Optimal design and suitable media for e-learning effectiveness: A student-driven choice

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***Abstract*— The advances in information technologies over the last decade have been significant, especially in terms of multimedia content management. e-learning is at the heart of research interest. Designing and developing e-learning programmes is a complex process and their deployment combines various educational considerations, questions of usability and learning environments. This study focuses on the usability and selection of the most appropriate presentation media for the content of e-learning programmes, with an aim to enhance learning effectiveness. It also focuses on the students intention to use such e-learning systems or learning information systems. The research model and the research data described in this article explain how different versions of e-learning applications are highly dependent on their intended use and the selection of media to present the multimedia material.**

***Index Terms*— ANOVA, Computer science education, Electronic learning; Training.**

I. INTRODUCTION

The use of information technology in education has been long debated by the academic community. The prevailing views are quite varied, from those purporting that it has no impact on learning effectiveness to those in favour of using it as a necessity. Clark [3] purported that multimedia applications in education do not affect learning effectiveness, but he also acknowledged that choosing the appropriate multimedia content presentation media affects both the cost and speed of learning. Kozma, [4, 5] argued that the impact of information systems on learning effectiveness should be further investigated. The different views in the above articles serve as a stepping stone to study deeper how information systems could benefit education. Of course, the primary question is the intended use of such systems by both instructors and learners. Furthermore, the mode of content presentation as well as how such mode impacts learning effectiveness should be studied. In their work, Daft et al. [6, 7] suggested a theory with regards to the plethora of functions offered by multimedia, determined by its ability to reduce information uncertainty and consequently achieve the desired level of performance. Nonetheless, many researchers have questioned the applicability of the theory expressed by Kozma [4, 5]. The main reason is that he focused on technology appropriateness rather than the characteristics of the user employing the application.

In his work, Cheng [8] applied a model determining acceptance of e-learning programmes. Several factors, such as functionality, interactivity etc., have been investigated both in that study and the current one. Liu et al [9] conducted an in-depth study of the content of e-learning programmes, i.e. text, audio, video and acceptance by students using e-learning systems. Particular emphasis was also placed on the impact of the above factors on student concentration. It was concluded that enriched content is positively associated with user concentration; the results vary when associated with perceived usefulness. These results indicate a possible interaction between the selection of multimedia content presentation and other variables affecting not only perceived usefulness, but also learning effectiveness [10 – 15].

The need to also investigate additional variables apart from the above has been referred to in the work of Zhang et al. [2] this indicates the need to examine the characteristics of the student and its impact on the e-learning system's effectiveness for the application. The work of Arbaugh et al. [1] moves along the same lines, stressing the need to create more explanatory variables. The need to investigate the role of information technology, student characteristics and learning context is also described in the works of Leidner and Jarvenpaa, Alavi and Leidner, Piccoli et al, Arbaugh, Arbaugh [16 – 20].

This study is structured as follows: At first, the theoretical bases forming the study model are given. Subsequently, the research model and the assumptions are described. Then, the research methods adopted to test the research model are given. The final part of the work covers the analysis of empirical data and includes a discussion about the study results as well as the possible extensions of the study [1, 2].

II. ESTABLISHING THE RESEARCH ASSUMPTIONS AND CONCEPTUAL FRAMEWORK OF THE STUDY

The variables employed in this study are taken from an extensive literature review [16 – 20]. Through the study of previous empirical researches, it was possible to draw a model consisting of 7 variables:

1) Awareness and use of educational programmes
2) Location and media for e-learning
3) Use of auxiliary educational material
4) Effectiveness of educational material
5) Content of educational material
6) Application environment
7) Application support supervision

The dependent variable, as derived from the above studies, is the evaluation of results.

Relationships are established among the 7 variables above. Some of them have been investigated in previous studies [16 – 20], while others have not been widely analysed by the Greek

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research community as yet. This study aims to cover this "research gap". The target of this research effort is achieved by means of controlling the 7 assumptions regarding the relationships among the 7 independent variables and the dependant variable (effectiveness of the e-learning application).

In terms of the first variable "Awareness and use of educational programmes", it is investigated whether the student is using educational programmes and whether he/she is informed of educational programmes in general. If so, it may be assumed that involvement with e-learning is not casual. Thus, the first assumption is derived:

First assumption: The use of educational programmes is positively associated with e-learning process effectiveness.

Then, the "Location and media for e-learning" variable examines the location where the educational programmes are used. The aim is to study to what extent use and location affect e-learning application effectiveness. Thus, the second assumption is derived:

Second assumption: Location positively affects the results of the e-learning process.

The next variable is "Use of auxiliary material". The user describes to what extent the auxiliary material of the e-learning system contributes to usage effectiveness. It is also examined to what extent the content of the auxiliary material is comprehensible and whether the processes described are appropriate or could lead to achieving the right results (resolving problems concerning application use and installation). Thus, the third assumption is derived:

Third assumption: The existence of appropriate auxiliary material is positively associated with the effectiveness of the e-learning process.

Next, the effectiveness of educational material is measured by the "Effectiveness of educational material" variable. Since the educational material is about the Chemistry course, it is examined to what extent the educational material contributed to the comprehension of definitions, chemical equations and laboratory arrays. Thus, the fourth assumption is derived:

Fourth assumption: The effectiveness of educational material is positively associated with the effectiveness of the e-learning process.

For the fifth variable, "Content of educational material", it is examined to what extent the student considers the content as comprehensible. It is also examined whether the teaching material follows the established learning standards; whether the content is unique; whether it includes knowledge associated with the course to be taught; and finally whether there are targets for more efficient learning of the material. It is very important to examine to what extent the content of the e-learning application affects its use and effectiveness. Thus, the fifth assumption is derived:

Fifth assumption: Content quality is positively associated with the use and effectiveness of the e-learning process.

Moreover, for the "Application environment" variable, it is examined the environment in which the e-learning process is used. Namely, whether the laboratory in which the application is used is appropriate or not and whether the PCs to be used are safe (free of viruses, etc). Thus, the sixth assumption is derived:

Sixth assumption: The application environment is positively associated with the use and effectiveness of the e-learning process.

The last variable, "Application support supervision", which is considered as one of the most important points associated with the use of computer applications, concerns the support of such applications. Thus, the seventh assumption is derived:

Seventh assumption: The possibility of supporting an e-learning application is positively associated with the use and effectiveness of the e-learning process.

System users

System users are a fundamental part of an information system. When designing –developing – implementing – operating an information system, there should be special emphasis on the characteristics of the user group, in order to customise processes and tools depending on the competencies, wishes and perceptions of users. The main aim is to approach students and collect data on group characteristics relating to user familiarity with new technology and distance learning.

Furthermore, the questionnaires completed by interview allowed the necessary conditions to hold discussions on the problems users are facing with the current e-learning process and to collect data on their wishes and concerns.

The study was conducted during the period from 01/09/2013 to 30/06/2014 with the participation of 87 students from the Department of Chemistry at the Aristotle University of Thessaloniki. Out of 87 questionnaires, only 85 were used; 2 were not properly completed. The study focused on students using the e-learning system. The questionnaires were disseminated to students; several oral interviews were also conducted in parallel with the questionnaires. Questionnaire results were processed using SPSS 22.0 software suites.

Structure of questionnaires

Questionnaire structure was based on the model introduced by Venkatesh et al [21], Leidner & Jarvenpa, Alavi & Leidner, Piccoli et al, Arbaugh, Arbaugh [16 – 20]. This model attempts to unify the above theories on technology acceptance and use.

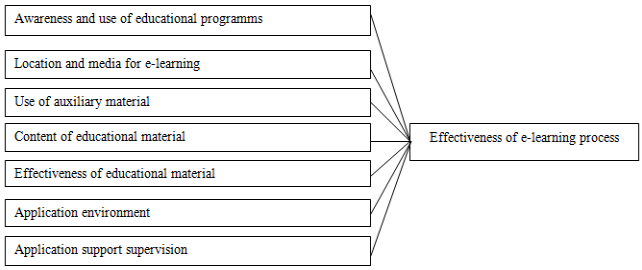

Fig. 1 Study model

The structure of the model illustrated in Figure 1 consists of 7 main factors. These factors affect system use, either directly or indirectly, both through the intention-to-use and through the efficiency-effectiveness of the e-learning process.

The expected performance remains the strongest factor affecting the intention-to-use regardless of whether this intention-to-use is voluntary or mandatory. The intention to use the system is affected by the perceived effort of the student to learn and use the e-learning system Venkatesh et al, Leidner & Jarvenpa, Alavi & Leidner, Piccoli et al, Arbaugh, Arbaugh [16 – 21].

Although the social impacts have been studied in the above

models, they show a growing trend. This factor (social impacts), determines to what extent the user believes that other persons that he/she perceives as important consider how he/she should use the new system.

Abbreviations and Acronyms

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User group

The student group consists of more women (60%) and less men (40%).

27% of the sample is aged 18-20 years old, 52% is aged 21-23 years old and the remaining 21% corresponds to 24+. These ages are particularly familiar with computers.

72% of students declare that they do not use a computer for educational programmes. In addition, in the questionnaires answered, many students stated that they use University computers rather than computers elsewhere. It is therefore concluded that further study is necessary whether students work alone when using an e-learning system or whether they prefer teamwork.

A recurrent theme in the interviews is the lack of staff (teaching assistants, administrative staff), who could assist by explaining and offering supplementary support on the e-learning process. This insufficiency is a determinant of system acceptance.

The model suggested by Venkatesh et al [21] may be used with a few modifications dictated by the nature of the information system (e-learning) and the user group consisting of students from the Department of Chemistry at the Aristotle University of Thessaloniki. The model applied is illustrated in Figure 1.

III. METHODOLOGY

According to the theoretical approach, a questionnaire of 59 questions was drawn up. These questions reflect the core elements of the theoretical approach. The aim of this study is to capture the complexity of the e-learning system, as well as the main reasons for its effectiveness and use. The study focused on the following aspects:

Collection of information on: complexity, effectiveness and use of the e-learning system.

The questionnaire method was chosen to conduct the study. The study was addressed to all students of the Department of Chemistry at the Aristotle University of Thessaloniki. The questionnaire-based collection of primary material was conducted from September 2013 to June 2014, i.e. during one academic year.

The statistical processing and data analysis of the study was performed using the SPSS 22.0 statistical suite for Windows, as well as Excel from the Microsoft Office 2010 suite.

This study does not aspire to offer a full picture of e-learning systems used by Greek Universities, but rather a "snapshot" of the students' view of the Department of Chemistry at the Aristotle University of Thessaloniki.

Measuring study variables

Closed-type questions were selected in this questionnaire in order to facilitate efficient completion and data processing. All questions, apart from the demographic ones, were five-point scale questions. Moreover, particular attention was paid to the questionnaire in terms of its clarity. The questions were short and clear. Negative questions were avoided to prevent misunderstandings, i.e. the negative word is overlooked and the respondents provide an answer which is opposite to their actual view [22 – 26].

The scales selected for this study were based on Likert [24 – 26] and Gutman [24 – 26], because the main issue is the attitude and the views of students. Rating on the Likert scale is: "very strongly agree"= 5, "strongly agree"= 4, "somewhat agree"= 3, "somewhat disagree"= 2, "strongly disagree"= 1.

Rating on the Gutman scale is: "YES" and "NO".

In the first part of the questionnaire, respondents were asked to complete their personal details. Then the questionnaire was focused on e-learning issues.

Table 1 Factors and most important questions per factor

Factor	**Most important question**
Use of educational programmes	I use educational programmes on my computer
Location and media for e-learning: first sub-factor	The educational computer I use for e-learning is located at: Friends' place.
Location and media for e-learning: second sub-factor	The educational computer I use for e-learning is located at: The University-Lab.
Use of auxiliary educational material	The auxiliary material of educational programme was comprehensible: The appropriate processes were applied.
Educational material	The educational material included in the educational programme was useful: to understand the examples

Content of educational material	Contents-Standards: There are standards and targets to learn the material
Content of educational material: second sub-factor	There is an intervention and special help, where appropriate
Content of educational material: third sub-factor	Content: It was comprehensible
Application environment	Environment-Psychosocial Factors: Inclusive environments.
Application support supervision	Supervision-Support-Management: Use of technologies to reduce inequalities
Evaluation of results	Evaluation of results: Students learn what they should learn

The R2 indicator value is satisfactory, which means that 62% is interpreted by the factors used in the model shown in Figure 1. Furthermore, Sig. F is equal to 0.000, which means that the results are statistically significant. The Durbin-Watson indicator value is 1.932 (Table 2); it is particularly satisfactory and confirms the model's validity.

Since Sig is 0.000, the statistical results of the anova table are statistically significant (Table 3). The value of the statistical F indicates the importance of relationships among variables, and thus the importance of the model, which is good in this case.

The table (Table 4) lists the coefficients and how they affect the students' final decision whether to use an e-learning system.

The statistically significant factors are:

1) Location and media for e-learning – i.e. the computer used for the learning programme.
2) Use of auxiliary educational material
3) Content of educational material – content quality of the learning programme
4) Application support supervision

IV Conclusions

Some of the user-student analysis findings are reported below. These are going to serve as a basis when designing and implementing a new learning information system.

The student group involved in the learning information system is highly experienced in using computers, the internet and social media (facebook).

The students' personal involvement with technology, if any, is highly associated (almost exclusively) with the use of online applications and social media.

The response time of the University's or developer's computer and network support department (gunet node) to resolve user problems (students-professors) is of particular importance.

Finally, the system should integrate functionalities to allow multiple changes and controls of input data in order to minimise errors and mitigate the insecurity of students that they could cause irreparable damages on their grades by pressing the wrong button.

The factors to be considered are how system content is formulated and, in specific, that each section should have clear targets to be achieved by students. Another point that the system administrator should pay attention to is the uniqueness of the system material.

It is concluded from this study that when students work with something out of the ordinary, they would like to have the necessary support in order to cope with difficult situations, regardless of whether they are going to use the service available or not.

Support provided by the University is another factor contributing to the involvement of students with e-learning. This study showed that students do not trust university- and the developer-provided support services.

Table 1 Summary of the model

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.792[a]	.627	.559	.538	.627	9.189	13	71	.000	1.932

Table 2 Anova table of the model

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34.638	13	2.664	9.189	.000[b]
	Residual	20.586	71	.290		
	Total	55.224	84			

Table 3 Table of model coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	4.180	.367		11.387	.000					
	Use of educational programmes	-.144	.146	-.177	-.987	.327	.387	-.116	-.071	.163	6.134
	Location and media for e-learning---1	.245	.084	.302	2.936	.004	.025	.329	.213	.495	2.020
	Location and media for e-learning---2	.147	.149	.181	.988	.327	-.453	.116	.072	.156	6.390
	The educational computer I use for e-learning is located: At home	.104	.089	.182	1.171	.246	.207	.138	.085	.218	4.590
	Use of auxiliary educational material	.392	.145	.484	2.704	.009	.525	.306	.196	.164	6.097
	Educational material	-.122	.148	-.150	-.825	.412	.339	-.097	-.060	.158	6.325
	Content of educational material---1	.396	.180	.488	2.200	.031	.373	.253	.159	.107	9.377
	Content of educational material ---2	.113	.081	.139	1.401	.166	.208	.164	.101	.531	1.884
	Content of educational material ---3	-.092	.152	-.114	-.606	.547	-.089	-.072	-.044	.149	6.707
	Application environment	-.038	.080	-.047	-.479	.633	-.218	-.057	-.035	.545	1.835
	Application support supervision	-.359	.124	-.443	-2.903	.005	-.518	-.326	-.210	.225	4.443
	Supervision-Support-Management: Satisfactory financial resources for educational systems of distance learning	-.178	.101	-.193	-1.766	.082	-.112	-.205	-.128	.441	2.269
	Evaluation of results	.107	.115	.132	.934	.354	.350	.110	.068	.262	3.822

a. Dependent Variable: Are you satisfied with the whole computer-based educational process?

In the new academic year, the study is going to be repeated towards two directions. The first direction will aim to verify the results of this study with regards to students, taking into account that independent pages have been developed on social media platforms for both our University and our School, allowing students to communicate and share information. The second direction concerns the professors who will be asked to use the e-learning system. Moreover, it should be stressed that both the lack of university teaching staff and the increased number of students which in many cases exceeds the educational opportunities of the university generate the major need to develop distance learning applications. In conclusion, it is estimated that e-learning applications are going to play a particularly important role in 21st century education.

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The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” **Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page**.

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