groups, and whether the role of the instructor is only to facilitate learning as an authority figure or to be part of the information flow in these communication exchanges between students.

In studying the work group behaviors in a class environment, (Johnson, Johnson, & Holubec, 1998) have suggested that students in work groups or a class environment tend to assign themselves according to four types of skills: forming skills, functioning skills, formulating skills, and fermenting skills. The student with forming skills will be the one to monitor turn-taking in the group. The roles for the group member with functioning skills will be to record the discussion, encourage all to participate, clarify/paraphrase the group discussion, and work to seek a group consensus. Formulating skills require a student to generate discussion and to summarize the group’s work. Finally, the student with the fermenting role works to ask for justification of the group’s outcome and also helps to give a rationale for the group’s activities. In network terms, these roles can be assigned to each actor (student) or they earn these roles based on their past record and performance in other group or class activities.

Based on the roles and positions students in class groups assign themselves, network communication patterns in CSCL systems will reveal student self perceptions of their influence in their groups and the respect they feel they get from their group members and this in turn will help in their assessment and learning processes. The role of the instructor also becomes a point of interest, to see how the instructor is able to facilitate both the assessment and the learning processes. Thus we are looking at the network structure having an effect on the social dynamics in the group/clique and whether that leads to the success or failure of the group effort (Fernandez, 1991).

When performing social network analysis one often looks at the centrality measures for the network under study. Centrality of a node in an ego network determines the relative importance of the node (ego or node under consideration) within that network and how well the node is connected with respect to other nodes (alter egos or alters) in the network. While there are several types of centralities, degree centrality (based on the number of incoming and outgoing connections), closeness centrality (based on the shortest path between a node and all other nodes reachable by it), betweenness centrality (based on nodes that occur on many shortest paths between other nodes) and eigenvector centrality (based on the importance of a node in a network – Google’s PageRank® is a variant of this type of centrality measure) are four of the more popular measures of centrality. Of these, betweenness centrality allows an actor to be either a control or conduit for information flow, between two or more other equally or more important actors and hence I have chosen this measure for this study. Brass & Burkhardt, (1993) also revealed that centrality and influence strategies each mediated the other in relation to power. Fernandez, (1991) on the other hand showed that respect in relationships follow formal structures in hierarchical organizations.

Cho, Stefanone & Gay (2002) have shown that social influences, in the form of network prestige effects, strongly affected the likelihood and the extent to which information posted in the CSCL environment was shared by peers in this learning community. Thus participation in the group/class effort was validated by their peers and increased the network prestige efforts of the participants, motivating them to continue participating and collaborating. Martinez, et al (2003) have proposed the integration of SNA in a mixed evaluation approach for the study of participatory aspects of collaboration and have adapted the SNA-related procedures to the demands of evaluators (instructors, system designers and the students themselves). In a study involving Asynchronous Learning Networks (ALNs) Aviv, Ehrlich, & Ravid (2003) found that the students took on bridging and triggering roles, while the instructor had relatively little power and they concluded that a well-designed ALN develops significant, distinct cohesion, and role and power structures lead the knowledge construction process to high phases of critical thinking.

In summary, the use of SNA to study the nature of the interactions among individuals in a CMC/CSCL environment has demonstrated that higher structured communication is more likely to create constructed knowledge than less structured communication and makes the case for the use of this approach in studying students’ interaction and participation in CSCL environments and how they help the students in their learning processes.
5. Research hypotheses

Respect and influence play a role in the formation of “well-oiled” group dynamics with communication and network factors leading to cohesion within the group and aiding in the formation of the above social factors leading to “learning”. While the literature recommends the study of all the technologies used in the CSCL environment, in my study I have limited it to the students’ use of IM (instant messenger), Email and Bulletin Boards (BB), which were provided to them in the Elluminate® & WebCT® environments, in addition to Whiteboard, web camera and Voice-Over IP (VoIP) features.

To summarize the hypotheses, Betweenness Centrality (BET) from use of email (EML), IM (instant messenger), BB (bulletin boards) and FTF (face-to-face) communication respectively has positive influence on Respect and Influence (IMELMBET will have a positive impact on RESP – motivation due to perceived respect and INFL – motivation due to perceived influence). These in turn will have a positive impact on new knowledge gained NEWKNOW, conceptual knowledge gained CONKNOW, satisfaction with one’s performance in the course SATPEF and perception of getting a grade of A for the course SELFGRDA. Due to space constraints, the hypotheses are mentioned and discussed along with the results. Figure 1 depicts the hypotheses in a schematic.

Figure 1: Hypotheses diagram for individual level measures

6. Data collection and sample

The Elluminate® CSCL tool had been successfully used in several classrooms in a medium-sized private university in the northeastern part of the US and for a variety of courses ranging from engineering and science classes to technical communication and HCI (Human Computer Interaction) classes. In all, survey data was collected from eight courses over the period of three semesters, summer 2005, fall 2005 and spring 2006. These courses were GMPM – Global Marketing and Product Management - Mgmt – 18/104 – summer ’05, CDW – Communication Design for WWW – Communication – 7/46 – fall ’05, FHCI – Foundations of HCI Usability – Communication –7/78 – fall ’05, PP –Proposing and Persuading – 2/20 – fall ’05, ETC – IT and Decision Systems Capstone – 3/26 – spring ’06, SD – Studio Design in HCI – 4/35 – spring ’06, IB – International Business – 5/54 – spring ’06, and TCTR – Theory and Research in Technical Communication – 3/21 – spring ’05. The students participating in the survey were asked to sign an informed consent form, which explained the study. Participation in the study was voluntary and the questionnaires used in the survey had the approval of the Institute Review Board (IRB). The same survey instrument was used for the entire study and proved to be reliable across the different semesters and different courses.

For this study, of the 35 items in the survey, 19 were communication items – use of email, IM, bulletin board and face-to-face, the social dynamics items, collaboration and friendship items, motivation items and the learning outcome items, while 16 items related to the use of Elluminate® tools (VoIP, the whiteboard, the video streaming quality and audio quality etc.). All items were measured using a 7-point Likert scale with 7 being most helpful or completely agree to 1 being least helpful or
completely disagree and 4 being neutral. Item 1 specifically asked the respondents about the usefulness of Instant Messenger (IM), Email, discussion boards (bulletin boards BB) and face-to-face (FTF) interactions in keeping them up-to-date in their class projects.

The 19 communication items consisted of questions that asked the respondents whether they completely agreed or completely disagreed (7-point scale) to “I feel that I gained conceptual knowledge about the course material while working with my distance classmates in this course”, and a similar items addressing “new knowledge”, “working collaboratively”, “satisfied with my performance in the course”, “confident of getting an A grade in the course”, “feel that I gained the respect of my classmates during the course”, “gained influence over decisions on class projects during the course”, “gaining respect motivated me to participate in IM and BB discussions”, “having influence on project decisions motivated me to participate on IM and BB discussions”, and even “I feel that I made good friends while interacting with distant students”. A set of items then asked the respondents to list between 3-5 people in their groups or in the rest of the class, whom they interacted the most with during the course of the semester, and of these who they perceived they learnt the most from. The respondents were then asked how often they used the various communication media (IM, Email, BB, FTF) with the people in their list. This is network data and was used to plot the network maps (sociograms) and calculate actor centralities.

The respondents were on-campus students as well as distance students (mostly working professionals). Of the respondents, while there was no significant difference in the gender of the students (28 male and 21 female), 37 were working professionals and 12 on-campus students. Of the 12 on-campus students, 3 were graduate students and the rest undergraduates. 30 of the respondents were 27 years old or more, and 22 were between 18-26 years old. 40 out of the 49 had taken a distance education course using the Elluminate® CSCL system. This thus posed an interesting challenge while interpreting the results. Distance working professionals had more need to use the various communication tools provided in the CSCL system as they were geographically dispersed, while on-campus students, being co-located probably had more face-to-face interaction opportunities both among themselves and with the course instructor. In most cases, while motivation levels of older working professionals is already probably higher than younger on-campus students, hence higher survey responses from this demographic, the qualitative responses (not discussed in this article) from the rest of those surveyed indicated the importance of respect and influence in group work and need and efficacy of intuitive CSCL systems.

Despite repeated attempts to remind students to participate, very few actually did and only 60 (~ 17%) out of a possible 358 (over all the courses – breakups per course given above) completed responses were received. Out of the 60, 11 were rejected (8 from students who had participated in an earlier semester and 3 due to incompleteness). The final N was 49 (~14%). This is a small sample size especially when a path analysis using structural equation modeling (SEM) was also going to be performed. Hoyle (1994), states that experimental comparisons do not require as many subjects as exploratory model-building, and studies using SEM with small samples are not unusual and that experimental social science literature contains quite a few publications using SEM in small samples (N < 50) and gives examples of the publications that have conducted these studies.

With N=45 (there were missing values in four of the completed surveys), and all of the 35 items, the Cronbach Alpha was 0.9082. With N=49 and only the 19 non-Elluminate® specific items, the Cronbach Alpha was 0.9106. Also, with N=49, the communication items registered a Cronbach Alpha = 0.6045 and proved to be not reliable at all. This Alpha may be low because of lack of homogeneity of variances among items, for instance, and it is also lower when there are fewer items in the scale/factor. In this case, the possible reason for the low Alpha is probably because all of the students did not use the media equally (more distance students than on-campus ones). Students who were familiar with one another (from earlier classes and interactions - history) reported a higher usage of cell phones and IM, while those who were new to the course/class reported a higher usage of email and bulletin boards.
7. Analysis and results

The information collected about the communication patterns was input into an adjacency matrix and that indicated degree for each communication type – email, IM, BB and face-to-face. UCINET (Borgatti, Everett & Freeman, 2002) software was used to determine the various centrality scores for each individual in the group and plot the sociogram (figure 2). I then used Structural Equation Modeling (SEM) to test the path leading from respect and influence obtained from the betweenness centrality scores and how they affect students’ motivation to participate in class discussions using the CSCL tools and how they affect the self-perception of knowledge gained (individual), satisfaction with the performance in the project (individual) and the grade for the course (individual).

8. Social network analysis

Understanding the way students in a class learn is never easy, but a pictorial representation of the flow of information among these students can shed some light on how their interactions affect the way they form social structures, and possibly impact their learning. Figure 2 depicts the sociogram of actors in all the eight courses over three semesters. As you can see, since the N's are small, the networks are also small and sparse. The impact of this low N can vary depending on the type of network that emerges. If a decentralized network were to emerge (an all-channel network in which everyone connected to everyone else), then information floats inefficiently in such a network (Lazer, 2007). In the case of a centralized network information transfer would be more efficient (Lazer, 2007). Of the various centrality scores, betweenness centrality was the centrality measure of choice because this score is calculated based on who else the actor is connected to and whether they are strategically placed between others with higher degree/power.

The names of the courses are mentioned along with the actor names to differentiate the networks from one another. Though there were a few students who took more than one of the above courses at the same time there was no evidence of them talking to one another across courses, hence there are no lines linking them. Degree, closeness and betweenness centrality scores were computed for all the actors (for email and IM communications). The scores for bulletin board conversations were not computed as the N was very small from the bulletin boards. Even though they were computed together, these networks are distinct from one another and the values are specific to their network alone.

Figure 2: Sociogram of actors in eight different courses over three semesters

The reason for betweenness centrality being the centrality measure of choice is because this score is calculated based on who else the actor is connected to and whether they are strategically placed between others with higher degree/power.
Their connectedness to other actors with power (or knowledge) places them in a position to act as controls or conduits for information and hence provide them with indirect network prestige effects. For those who did not respond to the survey, there was no data to suggest whether they were connected to these actors or not and hence that data was eliminated. Thus the networks are only for the respondents and in essence this would be an incomplete network representation of those who took the courses. However, this is a limitation and as is the case with any survey based study, the self-selected sample (as they volunteered to participate) is expected to represent the population. Table 1 lists the actors with high betweenness centrality scores.

### Table 1: Betweenness centrality scores of some actors

<table>
<thead>
<tr>
<th>Number</th>
<th>Actors</th>
<th>Betweenness Centrality Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>calg-sum05</td>
<td>0.162</td>
</tr>
<tr>
<td>2</td>
<td>grj-sum05</td>
<td>0.262</td>
</tr>
<tr>
<td>4</td>
<td>ksks-sum05</td>
<td>0.437</td>
</tr>
<tr>
<td>8</td>
<td>drgj-sum05</td>
<td>0.662</td>
</tr>
<tr>
<td>25</td>
<td>grcr-fallFHCI</td>
<td>2.709</td>
</tr>
<tr>
<td>29</td>
<td>pws-fallFHCI</td>
<td>1.199</td>
</tr>
<tr>
<td>33</td>
<td>rosm-fallFHCI</td>
<td>0.424</td>
</tr>
<tr>
<td>35</td>
<td>trdr-fallFHCI</td>
<td>1.199</td>
</tr>
<tr>
<td>39</td>
<td>vnkt-fallFHCI</td>
<td>1.086</td>
</tr>
<tr>
<td>59</td>
<td>instr-SpringIB</td>
<td>0.799</td>
</tr>
<tr>
<td>79</td>
<td>grcr-SpringTCTR</td>
<td>1.223</td>
</tr>
<tr>
<td>81</td>
<td>dnnd-SpringTCTR</td>
<td>0.662</td>
</tr>
<tr>
<td>86</td>
<td>lmrd-SpringTCTR</td>
<td>0.412</td>
</tr>
<tr>
<td>88</td>
<td>srpm-SpringTCTR</td>
<td>0.824</td>
</tr>
</tbody>
</table>

9. **SEM results for this study**

Structural equation modeling (SEM) is an extension of the general linear model (GLM) that enables a researcher to test a set of regression equations simultaneously. SEM software can test traditional models, but it also permits examination of more complex relationships and models, such as confirmatory factor analysis and time series analyses. The researcher first specifies a model based on theory, determines how to measure constructs, collects data, and then inputs the data into the SEM software package. The package fits the data to the specified model and produces the results, which include overall model fit statistics and parameter estimates. The input to the analysis is usually a covariance matrix of measured variables such as survey item scores, though sometimes matrices of correlations or covariances and means are used. The betweenness centrality scores (some of which are depicted in table 1) were converted to integer values using a CEILING function in Excel® to round them to the nearest integer values and these formed the variable “IMEMLBET” – betweenness centrality from IM and Email communication, the primary exogenous variable in the (SEM) path analysis in the AMOS® SEM package.

IMEMLBET (betweenness centrality due to IM and Email usage) would form the primary exogenous variable to test the model depicted in Figure 1. RESPMT (motivation due to perceived respect among group/class members) and INFMLMT (motivation due to perceived influence among group/class members) form the intermediate tier, while CONKNOW (conceptual knowledge gained), NEWKNOW (new knowledge gained), IMBBLERN (IM and Bulletin Boards were useful to the learning process), SATPEF (completely satisfied with the performance in the course) and finally SELFGRDA (confident of getting an A in the course), were the final outcome variables. The Chi-square was 16.893 (df = 13, p = 0.204) and CMIN = 1.299. This Chi-square value is high but indicates a better fit as shown both by the probability level and the CMIN value. One additional metric of the significance of the path parameter is the Critical Ratio. When the Critical Ratio (CR) is > 1.96 for a regression weight, that path is significant at the .05 level (that is, its estimated path parameter is significant).

Table 2 gives the standard errors and the critical ratios for the default model, which contains the fit measures for the model in figure 1 and we note that CR values for all the variables are greater than
the required 1.96 and they are all significant at the 0.05 level, thus affirming that the model fits the data acceptably.

Figure 3: Final Path Model with five outcome variables comparable to hypotheses model in figure 1 – presented here with standardized weights - chi-square = 16.893, degrees of freedom = 13, probability level = .204, cmin/df = 1.299

In addition to presenting the Chi-square results and the CMIN results, the results of the RMSEA goodness of fit test (Root mean square error of approximation) are also presented. By convention, there is good model fit if RMSEA is less than or equal to .05. **RMSEA for the model in figure 3 was 0.00313 and we see that this is < 0.05 and by convention indicates a good model fit.** Also, for this model, the PCLOSE value is 0.302 confirming that the RMSEA value is < 0.05 and confirms that the model fits the data acceptably.

Table 2: Standard error and critical ratios for each of the parameters

<table>
<thead>
<tr>
<th>Estimate</th>
<th>S.E.</th>
<th>C.R.</th>
<th>P</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMEMLBET</td>
<td>1.918</td>
<td>.237</td>
<td>8.108 &lt;.001</td>
<td>par_22</td>
</tr>
<tr>
<td>RESPMOTV</td>
<td>4.624</td>
<td>.376</td>
<td>12.292 &lt;.001</td>
<td>par_21</td>
</tr>
<tr>
<td>INFLMOTV</td>
<td>4.502</td>
<td>.388</td>
<td>11.597 &lt;.001</td>
<td>par_23</td>
</tr>
<tr>
<td>IMBBLERN</td>
<td>1.467</td>
<td>.550</td>
<td>2.668 .008</td>
<td>par_16</td>
</tr>
<tr>
<td>CONKNOW</td>
<td>2.596</td>
<td>.606</td>
<td>4.285 &lt;.001</td>
<td>par_17</td>
</tr>
<tr>
<td>NEWKNOW</td>
<td>1.508</td>
<td>.639</td>
<td>2.361 .18</td>
<td>par_18</td>
</tr>
<tr>
<td>SATPEF</td>
<td>4.413</td>
<td>.588</td>
<td>7.502 &lt;.001</td>
<td>par_19</td>
</tr>
<tr>
<td>SELFGRDA</td>
<td>4.294</td>
<td>.637</td>
<td>6.736 &lt;.001</td>
<td>par_20</td>
</tr>
</tbody>
</table>

10. Hypotheses with the results

Respect (and influence) and perceived respect (perceived influence) have been used interchangeably and the results are not affected as the questions were framed in a manner that records only the students’ perceived respect and influence.

H1: Betweenness centrality from use of email and IM, among students in a computer-supported collaborative learning (CSCL) environment will positively impact respect and influence among the class members.
The CR for the relationship between IMEMLBET and RESPECT was 0.887 (p = 0.375) indicating a weak relationship and the CR for IMEMLBET and INFLUENCE was 2.014 (p = 0.044) indicating a significant relationship. Therefore even though the model fits the data acceptably, hypothesis H1 is only partly supported, i.e. betweenness centrality from use of email and IM has a relatively higher positive impact on influence among class members than it does on the respect gained from class members.

H2: Presence of social dynamics factors like respect and influence gained from email and IM, communication among students in a computer-supported collaborative learning (CSCL) environment will positively impact the students’ motivation to participate and interact in class discussions via instant messenger chats and bulletin board message posting.

RESPECT vs. RESPMOTV had a CR = 2.757 (p = 0.006) and INFLUENCE vs. INFLMOTV had a CR = 5.295 (p < 0.001). This indicates again that respect and influence gained from and among class members has a positive impact on the motivation to participate in class discussions using the CSCL tools. Contrarily, RESPMOTV vs. IMBBLERN (participation in IM aided in the learning process) had a CR = 2.801 (p = 0.005) indicating a positive relationship and INFLMOTV vs. IMBBLERN had a CR = 0.784 (p = 0.433). This indicates that motivation from perceived respect impacted usage of IM and Bulletin Boards to learn (IMBBLERN), while motivation due to perceived influence did not impact IMBBLERN. These are mixed results. Both RESPMOTV and INFLMOTV were expected to impact IMBBLERN, but only one of them did. So hypothesis H2 is supported. Respect and influence do have a positive impact on the motivation for students to participate in class discussions that use the CSCL tools like IM and email and that aided their learning process.

H3: Motivation to interact and participate in online discussions, gained from perceiving respect from peers and influence in class matters gained from email and IM communication among students in a computer-supported collaborative learning (CSCL) environment will positively impact the students’ self-perception of knowledge gained.

RESPMOTV vs. CONKNOW had a CR = -0.877 (p = 0.380) and RESPMOTV vs. NEWKNOW had a CR = -0.101 (p = 0.919) indicating that respect gained from classmates did not play a role in either conceptual or new knowledge gained during the course. We also note that INFLMOTV vs. CONKNOW had a CR = 2.635 (p = 0.008) and INFLMOTV vs. NEWKNOW had a CR = 2.948 (p = 0.003), indicating that influence (by the self) among class members has a positive and significant impact on both conceptual and new knowledge gained during the course. So hypothesis H3 is partially supported in that while respect gained amongst class members motivated the students to participate (H2), it did not have a significant effect on knowledge gained. On the other hand, influence gained among class members had positive impact on their motivation to participate (H2) and a significant positive impact on knowledge gained.

H4: Motivation to interact and participate in online discussions, gained from perceiving respect from peers and influence in class matters gained from email and IM communication among students in a computer-supported collaborative learning (CSCL) environment will positively impact students’ satisfaction with their performance in the course.

RESPMOTV vs. SATPEF had a CR = 0.662 (p = 0.508) and INFLMOTV vs. SATPEF had a CR = 0.696 (p = 0.487) indicating that the motivation to interact and participate in online discussions gained from perceived respect and influence among class members did not have a significant effect on the students’ perceived satisfaction with their performance in the course. Since the CR values are not significant, we cannot reject the null. Thus hypothesis H4 is not supported in this model. Students, who are new to a class or group, earn their respect by not just being nice, but by doing their assigned parts of a group task well and to the satisfaction of the group. They earn their credibility by performing and are motivated to perform in anticipation of acceptance by the group. This is the case among non-familiars. It is the newcomers who strive for the perceived respect and influence within the group.

H5: Motivation to interact and participate in online discussions, gained from perceiving respect from peers and influence in class matters gained from email and IM communication among students in a
computer-supported collaborative learning (CSCL) environment will positively impact students' confidence of getting an A in the course.

RESPMOTV vs. SELFGRDA had a CR = 1.239 (p = 0.215) and INFLMOTV vs. SELFGRDA had a CR = 0.121 (p = 0.903) indicating that the motivation to participate and interact in online discussions gained from perceived respect and influence among class members did not have a significant effect on the students' confidence of getting an A in the course. Again, since the CR values are not significant, I cannot reject the null. Thus hypothesis H5 is not supported.

11. Discussion, conclusions, and future directions

Respect (whether real or perceived and not very different from esteem) as a social factor is important to people in order to validate themselves and the skills they bring to the table in collaborative work situations. Influence in a group and among class members and motivation to actively collaborate and not be a free rider, follow from the respect that the individual gets from group/class members. This respect may be there as a result of past achievements or may be earned by the individual during the course of collaboration. In the case of distance students, respect will primarily be gained from networked communication when the students interact with one another in class. However, it is possible that they may already know one another from previous interactions from having taken similar classes before or coming from the same high school or maybe if they are working in the same/different department in the same organization. In either case, since respect and its companion, influence in a group (hypothesis H2), have emerged as important dimensions in collaboration among members in group/class project work, one can make a case for designing learning and collaborative systems which incorporate this need for validation.

Designers of CSCL systems could consider the following recommendations. They can have tools to validate the quality of the contribution to the work, for instance a tool that would prompt group/class members to send both a visual validation for work done, such as an emoticon, or textual feedback to their group members. This again follows closely from hypothesis H2. This would be helpful in preventing situations in which members, who are contributing, don’t feel valued and might feel like the payback for contributing in the work doesn’t meet the cost. This is exactly the type of situation that leads someone who might be productive, into becoming detached and eventually a free rider. A similar idea is to include a participation meter and making it available to the group. A group/class member could indicate the percentage of work each member has contributed and this could allow the group to address any problems that arose from lack of participation, before it got to the stage where an instructor has to intervene.

Tools to support reputation building, perhaps through building profiles showing prior examples of collaborative work, successful decision making, references and testimonials could all help people earn a reputation prior to collaborative work. These are the network prestige effects discussed by Cho, Stefanone & Gay (2002) and follow from hypothesis H1. Even simple ideas, like a star rating given by one’s peers, could motivate students to actively participate in collaborative learning exercises. To avoid Groupthink, a system could support voting in decisions with the percentage of confidence in the decision, e.g. “I vote with 50% confidence that we should follow our design plan.” The system should support doing this anonymously to avoid students with more authority than others dominating decisions. While negative feedback could cause people to shrink into the background, especially if they are new to a group, if they realize that the feedback is fair and based on accepted norms, they will be more accepting of this feedback.

Thus peer assessment becomes an integral part of the decision-making and the learning processes. For effective collaborative work, whether in classrooms or in industry settings, a team needs to avoid Groupthink and free riding and build a solid social network, where members feel respected and influential. Communication is a key component of this, and systems can be built to better facilitate this communication. The implementation of CSCL systems with a social network engine would aid in this endeavor and the first of such systems have already begun making their appearances in the market. Tosh and Werdmuller (2005) have created elgg® – a social network software for education (O’Hear, 2006). Described by its founders as a ‘learning landscape’, elgg® provides each user with their own weblog, file repository (with podcasting capabilities), an online profile and an RSS reader. Additionally, all of a user's content can be tagged with keywords - so they can connect with other users with similar interests and create their own personal learning network. However, where elgg® differs from a regular weblog or a commercial social network (such as Facebook® or MySpace®) is the
degree of control each user is given over who can access their content. Each profile item, blog post, or uploaded file can be assigned its own access restrictions - from fully public, to only readable by a particular group or individual (O’Hear, 2006).

The reason for discussing an environment like elgg® and Elluminate® is to look at similarities and differences between these environments in the context of the constructivist and collaborative learning paradigms. While, there is much evidence in the literature and in this study that the formation of networks among students in a collaborative CMC environment does impact how they perceive one another and use these relationships to learn from one another, for all of these to work in concert, there must be more mentoring of the students as they use these environments to study and learn. The concepts of peer-assessment and collaborative learning should be inculcated from an early stage. The present generation of students is weaned on IM, AOL®, MySpace®, Facebook® and YouTube® and many form lasting relationships (online and offline). The instructors only need to leverage these behaviors in order to give the students the best experience during their learning activities. In this study some of the hypotheses were confirmed while others were not. But this is good, as it indicates that several students chose not to participate and thus exercised control over what they wanted to do. It is this control that manifests itself positively when you introduce peer assessment and students will be motivated to participate, assess and be assessed because they choose to do so.

The formation of social network structures due to communication patterns did have some significant impact on how the students perceived whether they gained respect among their classmates and whether they had influence on work related matters in online discussions. This in turn did appear to have some significant impact on the students’ perception of conceptual and new knowledge gained during the course. However, this could be the result of a halo effect, but to a certain extent an individual can gauge the reactions and responses of others by the way in which they accept or reject suggestions made by the individual. So the perception is not necessarily always a halo effect.

One of the goals of this study was to look at CMC-supported collaborative learning and attempt to identify some of the underlying factors that improve learning and collaboration at the individual level. Group effects like cohesion and clique formation, Groupthink and presence of free riders have not been tested and are the subjects for a future article. It is encouraging to note that the elgg® software is an open source social networking platform that allows people to customize the tools to their needs and it will be useful to compare performance of students in the elgg® environment to the performance of students in the CSCL environment like Elluminate®.

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References

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Realizing Wisdom Theory in Complex Learning Networks

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Abstract: The word “wisdom” is rarely seen in contemporary technology and learning discourse. This conceptual paper aims to provide some clear principles that answer the question: How can we establish wisdom in complex learning networks? By considering the nature of contemporary calls for wisdom the paper provides a metatheoretial framework to evaluate the appropriateness of the characteristics of learning technologies in the postmodern context. By taking into account the complexities of paradox and uncertainty in contemporary life, the paper also indicates where future research would be best directed and considers how wisdom might practically be applied via use of learning technologies.

Keywords: wisdom, learning networks, e-learning, digital learning technologies, knowledge

1. Introduction

The word “wisdom” is rarely seen in contemporary technology and learning discourse. This is problematic at a time when excellent judgment and insightfulness and character are needed. This paper argues that learning requires wisdom to provide excellence in judgment and insight and that if the principle features of wisdom are understood learning technologies can be evaluated according to a robust criteria based on these principles.

The purpose of this conceptual paper, therefore, is to provide clear principles that answer the question: How can we establish wisdom in complex learning networks? The paper begins by considering the nature of contemporary calls for wisdom. This provides a metatheoretial framework to evaluate the appropriateness of the characteristics of learning technologies in the postmodern context. By taking into account the complexities of paradox and uncertainty in contemporary life, the paper also indicates where future research might be best directed and considers how wisdom might practically be applied via use of learning technologies.

2. The Nature of wisdom

Many theorists and practitioners have increasingly become interested in wisdom. For example, Srivastva and Cooperrider (1998) assert that the need for wisdom is higher than ever and less and less available. Vaill (1998) claims that as wisdom principles are characterized by flexible and intuitive methods they are especially appropriate for our times. Perhaps the most active consideration of wisdom is in the strategic leadership literature (Boal and Hooijberg, 2000; Korac-Kakabadse, Korac-Kakabadse, & Kouzmin, 2001; Kriger & Seng, 2005; Whittington, Pitts, Kageler, & Goodwin, 2005) where it is seen as essential for complex decision making, applying knowledge and for welfare reasons.

It is important that the nature of wisdom be understood. Wisdom can be presented as a set of principles to be used as an a priori construct. In the day to day practice, each of these principles can be simultaneously balanced. These principles collectively constitute an a priori construct and present an ideal wisdom that is beyond fallible humans. Nonetheless, this ideal of wisdom can be aspired and used as a standard to measure. The goal would be to enhance those practices that fulfil these principles:

Principle 1:

Wisdom requires the formulation and understanding of logical arguments based on sound propositions. Nonetheless, wise people are epistemologically sceptical. Their fluid intelligence questions the knowledge inherent in propositions. Thus, a wise person needs occasionally to be sceptical of the facts, common sense and orthodoxy.

Wisdom also requires one to focus at the right level by choosing what facts are salient in a given situation. In other words, filtering and interpreting the noise from within their own community and determining the salient points on which to act are crucial to wisdom. Good judgment should also be used to reach better decisions (Sternberg, 1990).
Principle 2:

Non-rational aspects should also be used in the process of wise decision making. These include insight, imagination and foresight that occur outside a rational process of intersubjective verification (reaching a consensus on what the facts and evidence are). As 'gut' level intuition can be valuable in making judgments, wisdom is manifested as a coordinated and balanced interplay of intellectual, affective and motivational aspects of human functioning. So, the ability to interpret and decode meaning and mental maps of other community members is essential to wisdom (Malen & Kriger, 1998).

Metaheuristics is a combination of two heuristics: one that organizes at a high level of aggregation and another at a more explicit level used by individuals in planning and evaluating issues surrounding the pragmatics of life such as knowledge about oneself, insight into the social nature of human existence and variability of life goals. This might also be referred to as a 'sixth sense' or well-developed intuitive powers that implies moving beyond existing rules.

Wisdom requires one to respect tradition and experience and use them appropriately. Issues can be considered reflexively from cultural-historical perspective. These insights complement the reasoning process.

Visioning and a perspective-taking capacity that incorporates long-range goals is also a characteristic of wisdom. This is the capacity to overcome and revise the quotidian and ephemeral features of any judgment and to see the effect of alternative actions in the longer term. Having backgrounds of domain-specific knowledge, focusing at the right level and making unusual associations might also contribute to this perspective-taking capacity (Effin, 2003).

Reason-based approaches work best with established propositional assumptions and are less effective when the epistemic and ontological foundations of these assumptions are mutable or contested. Wisdom requires one to deal effectively with uncertainty. This refers to being aware that life is constructed from various perspectives, ontogenetic and historically situated. This awareness in itself also allows them to recognize the limits of reason-based cognition. At an interpersonal level, this capacity refers to wise people's ability to grasp and reconcile the paradoxes, changes and contradictions of human nature. So, wisdom requires one to grasp the meaning of several contradictory signals and stimuli and interpret them holistically (Malen & Kriger, 1998).

Principle 3:

Since Aristotle (1984), wisdom theory has been concerned with the role of ethics and virtue. A central capacity for practical wisdom is ethical judgment. For Aristotle (1984), the inclination to virtue defines our humanity: one should do what one does just because one sees those actions as noble and worthwhile. Values are therefore an integral part of wise thinking. Wisdom manifests as concern for others, being thoughtful and fair, admitting mistakes and also learning from them (Sternberg, 1990). Both the protection of values and smoothening the path of human interaction are essential to gaining wisdom.

As wisdom is essentially practical it is concerned with navigating the travails of day-to-day living and working in a way that contributes to well-being. While one should know absolute principles one must know how and when to apply them to a complex reality as decision-making rarely involves applying absolute principles. Wisdom requires rich factual or declarative knowledge about the fundamental pragmatics of life. So, wisdom is for making decisions and taking action in everyday life.

Aesthetic capacity refers to the ability of articulating insights and judgment in decision-making to others. So, wisdom must be articulated in an elegant way so that it reaches out to meet the affective as well as cognitive needs of those who will be affected. Besides, interacting with people all the time and continually picking up clues and meaning from these interactions is also essential to wisdom.

To sum up, wisdom is essential as we are not just conscious deciders but also conscientious deciders who use cognitive processes rather than simply habitual patterns of thought. The greater an enquirer's ability to move fluidly between producing alternatives and evaluating them and to operate at both levels simultaneously the better he will be at finding valuable discoveries (Effin, 2003). As Effin
Ayse Kok (2003) states, the central epistemic Aristotelian virtues are ingenuity, perceptual creativity, acuity of inference, a sound sense of relevance and an active ability to determine the relative importance of heterogeneous ends.

Derived from these statements, main principles of wisdom can be summarised as follows:

- Using reason and careful observation to make logical deductive explanations
- Evaluating the salience and truth-value of logical propositions by using clear understandings of ontological categories that theoretically describe substance, process and quality through logical argument
- Acknowledging the sensory and visceral as important components of decision-making and judgment
- Having a metaphysical and spiritual quality that does not bind one absolutely to the rules of reason thereby enabling vision, insight and foresight
- Respecting and drawing upon tradition as a means of apprehending who and what one is as a form of personal insight enabling them to understand the contingency of life and constructedness of phenomena
- Being humane and producing virtuous and tolerant decisions
- Being practical and oriented towards everyday life
- Being articulate and understanding the aesthetic dimension of one's work and seeking the intrinsic personal and social rewards of contributing to the good life (Effin, 2003).

3. The role of knowledge in wisdom theory

Understanding how collective knowledge impacts on learning is important when considering the role of wisdom. Cognitive complexity theory which relates to the number of dimensions used by individuals to perceive stimuli and the capacity to think and decide about complex phenomena (Wang & Chan, 1995) emphasizes an individual’s rational thought but contemporary knowledge goes beyond this and sees knowledge as a socially shared resource. Thus, knowledge can be characterized as pluralist, socially constructed, fragmented and discontinuous and having an axiological dimension. Disappointingly, the learning technologies literature makes little direct comment about knowledge despite the fact that learners constantly deal with high-level knowledge work of analysis, synthesis and deciding. The literature suggests that there is a considerable mental load in discerning, clarifying, deciding and communicating knowledge at the ontological and epistemological levels. This paper argues that the more needs to be said about knowledge in online learning communities as the capacity to handle knowledge is a crucial component of wise learning. Wisdom principles assume not only that there is significant knowledge in these networks, but more importantly that learners deal effectively with the shifting nature of knowledge. This requires artfulness and craft that are also implied by some of the wisdom characteristics.

Knowledge is a major source of complexity and can only be exploited to its maximum degree when complemented by wisdom. Knowledge is not a unitary thing, but a complex network of facts, ideas, beliefs, memories and intuitions (Rooney, Hearn, Mandeville, & Joseph, 2003; Rooney & Schneider, 2005; Saul, 2001). Ideas need to be connected to other ideas to create meaning and to find answers to problems. So, knowledge networks are not static as one’s state of knowledge is constantly changing. While knowledge helps us to decide and solve, it also produces ambiguity and complexity. For example, research can produce radically different knowledge about a particular question and some people who are creative might produce knowledge that is simultaneously imaginative and insightful by pulling together disparate ideas. Dealing with the extent and scope of knowledge systems can therefore cause as many problems as answers. So, digital learners who pursue wisdom are those who apply creativity, vision, foresight and insight to knowledge issues. Given the central role of knowledge in learning networks – collective knowledge- and the complex nature of knowledge, it is crucial that knowledge is characterized in a community context that is relevant to a wisdom-oriented view of learning.
Collective knowledge residing in the learning networks is pluralist (Spender, 1996). Knowledge systems are taken to be constructed of multiple and contradictory ideas, assumptions, beliefs, intuitions and memories that are taken by their possessors to have socially justifiable truth values (Rookey & Schneider, 2005). So, knowledge is taken to have truth values that are (re)constructed in social relations and especially through online communication. This is also consistent with the sociological view of knowledge that sees knowledge as an expression of culture, as symbolic rather than simple explanatory (McCarthy, 1996, Berger & Luckmann, 1966). This symbolic perspective suggests that sophisticated communication is essential if knowledge is to be shared and diffused throughout a community (Rogers, 1980; Winter, 1987; Zander & Kogut, 1995). So, a large part of wisdom is the steering and facilitating activities using collective symbols and communication.

Complex formal and informal social networks through which knowledge is communicated form an essential part of learning networks. In such uncertain environments, knowledge has been characterized as being “fragmented” and “discontinuous” such that there is much ontological and epistemic confusion (Murphy, 2005). To negotiate these relationships, social intelligence and skill are essential for wise learning as knowledge is embedded in relationships and within individuals. In other words, the context in which we learn is messy. Without wisdom, learning might be compromised by complexity and by epistemic and cognitive uncertainty and so is more likely to lead to conflict, mistakes and confusion.

Learning networks can be considered as complex, autonomous self-organizing systems that emerge as the outcomes of the interaction of different types of knowing within a bound and deliberately created context (Spender, 1996; Tsoukas, 1996; Chia, 1996; Hannan, 1995; Snowden, 2000; Schneider, 2001; Stacey, 2001). Throughout the literature, such systems have also been referred to as socially distributed activity systems (Engestrom, 1991, 1993; Blackler, 1995) and shared contextual spaces (Nonaka, Toyama, & Konno, 2000). So, knowledge is not formulated in relation to content, but, rather, as flows, relations, patterns, contexts and emergence in complex systems. For learners, the realization that knowledge is a background of complex processes should bring with it an understanding that knowledge work is a social challenge. Simon (1955, 1987, 1991) argues that we are boundedly rational and Berger & Luckmann (1966) argue that knowledge is subjectively constructed. Wisdom is an ability that minimizes these cognitive limitations for learners.

4. Wisdom as complexity: a meta-theory of effective digital learning

Wisdom is a process that brings together the rational and the transcendent, the prosaic and higher virtues, the short- and long-terms, the contingent and the absolute, and the self and the collective rather than being only concerned with rational processing of knowledge. Wisdom accepts the complex, cuts through ambiguity, and derives its energy from the uncertainties of a complex world. So, wisdom involves both complexity/nonlinear unpredictability and discernment/clarity/knowledge. This complex system is the learning environment of the millennial learners. This paper argues that wisdom enables today’s learner to both see more complexity and know how to respond appropriately in such complex learning networks. The capacity to simultaneously discern the technical complexity, the social complexity and the cultural complexity of such networks is crucial to gaining wisdom through learning.

These wisdom characteristics inherent in learning networks is also aligned with Siemens’ statements about learning in networks. This approach to learning has been captured under the heading of ‘connectivism’. In his paper of the same name, Siemens (2004) articulates the major theses: Learning and knowledge rests in diversity of opinions. Learning is a process of connecting specialized nodes or information sources. Learning may reside in non-human appliances. Capacity to know more is more critical than what is currently known. Nurturing and maintaining connections is needed to facilitate continual learning. Ability to see connections between fields, ideas, and concepts is a core skill. Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities. Decision-making is in itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality which might ultimately lead to the cultivation of wisdom.

As Siemens (2004) argues, in any network, there will be three major elements:

Entities, that is, the things that are connected that send and receive signals
Connections, that is, the link or channel between entities (may be represented as physical or virtual)

Signals, that is, the message sent between entities. It must be noted that meaning is not inherent in signal and must be interpreted by the receiver.

Given this description of networks, the essential elements of learning network semantics can be identified. First, context, that is, the localization of entities in a network (Siemens, 2004). Each context is unique –entities see the network differently, experience the world differently. Context is required in order to interpret signals, that is, each signal means something different depending on the perspective of the entity receiving it (Siemens, 2004). Second, salience, that is, the relevance or importance of a message (Siemens, 2004). This amounts to the similarity between one pattern of connectivity and another (Siemens, 2004). If a signal creates the activation of a set of connections that were previously activated, then this signal is salient. Meaning is created from context and messages via salience. Third, emergence, that is, the development of patterns in the network. Emergence is a process of resonance or synchronicity, not creation. We do not create emergent phenomena. Rather, emergence phenomena are more like commonalities in patterns of perception. It requires an interpretation to be recognized; this happens when a pattern becomes salient to a perceiver. Fourth, memory is the persistence of patterns of connectivity, and in particular, those patterns of connectivity that result from, and result in, salient signals or perceptions (Siemens, 2004).

This is not the definitive statement of network learning, yet it is developed in the classic mold of network learning, through a process of immersion into the network and recognition of salient patterns (Siemens, 2004). What sort of network? The following list is typical of what might be called ‘wisdom network’ practices online:

Practice: Content Authoring and Delivery
- Numerous content authoring systems on the web
- Weblogs
- Content Management Systems
- Audio and Podcasting
- Digital imagery and video
- Collaborative authoring

Practice: Organize, Syndicate Sequence, Deliver
- Aggregation of content metadata
- Aggregators
- Aggregation services
- the Semantic Social Network

Practice: Chatting, Phoning, Conferencing
- Bulletin board systems and chat rooms, usually attached to the aforementioned content management systems
- Audioconferencing
- Videoconferencing

Derived from these statements, a wise learner in the digital age will be a person who becomes a laudable instantiation of the five characteristics of wisdom via these learning networks as specified above. In the digital age, wise learners must have cognitive complexity; a capacity to deal with complex and ambiguous phenomena in complex environments. Secondly, wise learners must be rational and deep thinkers; having a capacity to seek out and understand the facts of a situation and to deal with them rationally, but also to understand and question the ontological basis of these facts. Thirdly, a wise learner displays creativity and draws on the non-rational as appropriate; having a capacity to think creatively and to acknowledge the potential worth of one’s own instincts in making judgments. Fourth, a wise learner displays long-term vision; having a proven commitment to life-long learning. Finally, a wise learner is articulate; having a proven capacity to reach people online.
It might be argued that these five features of a wise learner could have been devised without having to go through the theoretical process outlined in this paper as wise action is self-evident. Yet, this analysis provided a meta-theoretical framework for understanding the nature of wisdom and judging wise learning based on philosophical and psychological traditions. Wise learners will require each of these characteristics to varying degrees according to the circumstances.

5. Implications for future research

The theoretical approaches to wisdom seem to vary according to whether research should use implicit – based on beliefs and mental representations about wise people- or explicit theories – as determined by researchers- of wisdom. While the Berlin School asserts wisdom as an expert knowledge system in the fundamental life pragmatics including learning (Baltes & Smith, 1990), Sternberg (2004) defines wisdom as the application of intelligence, creativity and knowledge to the common good by balancing intrapersonal (one’s own), interpersonal (others’) and extrapersonal (community or larger interests) over the long and short terms through the mediation of values. According to Webster (2003), wisdom is multifaceted and involves the following dimensions: experience, emotional regulation, reminiscence, reflectiveness, openness and humour.

Methodologies also vary. The Berliner School tends to use hypothetical scenarios to measure wisdom that involves the solving of difficult problems from one’s life. As wisdom is associated with many positive characteristics, further research into creating the online learning conditions that are conducive to wisdom would be warranted. The type and life-span of wisdom in online learning communities, the transfer of wisdom in social networks might also be significant research topics.

From a sociological perspective, research would focus on the nature of knowledge, on the socially constructed context and patterns of online communities that produce particular forms of knowledge. Discourse theory might assist in understanding the sociology of wisdom in terms of structure and agency as discourse links thought, ideas, agency and action (van Dijk, 1997).

Further areas of interdisciplinary wisdom-related research are the areas of creativity and intuition. Although creativity has been extensively researched its role in wise learning still needs much consideration.

Although many individuals will not become fully wise, the raw components of wisdom reside in all of us to one degree or another. This paper, therefore, takes an optimistic view that a better future is possible if we are able to look beyond the accumulative assumptions about technology to wisdom. Wisdom requires judgment, insight, creativity and other transcendent forms of human intellect rather than a great accumulation of knowledge. Wisdom is concerned less with how much we know and more with what we do and how we act. Wisdom is a way of being and is fundamentally practical in a complex and uncertain world.

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