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Designing Personalised Blended Learning Courses for Engineering Students

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***Abstract* — Blended Learning is a well balanced fusion of face-to-face learning and online experiences. In this paper we discuss some design aspects concerning the optimal proportion between the two means of education applied to Engineering students. Our approach is taking into account the creative potential of engineering students and their type of thinking that have been previously investigated through the Brain Lateralization Information System (BLIS) [1]. In this paper we aim at identifying ways in which creative thinking and problem solving techniques can be implemented as personalized Blended Education Programs for students attending courses in the fields of Engineering.**

A blended course has an integrated online component and a concomitant face-to-face seat time, in order to reach student populations that cannot attend a fully face-to-face program. The advantages of face to face and the advantages of online activities have been put into balance and discussed. The purposes behind learning activities should be expressed by: community building, trust building, spontaneous reaction, clarification on one hand and reflection, analysis, exploration, creation on the other hand. In our efforts of designing a blended course we have considered the best suited modality for each specialty.

***Keywords*— blended courses, brain lateralization, creative thinking, information system.**

I. Introduction

Blended learning is an emerging trend and a topic in Higher Education. After a long period of online education experiences that were not entirely successful, higher education institutions have realized that they have to refocus on enhancing the educational experience and increasing flexibility of learning regardless of where the students actually are. Recent studies on blended learning that compared face to face, blended and online delivery methods against a range of learning outcomes indicated that bended learning is more effective than either face to face or online in meeting identified learning outcomes [2].

The literature provides a few conceptual definitions of a blended course, there is no unique definition or rule of blended learning. As follows, we will give some points of views and comments on blended learning.

According to the group from the University of Central Florida UCF in blended learning "a portion of the traditional face-to-face instruction is replaced by web-based online learning." [3]. Garrison and Vaughn define it as a "the thoughtful fusion of face-to-face and online learning experiences." [4]. Another definition is given in [5] "…a significant amount of the learning activities have been moved online, and time traditionally spent in the classroom is reduced but not eliminated".

The reminder of the paper is structured as follows: in Section II it is described the research model for the Brain Lateralization System that was used to assess students' creativity and type of thinking. Section III discloses the results and discussions after applying the questionnaires of BLIS, section IV presents the design elements we have considered for the design of a course of Multimedia Techniques and Technologies. Section V provides conclusions by pointing to future works.

II. Research model for the Brain Lateralization Information System

Our research is based on the already established premise that the brain is made of two hemispheres that perform different functions, which can work together or separately: the left side of the brain, concerned with logical, analytical, verbal, numerical, judgmental tasks; and the right side of the brain, concerned with the creative, intuitive, whole-concept, visual aspects of human thinking.

The research model of the Brain Lateralization Information System (BLIS) framework suggests that Student Individual Assessment, Adapted Teaching Methodologies and Learning Environment have significant influence on the elaboration of Persona We conceptualized the design of the Personalized Education Programs by using BLIS framework's main constructs: System characteristics (SC), Student Autonomy (SA), Organizational Factors (OF), Student Individual Assessment (SIA) and its Controls (C) and Adapted Teaching Methodologies (ATM), as shown in Fig. 1.

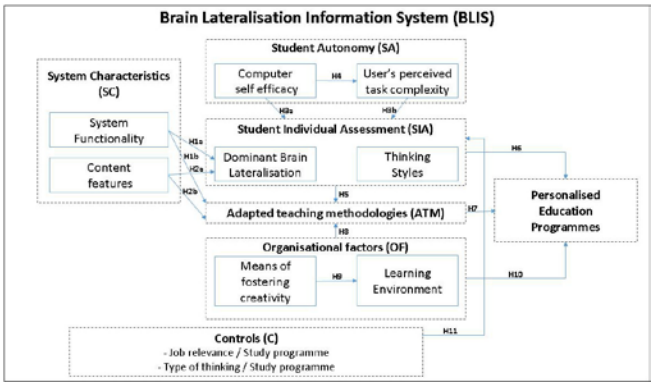

Fig. 1. Research model of BLIS framework

We conceptualized the design of the Personalized Education Programs by using BLIS framework's main constructs: System characteristics (SC), Student Autonomy (SA), Organizational Factors (OF), Student Individual Assessment (SIA) and its Controls (C) and Adapted Teaching Methodologies (ATM).

A. Effects of System characteristics on the Level of Student Individual Assessment and Adapted Teaching Methodologies

In comparison to evaluation scenarios which require personal attendance, BLIS applied within student empowerment initiatives offers the possibility to make evaluation without place and time constraints. For example, BLIS can be used even when traditional forms of evaluation are not available. If this form of evaluation is used for SIA, users should be able to find solutions to their problems quicker. As a result, the usage of BLIS is supposed to offer students a high level of flexibility in evaluation. Prior research has shown that information systems characteristics (SC) can significantly affect user beliefs in various contexts [6]. Optimized system functionality and content features are important external variables that directly affect both student individual assessment and elaboration of adapted teaching methodologies. In our study, system functionality and content feature are two system characteristics factors that are expected to influence BLIS use. System functionality is defined as the perceived ability of BLIS to provide flexible access to assessment media. For example, allow students to complete tests and quizzes online. In addition to system functionality, effective BLIS must provide high quality content feature. In our study, content feature is defined as the characteristics and presentation of BLIS information in user friendly and ease to manage presentation interfaces.

Thus, we hypothesized:

- H1a: System functionality has a positive effect on the students' individual assessment within BLIS.
- H1b: System functionality has a positive effect on the elaboration of adapted teaching methodologies within BLIS.
- H2a: Content feature has a positive effect on the student's individual assessment within BLIS.
- H2b: Content feature has a positive effect on the elaboration of adapted teaching methodologies within BLIS.

B. Effects of Student's Autonomy in the context of BLIS on the Level of Student Individual Assessment (SIA)

The Increasing Effect of Student Autonomy is connected mainly to computer self-efficacy.

Increasing student autonomy in SIA is a key part of student empowerment initiatives. In this context, BLIS can be used to provide students with a higher level of autonomy since it offers the possibility to choose place and time of assessment in a flexible manner. If universities decide to foster among students this higher level of autonomy, the users will apply the system when they need support during their decision-making processes.

Computer self-efficacy is defined as "a judgment of one's capability to use a computer" [7]. Computer self-efficacy has impact on user's perceived task complexity by increasing performance and the technological innovation of users, reducing computer induced anxiety, and promoting higher occupational positions. Computer self-efficacy studies have used student subjects at university level [8], [9]. Overall, these studies showed that higher levels of computer self-efficacy corresponded to greater achievement of computer competency and further to user's positive perceived of task complexity.

User's perceived task complexity relates to how well users can adapt to the system and navigate around it. Some studies of system diffusion suggested that the simpler the innovation is to understand, the more quickly it is adopted. For instance, a simple application may be easy to grasp. However, when the application is fully integrated into the organization's business processes, it could become a complex operation that could affect implementation. In short, perceived task complexity can greatly impact upon the user's time to learn the system. Based on the forgoing discussion, the following hypotheses were proposed:

- H3a: Computer self-efficacy within higher levels of student autonomy has a positive effect on the student's individual assessment within BLIS.
- H3b: User's perceived task complexity within higher levels of student autonomy has a positive effect on the student's individual assessment within BLIS.
- H4: Computer self-efficacy has a positive effect on the user's perceived task complexity within BLIS.

C. Students Individual Assessment in terms of Dominant Brain Lateralisation and Thinking Styles

Based on the reviewed theory [10], [11] the categories for each brain hemisphere have been defined as follows: for the left hemisphere: sequential, linear, symbolic, logical, verbal and reality-oriented, while the right hemisphere categories were: random, holistic, concrete, intuitive, non-verbal, fantasy-oriented. Ideally, the students should have displayed

an approximately equal percentage for both brain hemispheres. Student's creative potential is mainly represented by the activity of the right side of the brain, that concentrates creative, intuitive, whole-concept, visual aspects of human thinking.

Actually, the processes occurring in the two hemispheres rarely function cooperatively; it is actually impossible to do both types of thinking at the same time. Ideally, the engineer will learn to develop creative and conceptual thinking in conjunction with critical thinking, but this will take considerable experience and practice. As a matter of fact, engineering is one of the few professions or occupations that require several distinct thinking processes *from both sides of the brain.* Creative design and problem-solving are right-brain activities that the engineer shares with the artist, whereas applied design, project organization, materials assessment, and research are left-brain activities.

- H5: Automated testing environment within individual student assessment has a positive effect on the elaboration of the adapted teaching methodologies.
- H6: Automated testing environment within individual student assessment has a positive effect on the elaboration of the personalized study programs.

D. Effects of Adapted Teaching Methodologies on the development of Personalised Study Programs

From the point of view of teachers who want to stimulate creativity and develop all-round, comprehensive minds, one needs to try and use methodologies that will elicit as much material from students' creative side as possible before engaging the left side, since once you engage the judge in your mind, the flow of new ideas will be hindered. Researchers have emphasis on the fact that technology is advancing our society at an unprecedented rate and creative problem solving will be needed to cope with new challenges as they arise [12]. In addition to helping with problem solving, creativity also helps students identify problems where others have failed to do so [13]. Promoting intrinsic motivation and problem solving are two areas where educators can foster creativity in students. Students are more creative when they see a task as intrinsically motivating, valued for its own sake [14]. To promote creative thinking educators need to identify what motivates their students and structure teaching around it. Providing students with a choice of activities to complete allows them to become more intrinsically motivated and therefore creative in completing the tasks. Teaching students to solve problems that do not have well defined answers is another way to foster their creativity. This is accomplished by allowing students to explore problems and redefine them, possibly drawing on knowledge that at first may seem unrelated to the problem in order to solve it [13], [14].

High levels of adapted teaching methodologies focused on development of student's creativity are seen as a prerequisite for enhanced personalised study programs. Thus, we hypothesized:

- H7: A higher level of adapted teaching methodologies will positively influence the elaboration of personalized study programs.

E. Effects of Organisational factors on the level of Adapted Teaching Methodologies and on Personalised Study Programs

We are entering a new age where creativity is becoming increasingly important. Universities should focus on means to enhance creativity. In this conceptual age, we will need to foster and encourage right-directed thinking (representing creativity and emotion) over left-directed thinking (representing logical, analytical thought). Some of the approaches and creativity techniques have been proposed both for academia and industry [15] namely: establishing purpose and intention, building basic skills, encouraging acquisitions of domain-specific knowledge, stimulating and rewarding curiosity and exploration, building motivation, especially internal motivation, encouraging confidence and a willingness to take risks, focusing on mastery and self-competition, promoting supportable beliefs about creativity, providing opportunities for choice and discovery, developing self-management (metacognitive skills), teaching techniques and strategies for facilitating creative performance, providing balance. Such approaches development of a favorable learning environment. The interactions among students, between faculty and students, and collaboration in learning resulting from these interactions are the keys to the learning process. A positive learning climate encourages and stimulates the exchange of ideas, opinions, information and knowledge in the university as it is characterized by trust and collaboration between learners [16]. Universities should provide effective student-student and student-instructor interactions and improves learning climate.

Therefore, the following hypotheses have been proposed:

- H8: Means of fostering creativity has a positive effect on the elaboration of adaptive teaching methodologies.
- H9: Means of fostering creativity has a positive effect on the Learning environment.
- H10: Learning environment has a positive effect on the design of personalized education programs.

F. Controls applied to Students Individual Assessment

In order to introduce a feed back on the individual student assessment and the chosen of the attended curricula we have designed two control variables to ensure reliability of results. On the one hand, we control for job relevance and the chosen study program. Additionally, we also control the type of thinking and the chosen study program. Such controls may lead to corrections of the decision process within the student's self evaluation and further on may positively influence the development of the personalized study program. Therefore we proposed the following hypothesis:

- H11: Highly correlation between the job relevance – chosen study program and the type of thinking-chosen study program can positively influence the

individual student assessment and indirectly the elaboration of personalized study programs.

G. Design of Personalised Education Programmes

True personalization of study programs requires a major shift in focus from an institution/teacher - centered approach to an authentic, student-centered approach. True personalization provides a learning program and approach specifically tailored to the abilities, interests, preferences, and other needs of the individual student. Not in the last place, student's type of thinking has to be taken into consideration when personalization of education programs is discussed.

III. Results Obtained with the Brain Lateralization System (BLIS)

Data obtained by applying BLIS questionnaires were relevant as to students' dominant brain hemisphere and related processes (verbal vs. non-verbal processing; logical vs. intuitive, etc.). According to findings, students were then grouped so as to their needs in terms of pedagogical approach and teaching methodologies.

Questionnaires available through BLIS (Brain Dominance and Thinking Styles Inventory Test), were applied to 59 out of the 70 students of Computer Science (39 male, 20 female) (Table I). The results obtained were highly indicative of the fact that the majority were not actually suited to their prospective career. In terms of brain dominance, specialists in Computer Science should ideally display a combination between both left and right lateralization, more specifically they should be able to carry out logical, rational, analytical mental processes, while at the same time they would also need to be able to conceptualize, synthesize, understand metaphorical language and visually apprehend reality. Only 43% were actually proved as suited for a career in R&D, MIS/ Data processing, Engineering, or Inventing, Research science. A large percentage of respondents would be more suited for Business studies (Marketing/Management, Office management), Production and Planning, or even for Social studies (Occupational theory) or Services (Table II) as presented in Table II.

IV. Design Elements of Blended Courseware

One great advantage of blended instruction is that one is not restricted by the modality. One can choose the format that best meets the learning goals. In the meantime, this advantage can be turned into a disadvantage. Therefore, it is a requirement of a very carefully consideration of the learning outcomes in order to be able to choose the most advantageous modality. A careful design is required in order to obtain a thoughtful fusion of the two modalities of teaching, namely face-to face and on-line. The design elements are the blueprint of the course (Fig. 2) and are represented by:

- Course Description
- General Course Goals - what are the overarching goals of the course?
- Performance Objectives - each module will have objectives that the teacher desires for the students to achieve. These should be measurable.
- Learning Outcomes - these are the assignments that students will need to complete to demonstrate proficiency in learning the material.

Table I. Results of Brain Dominance

Variable		Total (%)		Left/Right Brain Quiz respondents (%)		Brain Dominance and Thinking Styles Inventory Quiz respondents (%)	
Gender	Male	80	0.62	80	0.62	39	0.66
	Female	48	0.37	48	0.37	20	0.33
Age	19	16	0.12	16	0.12	0	0.00
	20	24	0.18	24	0.18	0	0.00
	21	16	0.12	16	0.12	15	0.25
	22	54	0.42	54	0.42	37	0.62
	23	7	0.05	7	0.05	4	0.06
	> 23	11	0.08	11	0.08	4	0.06
Career choices	Eng./ Data process	15	0.11	0	0.00	15	0.25
	Inventing / Research and Develop.	10	0.07	0	0.00	10	0.16
	Operation / Systems analysis / Statistics	1	0.00	0	0.00	1	0.01
	Others	33	0.55	0.004	0.00	33	0.55
Study program	Computer Science	70	0.54	70	0.54	59	1.00
	Applied Electronic	39	0.30	39	0.30	0	0.00
	Env. Eng.	19	0.14	19	0.14	0	0.00

Table II. Career choices

Left Brain career choices		Right Brain career choices	
D/A	Production	C/B	Psychology/Psychiatry
D/C	Supervision/Management	B/A	Library science
A	Statistics	C/D	Teaching
A	Financial analysis	B/C	Arts/Design
A/D	Clinical medicine	B/A	Architecture
D/A	Marketing management	B/A	Entrepreneurship
D/A	Law/Attorneys	C/A	Buying/Purchasing
A	Accounting/Auditing	C/B	Sales
A/D	Managerial science	B/A	Writing
D	Law enforcement	C/D	Nursing/Health care
D	Military	B/A	Personnel/Organizational development
A/B	Business Analysis	B/A	Inventing
A/B	Research and development	C/D	Politics
A/B	MIS/Data processing	C/B	Training/Development
A/B	Engineering	C/D	Social work
A	Operations/Systems	C/A	Occupational therapy

	analysis		
A	Quality assurance	B/A	Research science
D/C	Management consulting	C/D	Public relations
A	Economics	C/A	Customer service
D/A	Investment consulting	C/B	Music
A	Insurance	B/A	Editing
A/B	Market research	C/D	Clergy
D/A	Office management	B/C	Behavioral science research

The decisions that have to be taken during the design process of a blended course depend on factors that include: course material, goals for the course, the type of interaction the teacher wants to foster, the comfort with technology, etc. There is no one-size that fits all; rather, we must ensure that the components are integrated, there is a clear purpose and rationale for the type of blend one is employing, and that it is learner focused. The focus is given to enhance learning outcomes for students. Discussion is the backbone of a blended course. Students use both in-person and online discussion as the classroom – that is where the learning is happening. It can be done in both modalities, but for different purposes and with different outcomes. In an online discussion forum students have the time and ability to carefully construct a reasoned post and response. They can research the topic, bring in outside sources, and edit their post. In an in-class discussion, student conversation will be more spontaneous, more reactive. The discussion may go in many different directions, and you are there at the moment to guide it or let it develop. Both discussion formats can be very meaningful and constructive, but they are different.

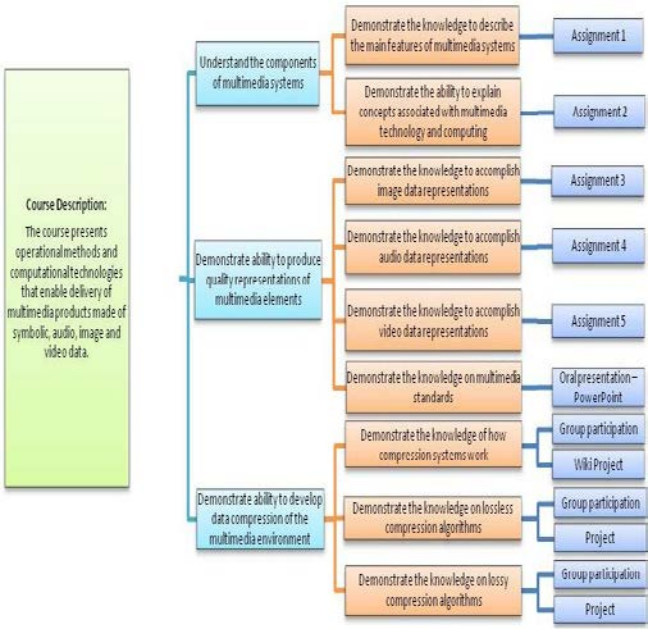

Fig. 2. Blueprint of a Blended course of Multimedia techniques and technologies

The blended learning mix-map (Fig. 3) provides the relationships between the face-to-face and online instruction modalities and their reciprocal influence during instruction.

Some requirements for the successful implementation of blended learning courseware:

- Blended learning models should be developed in order to respond to local, community or organizational needs rather than using a generic approach [17].
- The existence of sufficient technical resources, motivated faculty, good communication and feedback channels with students [18].
- Blended learning should be introduced as a scholarly and transformative redesign process within the institution, that rebuilds the course rather than simply adding on technology [19].
- There should be institutional practice of carrying out regular evaluations and publicising the results [2], [17].

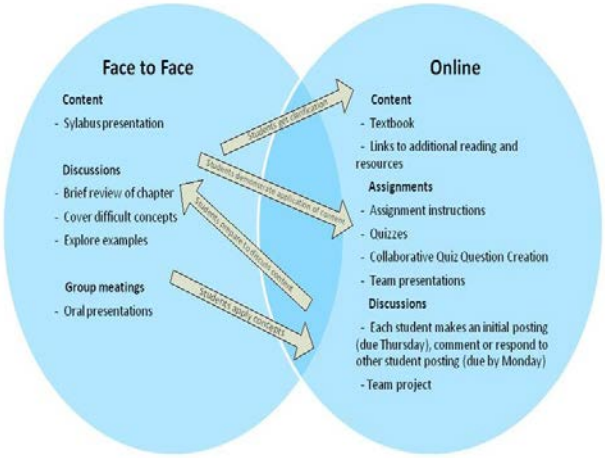

Fig. 3. Relationships between Face-to-face and online instruction in a Mix-Map

- The impact on teachers' workloads must be taken into account. In [19] the costliness in terms of both institutional and teacher investment have been investigated and it has been suggested the creation of shareable and reusable digital resources in an effort to ensure that blended learning is sustainable.

Creating a blended learning strategy is an evolutionary process. It is a process in which one invests more effort in a thorough redesign of the learning programs for maximum business impact. The high-level process (Fig. 4) presents the key decisions in the program design. The "dimensions of the blend" should meet the following criteria:

- Clear, High Value, Business Justification Case – to achieve executive sponsorship
- Executive Sponsorship – to provide the resources and management support required
- Committed Project Team – to execute project regardless of obstacles

- Change Management Strategy – to anticipate and overcome resistance to change
- Responsive Vendors – to provide resources and expertise for your success
- A Deadline – to maintain focus and commitment

The tasks to be fulfilled in the design of a blended learning course can be summarized as follows: 1.conceptualization of the blended course; 2. design of interaction within the blended course; 3. decisions taken upon the assessment of the blended learning course; 4. development of content /assignment for the blended course; 5. evaluation and assessment of course quality.

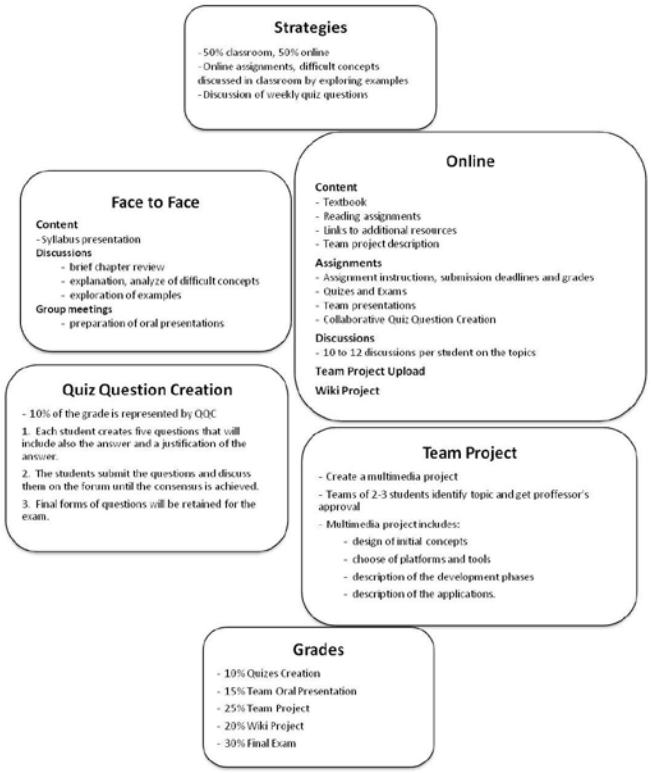

Fig. 4. Blended course interaction and assessment strategy

Determining the types of activities, assignments, interactive exercises and assessment is crucial as students need to understand the applicability of what they are learning. Providing sufficient examples and opportunities to practice the knowledge and skills they are acquiring is key for their self-assessment and the teacher's assessment on whether they are closer to achieving the proficiency expected of them.

V. Conclusions

One of the significant contributions of this research is the examination of the creativity level and the thinking style of the students' community and further on, of the academic community's needs towards blended learning environment. This study discovered clear strengths of blended learning design with direct impact on the community of students, which are as follows: (i) reduces the time needed to develop group cohesion, (ii) provides greater flexibility and student convenience.

In contrast with traditional instructions, blended learning courseware provides more learning resources and more opportunities to allow learners and instructors to communicate, collaborate, and interact with and among each other without regard to temporal or physical location. Such systems provide a variety of instructional aids and communication methods, and offer learners or instructors great flexibility as to the time and place of instruction. However, the combination of the virtual and physical environments should be made on the basis of an understanding of the strengths and weaknesses of each environment as well as the appropriateness of choice to the learners involved.

Our future endeavors will target towards a deeper research as we begin to understand components of perceived and realized satisfaction and quality of blended learning experiences. We will investigate students' satisfaction, organizational business performance and teachers' motivation on much larger samples, looking at effects created by the introduction of blended courses. Our efforts will focus on the enhancement of the level of understanding the needs of students, support students in blended courses, and promote successful learning experiences.

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