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CONFERENCE PAPER · AUGUST 2013

DOI: 10.13140/2.1.4072.8006

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Perceptions on Web supported Workplace Learning of Electronic Engineering Students: A Nonparametric Statistical Assessment

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Abstract: Workplace learning (WPL) of tertiary education students provides an important link by connecting real life working environments with Higher Educational Institutions (HEIs). As it concerns the case of engineering students, various scientific, technical and soft skills should be acquired during their WPL period, in order to achieve an effective overall engineering education. The focus of this paper is on the perceptions of all parties involved (students, workplace supervisor, academic supervisor) with the WPL at the Department of Electronic Engineering-Technological Educational Institute of Crete (DoEE/TEIoC). In particular, based on quantitative data collected at the end of the WPL period of DoEE/TEIoC students, a nonparametric statistical analysis is carried out. The data were extracted from questionnaires (sample size=91) completed by each student and their corresponding workplace and academic supervisors. Our aim is to compare the perception of the aforementioned three respondent groups in terms of students' competences and other WPL-related issues. Evaluation results of our research can provide an insight towards the achievement of an effective WPL for DoEE/TEIoC students.

Keywords: *Workplace learning, Learning outcomes, Non-parametric statistical analysis, Wilcoxon signed-rank test, Electronic engineering education.*

1. INTRODUCTION

As stated in [1], labor markets are only dynamic if employment policies facilitate the transitions that enhance productivity and job quality, if the workforce has adequate skills, and if people are mobile enough to respond to the geographical trends in job vacancies. The *Europe 2020 Strategy* places particular emphasis on labor market reform, the development of human capital and geographical mobility for making the EU labor force better equipped for change and providing job opportunities. However, Europe still does not have a comprehensive view of its skills needs. The *EU Skills Panorama*, launched at the end of 2012, is the first step that will provide a single overview of European, national and sectoral findings on the short-term to medium-term prospects for jobs and skills needs as they evolve up to 2020. In particular, science, technology, engineering and mathematics (STEM) skills as defined in [2], are the skills held by people with a tertiary level qualification in the aforementioned fields. Moreover, the anticipated future employment demand in key STEM-related sectors for EU-27 in 2010-2020 will present an overall employment growth of 9% (a growth of 1.3% from 967,000 to 980,000 employees for Electronics). However, this employment demand calls for higher level technical skills, as well as for certain personal and behavioural attributes. Thus, creativity, team working, communication and problem solving are critical in the context of applying STEM skills to develop new and innovative technologies.

Students' workplacements are recognized not only as one of the primary mechanisms for initiating partnerships between HEIs and industry, but, also, as an effective way for enhancing students' skills and competences. In such a framework, WPL of students constitutes an integral part of the engineering curriculum at the DoEE / TEIoC. More specifically, the six months' WPL duration of our students is carried out through internships between the DoEE / TEIoC and Host Entities (HEs), i.e. a company, an organization, a public authority, etc. In order to support the WPL of our students, we set up a Web 2.0 communications environment (http://practice-elec.chania.teicrete.gr). This communications environment facilitates the electronic collaboration of the learning triad of our internships (the student, the HE supervisor, the academic supervisor) [3].

The aim of the paper is to find differences (if any) in the perceptions of the learning triad as it concerns aspects for the effectiveness of the WPL, while the organization of the paper is as follows. In Section 2, discussion and results about the students' WPL outcomes and the assessment of other WPL-related issues, are exposed. In Section 3, the Wilcoxon Signed Rank (WSR) testing methodology used for the statistical analysis of the observation (questionnaire) data from students and supervisors, is presented. The evaluation results about the compared perceptions along with conclusions, are presented in Section 4.

2. THE WPL TRIAD

2.1. STUDENT LEARNING OUTCOMES

Students' learning is not just about knowledge acquisition through the curriculum courses. For engineering students, it is, also, about skills through the various lab assignments. In practice, all skills are supported by knowledge and are about patterns of behavior in the students' actions. However, from a WPL point of view, competences are considered to be the primary student learning outcomes. Competences are more complex, as they concern the application of knowledge and skills in a particular real life working context. According to [4], the categories of learning outcomes at work include: task performance, awareness and understanding, personal development, teamwork, academic knowledge and skills, decision making and problem solving, and judgment. The importance of capturing data about student learning outcomes has been stated by several national/international initiatives, standardization bodies and researchers. For example, the Accreditation Board for Engineering and Technology (ABET) in U.S.A. has adopted general and program criteria for accrediting engineering technology programs. *General criteria* apply to all programs accredited by an ABET commission and incorporate student outcomes, while *program criteria* provide discipline-specific accreditation criteria (see [5] for program criteria in Electrical /Electronics engineering technology and similarly named programs).

Table 1: Assessment of students' competences.

Student's competence	Mean	SD
Adaptability to the workplace environment (HE supervisors)	4.681	0.522
Adaptability to the workplace environment (Academic supervisors)	4.736	0.564
Teamwork (HE supervisors)	4.813	0.485
Teamwork (Academic supervisors)	4.802	0.543
Ability to undertake initiatives (HE supervisors)	4.286	0.419
Ability to undertake initiatives (Academic supervisors)	4.099	0.641
Responsibility (HE supervisors)	4.681	0.653
Responsibility (Academic supervisors)	4.714	0.752
Work diligence (HE supervisors)	4.758	0.787
Work diligence (Academic supervisors)	4.747	0.461
Constituency with HE's shift (HE supervisors)	4.714	0.539
Constituency with HE's shift (Academic supervisors)	4.813	0.462

The WPL-related student competences considered for DoEE / TEIoC students are listed in the left part of Table 1, and were assessed by both the HE and academic supervisors. Each row of Table 1 corresponds to a Likert questionnaire item, whereas the supervisors' perceived opinions (in terms of their mean and standard deviation (SD) values) about the DoEE/TEIoC students' achievements during WPL for each competence are, also, given. A symmetric five-point from strongly disagree (competence with high insufficiency) to 5 (competence with high sufficiency) rating was adopted for each Likert item.

2.2. QUESTIONNAIRE FOR WPL ASSESSMENT

In general, assessment for learning purposes provides a feedback mechanism for improving the overall learning process. Moreover, in [6] a clear distinction between formative and summative assessment is made. Formative assessment consists of regular assessment which takes place during the course of the learning process, and is associated with feedback provided by grades, comments, or both. As for the summative assessment, it is concerned with summarizing the students' achievements at the end of the learning process. Both types of assessment are employed for the WPL of DoEE/TEIoC students, while the latter is, also, employed for other WPL-related issues by all members of the learning triad.

During the WPL period the role of the academic supervisor is in most cases that of the on-line mentor through our Web 2.0 communications environment. Thus, a kind of formative assessment is carried out with the aim of:

- helping students to overcome various issues related to their learning objectives and learning outcomes,
- encouraging students with comments and advice, in order the WPL to be beneficial for all parties involved,
- providing feedback for the preparation of students' report that is uploaded on the Web 2.0 platform,
- resolving potential conflicts that may arise in the workplace environment.

Table 2: Assessment of other WPL-related issues.

No	WPL-related issue	Mean	SD
1	Efficiency of students' prior theoretical knowledge (Students)	4.011	0.570
2	Efficiency of students' prior theoretical knowledge (HE supervisors)	4.198	1.163
3	Efficiency of students' prior theoretical knowledge (Academic supervisors)	4.374	0.485
4	Efficiency of students' prior technical skills (Students)	4.110	1.245
5	Efficiency of students' prior technical skills (HE supervisors)	4.319	0.741
6	Efficiency of students' prior technical skills (Academic supervisors)	4.242	0.419
7	Overall rating of collaboration with the HE (Students)	4.747	0.616
8	Overall rating of collaboration with the HE (HE supervisors)	4.670	0.641
9	Overall rating of collaboration with the HE (Academic supervisors)	4.626	0.752
10	Prospects for recruitment (Students)	3.319	0.735
11	Prospects for recruitment (HE supervisors)	3.615	0.483
12	Relevance of curriculum with HE activities (Students)	4.308	0.467
13	Relevance of curriculum with HE activities (Academic supervisors)	4.582	0.522
14	Degree of satisfaction with working conditions (Students)	4.791	0.641
15	Degree of satisfaction with working conditions (Academic supervisors)	4.736	0.653

The summative assessment is based on three questionnaires completed by the student, the HE supervisor, and the academic supervisor at the end of the six month's WPL period. The student questionnaire contains Likert items about their prior knowledge and technical skills as they relate to the HE, the HE itself, the prospects for student's future recruitment, and the overall organization of WPL. The Likert items in the HE supervisor's questionnaire include items regarding the student's competences, the student's prospects for future recruitment, the organization of WPL, as well as issues for HE-TEIoC collaboration through WPL. Finally, the Likert items in the academic supervisor's questionnaire include items regarding the way of communication with the student and the HE for WPL monitoring, the prior knowledge and technical skills of students with regard to the HE's needs, items for assessing the student's competences, the suitability of the HE for collaboration through internships, and about the organization of the WPL. In Table 2, the assessment (mean and SD values) of selected items from the 91x3 received questionnaires, is provided.

3. WSR TESTING: METHOD AND RATIONALE

Statistical methods for data analysis have long been used in various fields of research (social sciences, marketing, health sciences, etc.). One common use of statistical methods is the analysis of differences that may exist between two or more groups of observations. If the difference is large enough, statistical tests may be regarded as dispensable. However, in case of moderate or small differences, as the ones for our data (see Tables 1 and 2), statistical tests are of great value. Furthermore, the choice of the appropriate statistical method is of paramount importance for valid conclusions. The decision criteria for the appropriate statistical method include the number of samples (number of groups of observations), the independence of samples (observations), the number of response variables, the data types (binary, categorical, ordinal, interval, continuous), and the dependency or independency on a specific form of the probability distribution being sampled (parametric and non-parametric/didtribution-free methods, respectively).

In order to carry out the data analysis from the three questionnaires of section 2, we selected the non-parametric WSR test with paired data (paired data coming from two of the students', HE supervisors' or academic supervisors' ratings) for each response variable (Likert item). In other words, we employ the WSR non-parametric test to compare two probability distributions by using the corresponding paired differences, as these differences may not be normally distributed (otherwise the paired t-test or the paired Z-test methods could be employed). Examples of paired difference use for testing occur when subjects are measured before and after a treatment, as well as for the so called *dilemma of two graders* (as the rating by the supervisors for each student in our WPL framework). Moreover, although the data type is ordinal as being the Likert rating in our questionnaires, Likert scales of rank sums on an interval scale are treated by our WSR test with paired data. Thus, the insufficiency of the ordinal data due to the Likert scaling, is alleviated.

The WSR two-tailed test for large samples ($n \geq 25$) we employ, is as follows [7]. Let D_1 and D_2 represent the probability distributions for populations' 1 and 2 ratings, respectively. The non-parametric approach developed by Wilcoxon requires that we calculate the ranks of the absolute values of the differences between the paired data (i.e., the ranks of the differences after removing any minus signs). If ties occur (two or more observations having the same value), the tied absolute differences are assigned the average of the ranks they would receive if they were unequal, but successive, observation values. After the absolute differences are ranked, the sum of the ranks of the positive differences of the original observation values, T_+, and the sum of the ranks of the negative differences of the original observation values, T_-, are computed. Then, the exploitation of our WSR test for making inferences about the population medians is based on testing the following null (H_0) and alternative (H_a) non-parametric hypotheses:

- H_0: the D_1 and D_2 probability distributions for populations' ratings are identical;
- H_1: The D_1 and D_2 probability distributions for populations' ratings differ in location (the D_1 is shifted either to the left or to the right of D_2).

Designing hypothesis testing is associated with the choice of the *level of significance* (a), since the value of a directly affects whether to accept or reject the null hypothesis. If the *critical value approach* using rejection regions of the normal probability distribution is adopted for hypothesis testing, then the test statistic:

$$z = \frac{T_+ - [n(n+1)/4]}{\sqrt{[n(n+1)(2n+1)]/24}}$$

determines a rejection region of $|z|>z_{a/2}$. It is to be noted that the use of the normal probability distribution is an approximation of the sampling distribution of the signed rank statistic. On the other hand, the *p-value approach* uses both the test statistic z defined above, as well as the p-value. A p-value (or probability value) is the probability of getting a value of the sample test statistic that is at least as extreme as the one found from the sample data, assuming that the null hypothesis is true. Thus, in order to make a conclusion in the hypothesis test, if $p \leq a$, then reject H_0, otherwise failure to reject H_0 occurs.

4. EVALUATION OF PERCEPTIONS AND CONCLUSIONS

According to the methodology described in section 3, the WSR testing results for perceptions' comparison for students' competences and other WPL-related issues are presented in Tables 3 and 4, respectively. In particular, we got the results by the aid of the MATLAB software for both the p-value and critical value approaches. A significance level of a=0.05 was used, while the h=1 value indicates a rejection of the null hypothesis at this significance level.

The findings from Table 3 show that there exists no statistically significant differences for all of students' competences as perceived by the HE and academic supervisors, except their ability to undertake initiatives. As it concerns the perceptions' comparisons in Table 4, the numbers of the left column correspond to the items of Table 2. It can be seen that there exist no statistical significant differences for:

- The overall rating of collaboration with the HE by all three respondent groups;
- The efficiency of students' prior technical skills, as perceived by the students and the academic supervisors;
- The degree of satisfaction with working conditions, as perceived by the students and the academic supervisors.

Table 3: Perceptions' comparison for students' competences.

Students' competence	p-value	z-value	h	Accepted	Rejected
Adaptability to the workplace environment	0.379	-0.880	0	✓	
Teamwork	0.849	0.191	0	✓	
Ability to undertake initiatives	0.038	2.079345	1		✓
Responsibility	0.647	-0.45803	0	✓	
Work diligence	0.866	0.168339	0	✓	
Constituency with HE's shift	0.086	-1.7192	0	✓	

On the other hand, the differences in perceptions for the efficiency of both students' prior theoretical knowledge and technical skills (between the students themselves and the HE supervisors), the efficiency of efficiency of prior theoretical knowledge between students and the academic supervisors, the prospects for recruitment (between the students and the HE supervisors), and the relevance of curriculum with the HE activities (between the students and the academic supervisors), are amenable for further examination as they more or less related to curriculum issues and the choice of the particular HE for WPL.

Table 4: Perceptions' Comparison for Other WPL-related Issues

WPL-related issue	p-value	z-value	h	Accepted	Rejected
1-2	0.016	-2.405	1		✓
4-5	0.022	-2.285	1		✓
7-8	0.237	1.183	0	✓	
7-9	0.101	1.640	0	✓	
10-11	0.016	-2.405	1		✓
12-13	0.005	-2.832	1		✓
1-3	7.044×10^{-5}	-3.975	1		✓
4-6	0.231	-1.198	0	✓	
14-15	0.273	1.095	0	✓	

In summary, the perceptions' evaluation performance carried out in this paper can provide useful insights to the whole WPL process and can identify mismatch issues concerning the curriculum and the labor market.

5. ACKNOWLEDGMENT

This work was co-financed by the European Union (European Social Fund-EKT) and Greece (Ministry of Education and Religious Affairs) in the framework of the Operational Programme for Education and Lifelong Learning ("Workplace Learning of Students of T.E.I. of Crete/Department of Electronic Engineering Department" project). The project for WPL of TEIoC students is within the TEIoC's DASTA Structure, including, also, the Liaison Office and the Innovation & Entrepreneurship Unit.

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Proceedings of the

8th International Conference on

New Horizons in Industry, Business and Education

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