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DEVELOPMENT OF INTERFACE FOR CONTROL OF THE POSTGRADUATE STUDENTS WORKLOAD IN TERMS OF ECTS CREDITS

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ABSTRACT: The globalization of education has enhanced the transfer and sharing of knowledge throughout the world. With this rapid and ever expanding globalization, there is a need to form standards that will govern the transfer of knowledge as well as learners from different parts of the world. The European Credit Transfer System (ECTS) is a student-centered standard of describing learning which assigns credits to learning outcomes in accordance to the workload of an average learner. However, the ECTS does not provide a clear and logical method that relates the credits to a given workload of lecture hours, exercise hours, laboratory hours, and self-study hours. Therefore, there is need to formulate a mathematical model that will relate the three variables (Lecture, Exercise, Laboratory hours) and output the correct number of self-study hours based on the workload. In this study, the input versus output data were analyzed using Box-Behnken design method to generate a mathematical model that relates the four (4) variables and assigns the correct number of credits to a given workload. With the developed mathematical model, it has been found with two (2) Lecture hours, one (1) Exercise hour, and one (1) Laboratory hour gives the same number of self-study hours like only two (2) Lecture hours and two (2) Laboratory hours which in total translates to five (5) ECTS Credits.

KEYWORDS: ECTS Credits, Lecture hours, Exercise hours, Lab/Practical hours, Self-study hours, Student Workload

1. INTRODUCTION

1.1 Overview

It is important to acknowledge that ECTS has been adjudged, after much debate, to be just as valid as a credit ACCUMULATION and credit TRANSFER system. This is scarcely surprising since it is self-evident that credit cannot be transferred unless it has first been accumulated. In any event, everybody in Europe, like it or not, is in the Bologna Process for the creation of the European Higher Education Area which requires all countries involved to put in place a Credit Accumulation and Transfer System (CATS), either ECTS or a system which is fully compatible with ECTS. This is to be placed in a wider context of a common framework of 'diplomas', Bachelors, Masters, Doctorate [1]

In ECTS, the learning outcomes and the associated workload of formal learning for one academic year are allocated 60 credits, this equates to 30 credits for a semester. The student's workload includes four activities, these are lectures, practical experiments, self-study and exercises (sometimes known as tutorials). A typical student workload ranges from 1500 to 1800 hours per academic year. Therefore, one credit corresponds to 25 to 30 hours of workload [1-4].

The credits are associated to the entire educational components of study program such as attending lectures, seminars, work placements (attachments), projects, laboratory exercises and self-study. The students receive a specified number of credits, typically 4 to 5 credits, for each course unit after successful assessment. The credits that the student earns in the process are accumulated to form the required number of credits for a successful completion of a degree course. For

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a 5-credit course, the student workload ranges from 125 to 150 hours [3-6].

The credits earned from one university can be transferred to another university in case the student wishes to transfer to another university within Europe and in other recognized universities around the world.

The student's workload is a function of the individual workloads of the activities associated with a given unit. For example, a student undertaking a course unit in humanities will tend to have a higher workload of lectures and self-study but minimal or no workload on laboratory exercises. However, a student undertaking a course unit in sciences or engineering will tend to have fewer lecture hours but more hours in laboratory exercises. These activities have different weights towards their contribution on the overall workload. Therefore, it is important to develop a mathematical model that will take the hours for each activity and output the correct workload for the student for a given combination of these activities [5, 6].

The current ECTS standard does not provide a mathematical model for calculating the student workload and the associated credits based on these different activities. There is no direct link between contact hours and credits. For example, a lecture hour may require three hours of independent study by the student, while a two-hour seminar might involve a full week of preparation. A student-workload based system such as ECTS, therefore, does not provide a relationship between credits and workload hours. Consequently, there is a need to come up with a mathematical model that relates the hours of these activities and the associated workload in order to accurately assign the correct number of credits [8].

1.2 Importance of self-study at post graduate level

At the end of every unit, the students are expected to achieve a specific set of skills known as outcomes; Learning Outcomes represent a dynamic combination of knowledge, understanding, skills and wider competences (abilities and attitudes). They can be subject specific or generic. Fostering these outcomes is the object of any educational program; they will be formed in various course units and assessed at different stages [6-8].

In order to ensure that the students achieve the expected outcomes for a given unit, each unit is based on a number of educational activities. These activities can be classified as:

I. Types of courses: these may include lecture, seminar, research seminar, exercise course, practical, laboratory work, guided personal study, tutorial, independent studies, internship, placement, fieldwork, project work, etc.

II. Types of learning activities: these could be attending lectures, performing specific assignments, practicing technical or laboratory skills, writing papers, reading books and papers, learning how to give constructive criticism of the work of others, chairing meetings, etc.

III. Types of assessment: oral examination, written examination, oral presentation, test paper, portfolio, thesis, report about an internship, report on fieldwork, continuous assessment, etc.

The hybridization of these activities is usually influenced by the type of course unit as well as the level of study of the student. The number of contact hours between the lecturer and the student are greatly reduced at the postgraduate level. Students undertaking masters and PhD programs are expected to do most of the learning activities with minimal or no supervision. As a result, the student's self-study hours need to be considered when calculating the workload for a given unit at the postgraduate level.

It is advisable to keep in mind that Credit is one aspect of a whole process of creating a CATS because Credits are there to indicate volume of work but there are a number of things which credits, by themselves, cannot indicate. Contents of the teaching unit, precise programme equivalence, level at which work is accomplished, and quality of a student's work are some of the aspects that are not included.

In this work, the Taguchi and Box-Behnken methods of design were used. Within the theory of optimization, an experiment is a series of tests in which the input variables are changed according to a given rule in order to identify the reasons for the changes in the output response [9].

2. ECTS Modeling

In this study, through literature survey, use of heuristic knowledge about the processes' dynamics, clear understanding of real-world activity to be performed, its integrity and feasibility, the authors conceived an ECTS interface.

2.1 Design of experiment

In the design of experiment (DoE), Latin Square experimental design was used because it aims at reducing the number of samples required without confounding too much the importance of the primary factor.

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Taguchi Orthogonal Array (OA) design L9 (9 runs, 4 variables, 3 levels), columns of L9 (3^4) array was used as required by Latin square design. In the design analysis, the input variables were Lecture hours, Exercise hours, Lab/Practical hours while the output responses was Self-study hours as shown in the Table 1.

Table 1: Taguchi Design (Input Variables versus Output Response)

Experimental Number	Input variables			Output Response	Signal to Noise Ratio (SNRA)	MEAN
	Lecture Hours	Exercise Hours	Lab/Practical Hours	Self-Study Hours		
1	1	1	1	4	12.0412	4
2	1	2	2	6	15.56303	6
3	1	3	3	8	18.0618	8
4	2	1	2	7	16.90196	7
5	2	2	3	9	19.08485	9
6	2	3	1	8	18.0618	8
7	3	1	3	10	20	10
8	3	2	1	9	19.08485	9
9	3	3	2	11	20.82785	11

The interpretation of the results with Taguchi approach demonstrated that the Lecture hours were a more influential parameter to self-study as shown in the main effects plot for Means (Fig.1) and main effects plot for Signal to Noise (SN) Ratios (Fig.2).

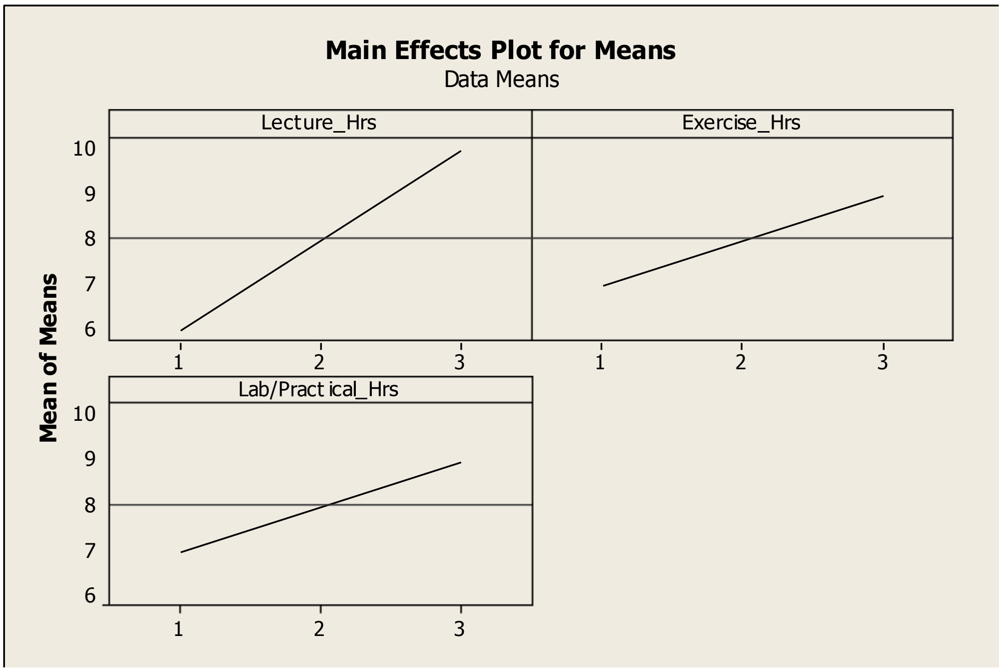

Fig. 1: Main Effects Plot for Means

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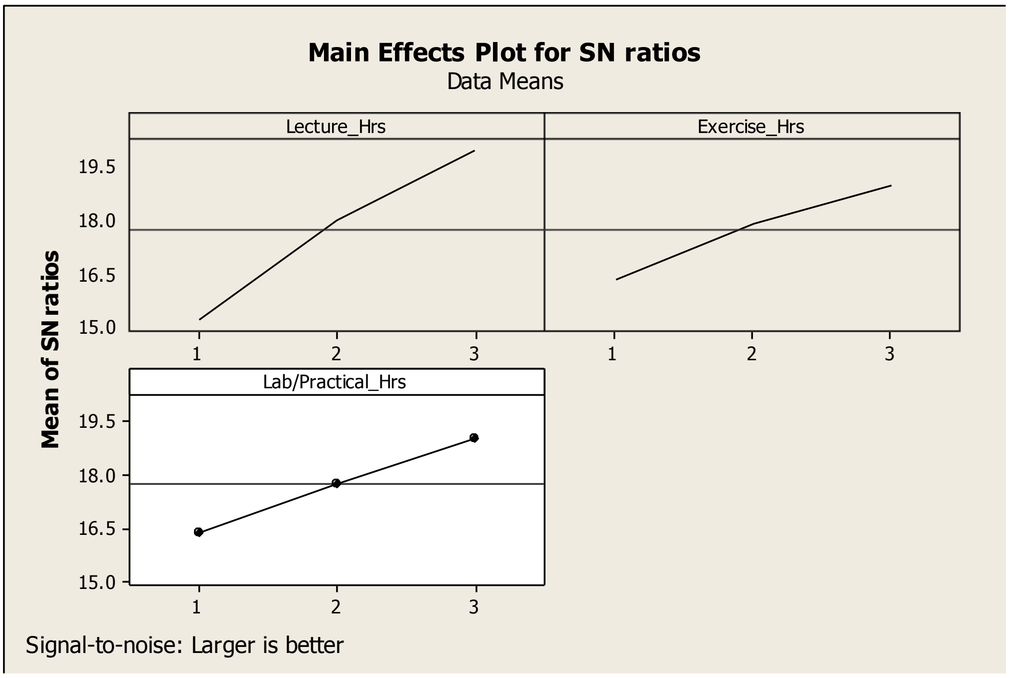

Fig. 2: Main Effects Plot for Signal-to-Noise Ratios

During design modeling, the Taguchi method was used to establish the ranks of the most significant study input factors for the Self-study hours. Their rankings, through analysis of the means and the signal to-noise (SN) ratios, are illustrated in the Table 2 and Table 3.

Table 2: Response Table for Means

Level	Lecture Hours	Exercise Hours	Lab/ Practical Hours
1	6.000	7.000	7.000
2	8.000	8.000	8.000
3	10.000	9.000	9.000
Delta	4.000	2.000	2.000
Rank	1	2.5	2.5

Table 3: Response Table for Signal to Noise Ratios

Level	Lecture Hours	Exercise Hours	Lab/ Practical Hours
1	15.22	16.31	16.40
2	18.02	17.91	17.76
3	19.97	18.9	19.05
Delta	4.75	2.67	2.65
Rank	1	2	3

The experimental investigations ranked the Lecture hours as the most effective factor in a student's workload, as shown in the Figs. 1 & 2 and Tables 2 &3. The larger-is-better methodology was selected in the DoE for the study variables against process responses because this characteristic involves continuously measurable results.

From Fig. 1 and Fig. 2, the Exercise hours and Lab/Practical hours were in good comparison with Lecture hours and they should not be neglected in ECTS empirical model.

The normal probability plot as the graphical technique for normality testing compared the empirical set against the theoretical set for a student's workload. It was observed that Self-study hours were normally distributed as shown in the probability plot of Self-study (Fig. 3) and Line plot of Means (Fig. 4). The P-value

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was equal to 0.835, while the alpha (α) risk of Taguchi method was selected to be at 5 %.

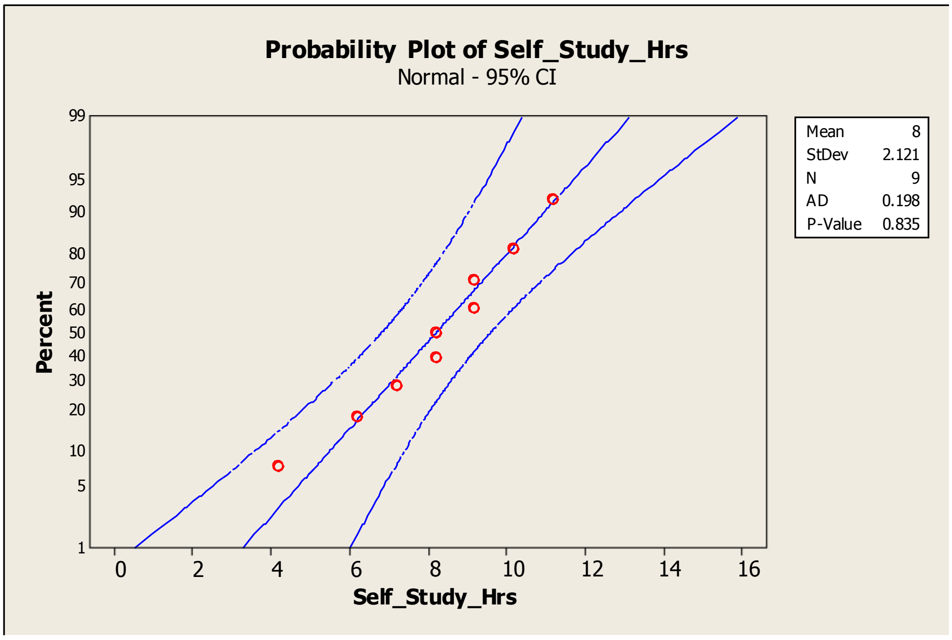

Fig. 3: Probability Plot of Self-Study Hours (Normal-95% CI)

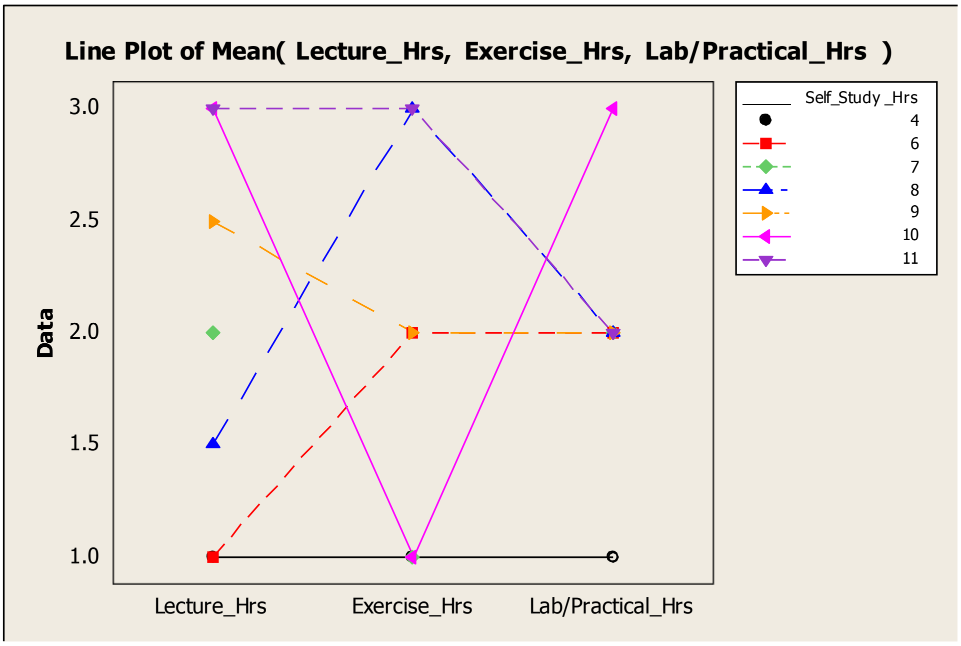

Fig. 4: Line Plot of Mean (Lecture Hours, Exercise Hours, and Lab/Practical Hours)

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Table 4: Box-Behnken design (Input Variables versus Output Response)

Std Order	Run Order	Pt Type	Blocks	Lecture Hours	Exercise Hours	Lab/ Practi-cal Hours	Self Study Hours	FITS	RESIDUALS
10	1	2	1	2	0	1	5	5	-1.64459E-15
13	2	0	1	1	1	1	4	4	4.44089E-16
8	3	2	1	1	2	0	4	4	-8.88178E-16
1	4	2	1	1	0	2	4	4	1.33227E-15
3	5	2	1	2	2	1	7	7	-1.64459E-15
2	6	2	1	0	1	2	3	3	1.64459E-15
6	7	2	1	2	1	0	5	5	-8.22293E-16
4	8	2	1	0	1	0	1	1	8.22293E-16
7	9	2	1	1	1	1	4	4	4.44089E-16
12	10	2	1	1	0	0	2	2	-8.22293E-16
14	11	0	1	1	1	1	4	4	4.44089E-16
5	12	2	1	0	2	1	3	3	8.22293E-16
9	13	2	1	2	1	2	7	7	8.22293E-16
11	14	2	1	1	2	2	6	6	8.22293E-16
15	15	0	1	0	0	1	1	1	4.11147E-16

2.2 Regression equation for student workload

In the development of the empirical model, a Box-Behnken design as a response surface methodology was used to further study the quadratic effect of the total student workload factors after identifying their significance through Taguchi approach. In the design, the treatment combinations were at the midpoints of edges of the process space and at the centre. These designs required 3 levels of each factor. In addition, Box-Behnken designs were not containing any points at the vertices of the experimental region. This was advantageous when the points on the corners of the cube represent factor-level combinations that were prohibitively impossible to test because of physical process constraints.

In the design settings, 3 factors (Lecture hours, Exercise hours, and Lab/Practical hours), 3 centre points, 15 observations, 1 replicate, 1 base block, and 1 response (Self-study) were set. Table 4 illustrates the factor properties for student self-study hours as well as the total student workload.

After performing the simulation experiment according to the DoE and recording the results, the data set was entered into the standard folio. The data set was analyzed with the risk (significance) level of 0.05, using individual terms.

It was observed that Self-study hours were normally distributed as shown in the probability plots of Self-study (Fig. 5 and Fig. 6). The input variables and output responses in the standard folio were analyzed at high accuracy (R-Sq = 100.00%, R-Sq (pred) = 100.00%, R-Sq (adj) = 100.00%). Estimated Regression coefficients for Self-study hours were obtained using data in uncoded format.

The Box-Behnken design method advised to utilize P-value displayed in the ANOVA tables of results as reference for the investigation of the parameter impacts in the empirical models development. In the results discussion, input factors - Lecture hours, Exercise

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Hours, Lab/Practical hours - were written in full to easily visualize their interactions.

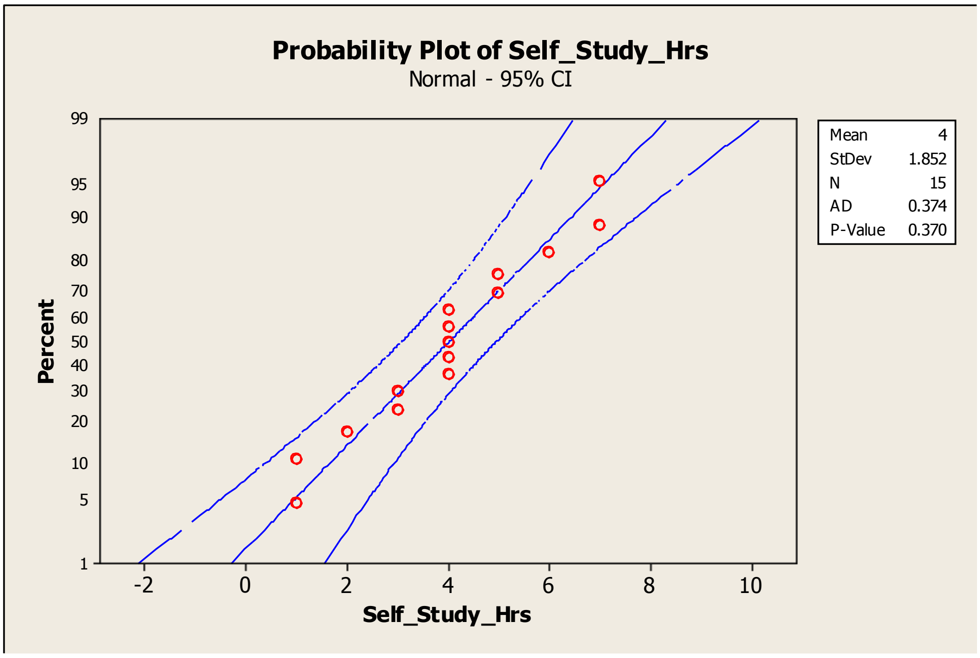

Fig. 5: Probability Plot of Self-Study Hours

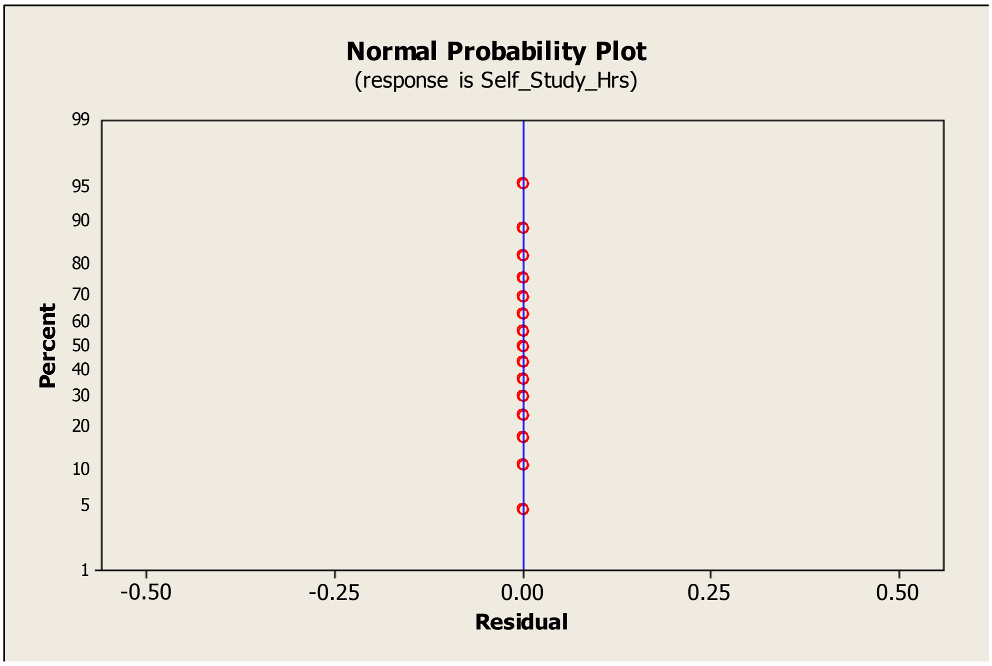

Fig. 6: Normal probability Plot (Response is Self-Study Hours)

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The reliability of the empirical models being developed was also supported by the interaction matrix plot for self-study (Fig. 7). From the plots, it has been observed that the relationships between input factors as well as their interaction matrix were very close.

Therefore, the last step was to assess the probability distribution of the residual versus self-study hours. As shown in the probability plot of the residual versus self-study hours, the output was normally distributed (Fig. 8).

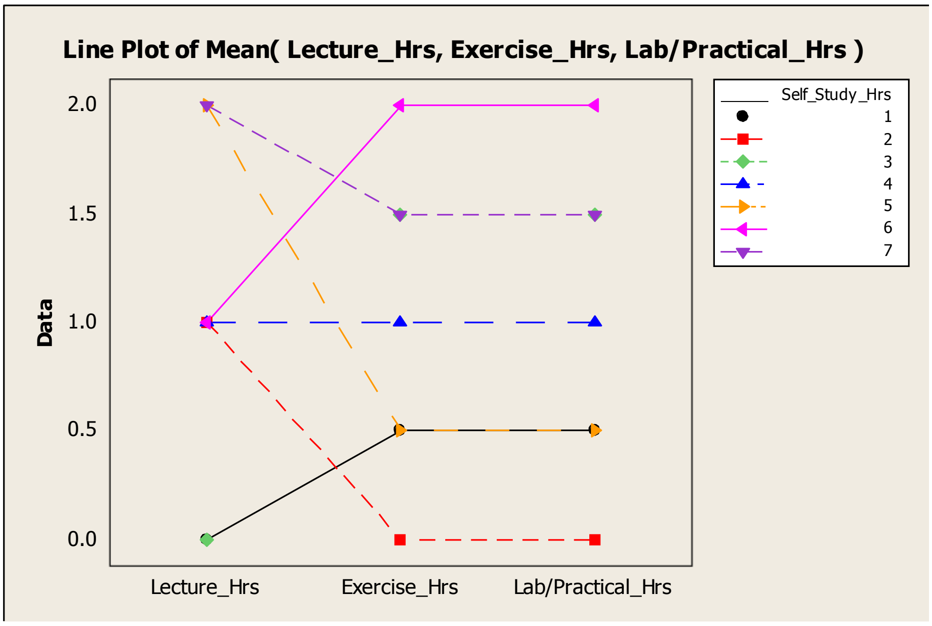

Fig. 7: Line Plot of Mean (Interactions Matrix)

Fig. 8: Residual versus Self-study (Response is Self-Study Hours)

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The empirical models for the student workload in terms of actual values have been developed as shown in the Equation 1.

$$W_h = \frac{1}{2} \times [(-3.99 \times 10^{-16} + 2L_h + E_h + L_{ph} + 3.16 \times 10^{-16}(L_h^2) + 6.81 \times 10^{-16}(E_h^2) - 3.07 \times 10^{-16}(L_{ph}^2) + 8.12 \times 10^{-17}(L_h E_h) - 4.03 \times 10^{-17}(L_h L_{ph}) + 2.01 \times 10^{-16}(E_h L_{ph})) + (L_h + E_h + L_{ph})] \quad (1)$$

Where,

- L_h: is the Lecture hours
- E_h: is the Exercise hours
- L_{ph}: is the Lab/Practical hours
- W_h: is the student workload in terms of ECTS Credits.

3. RESULTS

3.1 ECTS Credits Interface

The developed empirical model described in equation 1 was used to develop an effective and user-friendly interface that computes the postgraduate student workload in terms of ECTS credits. It is important to determine the student's workload for specific course units. Estimation of students' workload between social and science or engineering course units is still an ill-defined problem relying on heuristics. The choice of appropriate values of students' workload in terms of ECTS credits is generally based on the knowledge and experiences of individual professors.

In this study, the developed interface is able to compute ECTS credits depending on the number of Lecture hours, Exercise hours, and Laboratory hours. Fig. 9 and Fig. 10 show different teaching scenario and their ECTS credits. It is important to note that if the student has not completed required lecture, exercise or laboratory hours, no ECTS credits will be awarded as shown in the Fig. 11.

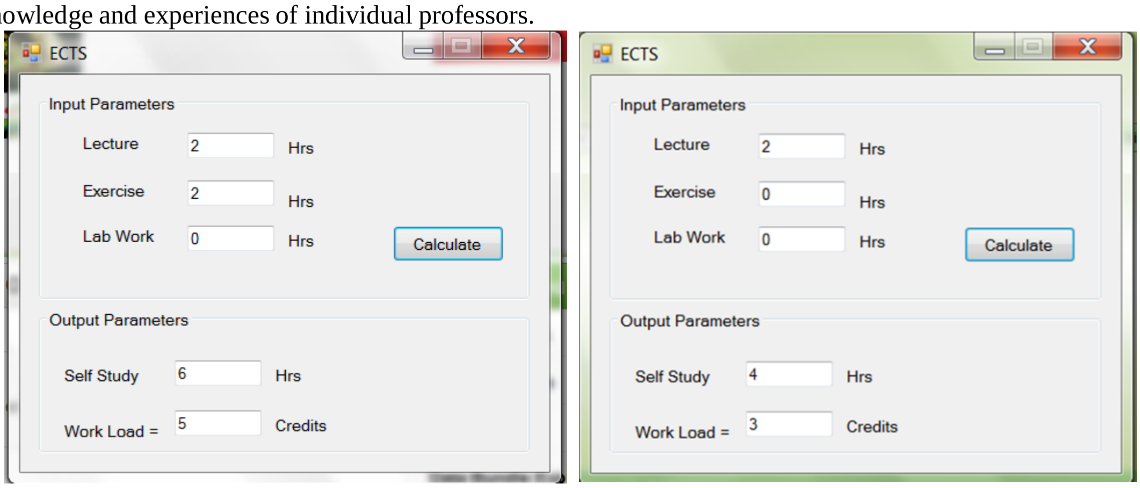

Fig. 9: Comparative ECTS Credits interfaces for course units with and without Exercise hours

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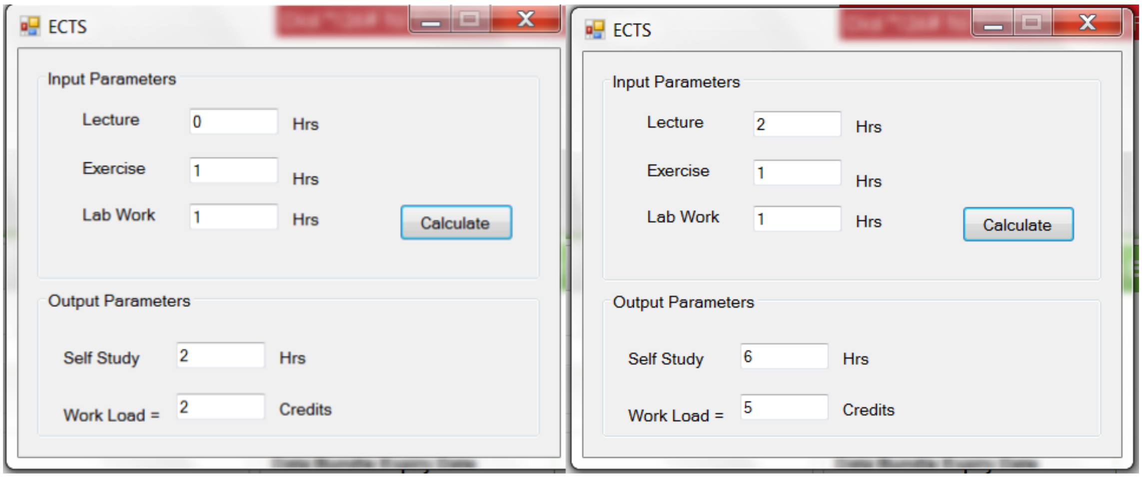

Fig. 10: Comparative ECTS Credits interfaces for course units with and without Lecture hours

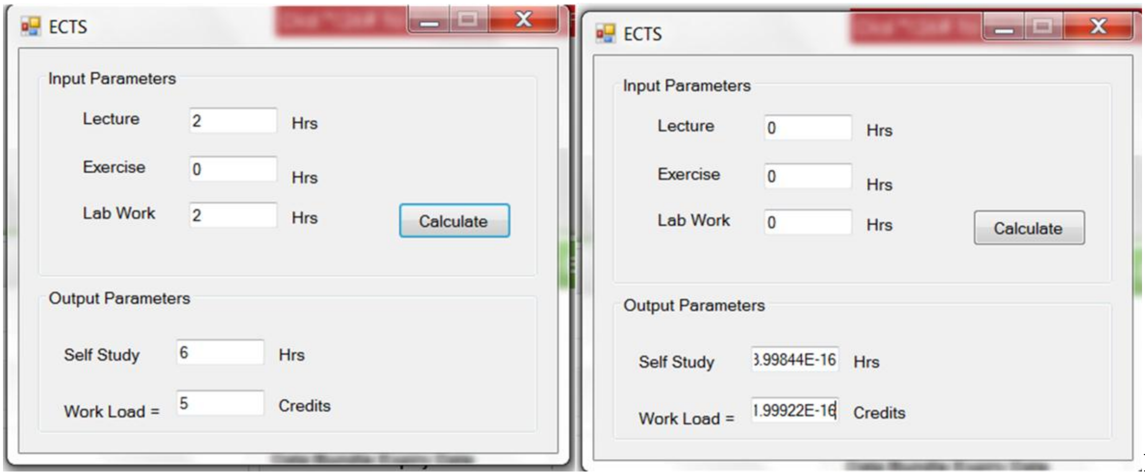

Fig. 11: Comparative ECTS Credits interfaces for course units with or without ECTS credits

3.2 Validation of the ECTS Credits interface

The effectiveness of the designed interface was validated by comparing results with ECTS credits for Masters units in Faculty of Electrical Engineering, University of Montenegro, Podgorica and Masters in Mechanical Engineering, Technical University of Applied Science (TUAS) Wildau, Germany as shown in Appendix I and Appendix II. It has been found that, in the Table 5 and Fig. 12, the developed interface tallies well with the ECTS credits for all Masters units taught at TUAS-Wildau.

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Table 5: Predicted versus actual results for ECTS Credits at TUAS-Wildau

S/N	Name of Units	Lecture Hours	Exercise Hours	Lab_Work Hours	Predicted ECTS Credits	Actual ECTS Credits
1	Mathematics	2	2	0	5	5
2	Numerical	1	1	0	2.5	3
3	Physics	2	2	0	5	5
4	Informatics	1	1	2	4.5	5
5	Mechanics	2	2	0	5	5
6	Dynamics	2	1	1	5	5
7	Simulation	2	0	2	5	5
8	Pneumatic	2	1	1	5	5
9	Coatings	2	0	2	5	5
10	Production	2	1	1	5	5
11	Complex	2	2	0	5	5
12	PPS	2	1	1	5	5
13	Management	2	0	7	7	7
14	Finance	2	2	0	5	5
15	Control	2	2	0	5	5
16	Business	2	0	0	5	3
17	Methodology	1	0	1	2.5	2
18	WPF	2	2	0	5	5

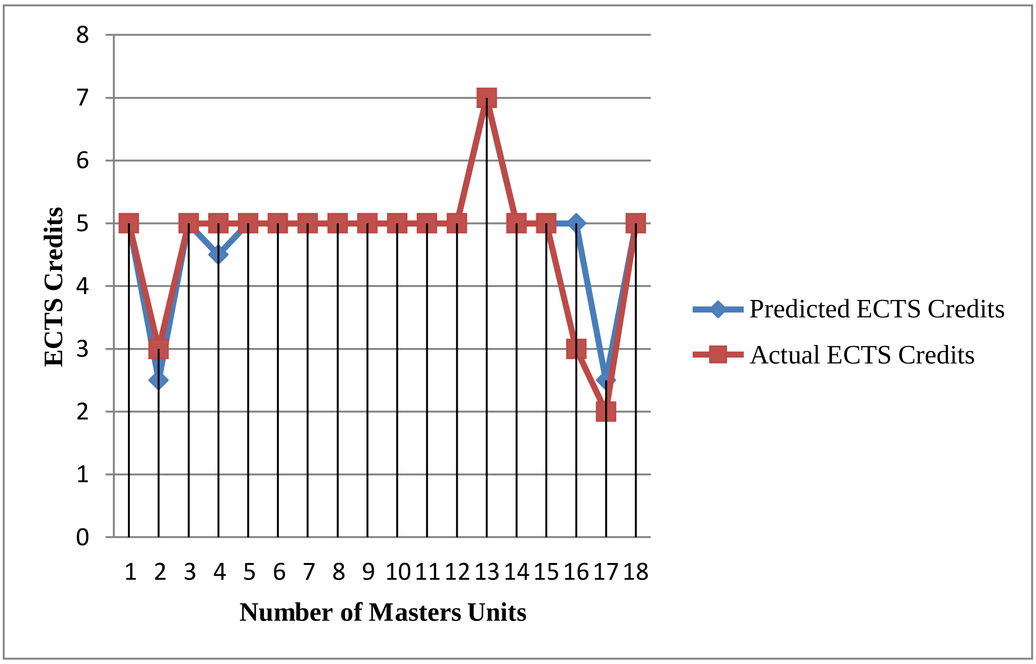

Fig. 12: Predicted versus actual results for ECTS Credits at TUAS-Wildau

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4. CONCLUSION

In the existing literature, there is no formula established to calculate the ECTS credits. Estimation of students' workload between social science and engineering course units was an ill-defined problem relying on heuristics. The choice of appropriate values of students' workload in terms of ECTS credits was generally based on the knowledge and experiences of individual professors. By use of heuristic knowledge about the teaching processes' dynamics, clear understanding of real-world activity to be performed, its integrity and feasibility, the authors conceived an ECTS interface. The mathematical model that relates the four variables (Lecture, Exercise, Laboratory, Self-study hours) and output the correct number of ECTS credits to a given workload has been successfully developed using Box-Behnken design method. In addition, Taguchi method was used to establish the ranks of the most significant study input factors for the Self-study hours. Based on these results, the developed ECTS Credits interface was considered to be reliable.

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APPENDIX I

http://www.etf.ucg.ac.me/eng/ECTS_ENERG/Models%20and%20dynamics%20of%20electrical%20machines.pdf

	Course title	*Models and dynamics of electrical machines*		
Course code	***Course status***	***Semester***	***Number of ECTS credits***	***Lecture hours***
PA5101	***Mandatory***	***I***	***5***	***2L+1E+1Lab***
Study program: Master studies, ELECTRICAL ENGINEERING, study program: Power systems and Control, department: Industrial electronics (studies last for 10 semesters, 300 ECTS credits). Postgraduate studies, ELECTRICAL ENGINEERING, study program: Power systems and Control, department: Industrial electronics (studies last for 8 semesters, 240 ECTS credits)				
Prerequisites: Rotation machines				
Course aims: Students will be introduced with mathematical models of DC, synchronous and induction machine. Characteristic transient processes in individual machines based on these models are analyzed analytically and numerically in visual program C++ and Simulink.				
Teacher(s) first and last names: ***PhD Milutin Ostojić, MSc Milanka Žugić, MSc Boris Marković***				

https://www.thwildau.de/fileadmin/dokumente/studiengaenge/maschinenbau/dokumente/Master/flyer_master_Machinenbau_2014.pdf

Module hand book Master - Mechanical Engineering 25. Februar 2014

Study Module: High performance materials and coating			**Semester Nr.** 3
4 Sem. hours per week	5 ECTS Points	**Form of teaching**: Lecture/ Exercise / Lab 2 0 2	**Proof of Performance:** Examination
Professor in-charge: Herzog, Richter			
Pre-requisites: Basic knowledge of materials engineering			

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APPENDIX II

MASCHINENBAU Master	SWS	CP	V|Ü|L	PF	SWS im Semester 1.	2.	3.	4.
Vertiefung der mathematisch naturwissenschaftlichen Grundlagen								
Mathematische Methoden und Optimierung	4	5	2/2/0	FP	4			
Numerische Mathematik	2	3	1/1/0	FP		2		
Physik	4	5	2/2/0	SFP	4			
Informatik für Ingenieure	4	5	1/1/2	FPL	4			
Ingenieurwissenschaftliche Vertiefungen								
Technische Mechanik	4	5	2/2/0	FP		4		
Maschinendynamik	4	5	2/1/1	SFP		4		
Numerische Simulation	4	5	2/0/2	SFP			4	
Hydraulik/Pneumatik	4	5	2/1/1	SFP			4	
Hochleistungswerkstoffe- und Beschichtungen	4	5	2/0/2	SFP	4			
Produktionstechnologien	4	5	2/1/1	FPL		4		
Komplexe Produktionssysteme	4	5	2/2/0	SFP		4		
PPS	4	5	2/1/1	SFP		4		
Produktionsmanagement (Projektarbeit)	6	7	2/0/4	FPL		2	4	
Fachübergreifende Lehrgebiete								
Unternehmensführung/-finanzierung	4	5	2/2/0	FP	4			
Controlling/Bilanzierung	4	5	2/2/0	FP	4			
Wirtschaftsrecht	2	3	2/0/0	FP			2	
Ingenieurmethodik	2	2	1/0/1	SFP			2	
Spezifische Vertiefungen								
Wahlpflichtmodule (WPF) I	4	5	2/2/0	SFP			4	
Wahlpflichtmodule (WPF) II	4	5	2/2/0	SFP			4	

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AUTHORS PROFILES

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