Experiential learning in web development courses: Examining students' performance, perception and acceptance

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Abstract
This study investigates students' performance, perception and acceptance when experiential learning approaches are integrated in Computer Science courses. An experiential learning approach has been designed to assist students in web development courses. The proposed learning approach in based on real-world examples and the abstraction of terminology using a sequential wizard-based logic. A survey model has been constructed and an exploratory study is conducted on 54 under and post graduate students. Results demonstrated high degree of perception and acceptance, as well as high performance scores. No gender differences have been detected in the examined sample and several strong correlations have been found among the measured variables. In particular, perceived ease of use and usefulness are strongly correlated to each other as well as to self-efficacy, willingness to learn and satisfaction. Satisfaction and self-efficacy are not correlated to each other, while performance has not been affected by anyone of the measured variables.

Keywords Experiential learning · Web-development courses · Computer science learning · Gender differences in computer science courses · Database learning

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1 Introduction

Using efficient learning tools and methodologies are crucial to learning outcomes and knowledge acquisition. Instructional designers have recognized the need for materials sensitive to learner nuances in order to stimulate active learning and enhance motivation to learn. According to Lacramioara (2014), adults prefer to learn with pleasure and participate creatively (creative learning) in building their own knowledge. Research demonstrates that learning is most effective when learners are involved in the process (Davies et al. 2012; Marin 2014) and according to Lacramioara (2014), adults prefer to learn with pleasure and participate creatively in building their own knowledge. Training strategies that engage students in learning stimulate the critical thinking and increase the level of awareness and responsibility on their part. To this end, modern learning theories attempt to leverage learners' engagement by providing interactive and experiential learning environments offering to students a hands-on and reflective learning experience which helps them to acquire new skills (Marin 2014).

Computer Science courses of programming and web development are usually perceived as difficult by students, especially from female students who tend to perform lower or not getting involved in this type of courses (EC 2019). Experiential learning is crucial to be implemented in computer education not only because it leverages students' engagement but also because it tends to equally affect male and female learners' achievement (Huang et al. 2017). The subject of motivating students in programming and data science courses through creative activities has been investigated (e.g. Giannakos et al. 2013; Serrano et al. 2017) revealing significant outputs. Recent literature has shown that experiential and creative learning is even more crucial. The research of Budd et al. (2016) after an extensive theoretical analysis, highlight the importance of implementing the principles of experiential learning, in order to obtain significant progress in graduate information science education. Konak et al. (2014) have integrated Kolb's Experiential Learning Cycle as a framework to design hands-on activities in virtual computer laboratories. Their research findings revealed increased students' interest and competency. In the same direction, Gasparinatou and Grigoriadou (2015) developed an adaptive tool which actively engages students in the learning process of Computer Science concepts. Serrano et al. (2017) concentrated on the effective results of experiential learning in data science courses. They investigated approaches where the student learns through reflection on doing instead of being a passive recipient and continued with describing an ongoing educational project for the study of adequate methods and tools. The potential of a creative learning procedure in university programming lessons has also been studied by Ferreira (2013) who introduced a dialogical framework to assist teachers of programming and interaction design. The preliminary results indicated that the dialogic process promoted students' collaboration and allowed exploring important creative strategies. Addressing the subject of experiential learning and End-User Development of mobile and web applications, Tzafilkou et al. (2015) and Protogeros and Tzafilkou (2015) have designed an End-User Development approach to teach students database concepts and assist them in building web applications.

Last but not least, the gender gap in Information Technology (IT) fields (EC 2019) pushes research education to provide gender-inclusive and gender-neutral learning environments. Experiential learning approaches bring one more privilege of equally affecting both male and female learners' motivation and achievement (Huang et al. 2017). HCI research has shown that gender attributes can many times affect users' performance and perceived acceptance items (e.g. Burnett et al. 2011, Bronwin et al. 2010, Terzis and Economides 2011; Tzafilkou et al. 2017; Tzafilkou and Protogeros 2018) and hence gender should be taken into consideration when designing software and computer science learning environments.

Despite the learning and gender-oriented privileges mentioned above, the biggest part of experiential education in Computer Science usually includes strategies such as internships, case studies, project-based coursework or laboratory sessions (e.g. McLoughlin and Nakano 2010), without involving experiential computer learning environments.

In the context of this background and the significant outcomes that experiential learning can bring in Computer Science education the primary goal of this study is to design a novel experiential learning approach for computer science courses (targeted at web development courses) and examine students' perception, acceptance and potential gender differences. Specifically, the purposes of this study are as follows:

- To design a prototype experiential learning platform for web development courses.
- To examine students' performance, perception and acceptance when interacting with the prototype experiential learning platform.
- To examine potential gender related differences in students' performance, perception and acceptance.

2 Methods

The research methodology follows a five-step approach to address the afore-mentioned research objectives. The methodological steps include i) the development of the prototype experiential learning platform including, ii) the design of the experiment including the learning task, the performance measurement and the survey model, iii) the complete procedure to be followed for the experiment, and finally iv) the data analysis process.

2.1 Prototype learning platform

A prototype web-based learning platform has been developed to integrate the experiential learning approach for database and web development courses. Based on the EUD paradigm of Protogeros and Tzafilkou (2015) and Tzafilkou et al. (2015) we have designed a wizard-based learning environment for web development courses to assist students in understanding graph database concepts, like nodes, properties and edges, via real-world examples and developing steps. A four-step natural language-based wizard guide (as depicted in Fig. 1) provides the student with a series of sequential steps to construct graph database objects. Real-world examples (for instance '*actor*'-node/entity, '*acted in*'-edge/relationship, '*movie*'-node/entity) are provided to the student in every step to assist them in conceptualizing and define the task-given database objects.

The overall learning procedure has been based on the idea of using sets of similar nodes and master-detail forms to construct all the necessary graph database objects for a database-centric web application. A set of nodes of the same type is used to represent an entity. Each

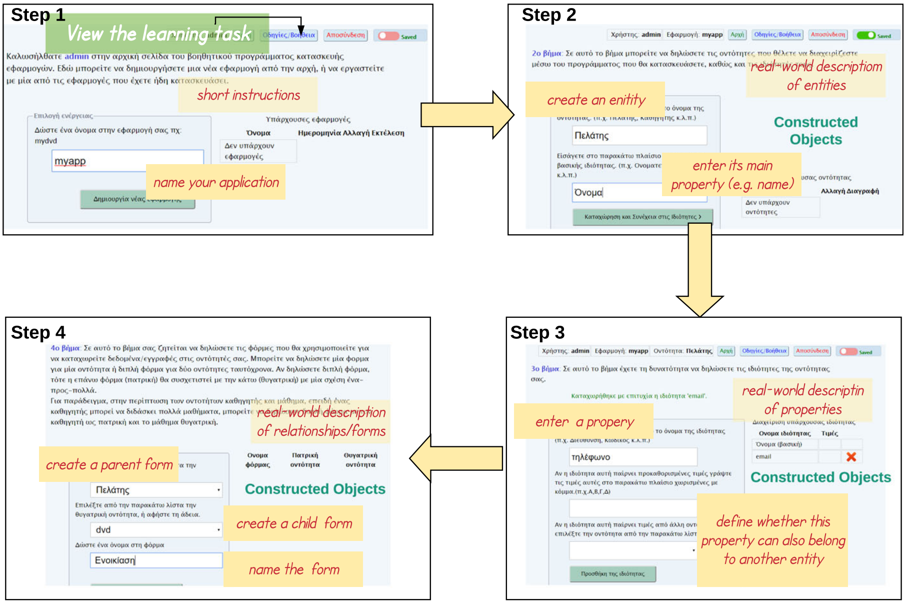

Fig. 1 Wizard-based logic of abstraction to design Graph database objects

node inherits its properties form the set of nodes it belongs to. Node properties are equivalent to entity attributes (table columns). The relationships are implicitly concluded by master-detail form declarations. Students can declare a single form or a parent-child form (master-detail). Finally, performance score is calculated (according to the requested/selected task) and feedback of achievement and history actions is provided in the interface.

Figure 1 below presents the learning wizards to teach database concepts and guide the student construct the task-given application. English translation is provided in the yellow and green background hand-written fonts.

As depicted in Fig. 1, the user is asked to construct several entities, attributes and forms. Following the wizard logic, the student creates all the graph database objects (nodes, properties, edges, etc.) which are stored in a temporary database to generate the requested application. In parallel, the achieved database scheme is evaluated via the comparison with the original scheme (task solution) that is already stored in the prototype database. Then, performance feedback is provided to the student who can move back to the wizard steps and edit their actions. Finally, the database-centric application is generated to enter the data records and a Cypher-based visual Graph as presented the example of constructed model in Fig. 2.

2.2 Survey model

A questionnaire survey consisted of 19 question items was used to measure technology acceptance items, (perceived ease of use and perceived usefulness), satisfaction, self-efficacy and willingness to learn. A five-point Likert-type scale from “strongly disagree” to “strongly agree” was used to measure the examined items. The questionnaire structure for was based on previous related questionnaires (Venkatesh et al. 2003;

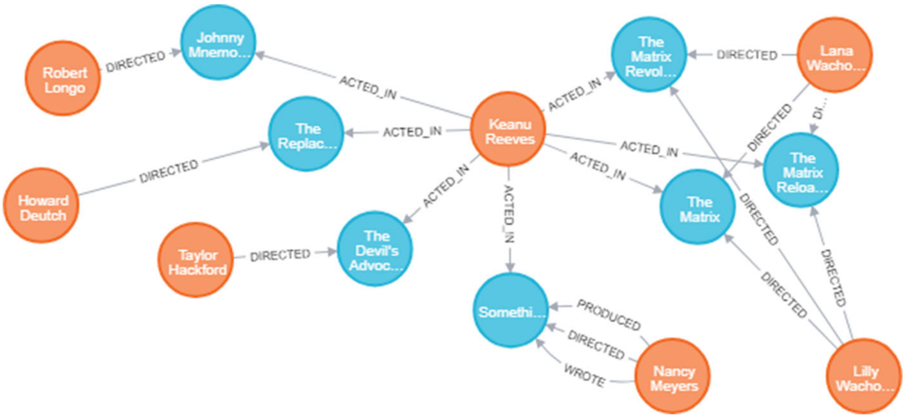

Fig. 2 Example of Cypher-based graph (actor and movies)

Thompson et al. 1991; Protogeros and Tzafilkou 2015; Tzafilkou et al. 2017; Tzafilkou and Protogeros 2018). Five items were used to measure perceived ease of use, four items to measure perceived usefulness and willingness to learn, and three items were used to measure self-efficacy and satisfaction.

The survey model has been validated and reformulated in terms of internal consistency according to Cronbach's a result, as depicted in Table 1.

2.3 Learning task and performance measure

A learning task was designed to be provided as a database exercise to the participants. The task was similar to the one designed in Protogeros and Tzafilkou (2015) requiring from the student to create a web application for a DVD store.

The customized learning task was attempted to enclose all the basic graph objects so that and students are expected to describe in simple words the graph database schema of Fig. 3, (2 versions of the solution are depicted):

Based on the above presented solutions, students' performance was calculated according to the achievement level in a range [0, 5] based on the following formulas:

$$\boldsymbol{Pe} = 0.5{*}N + 0.5{*}P + 1{*}E \tag{1}$$

Table 1 Cronbach's Internal Consistency

Construct Item	Number of items	Cronbach a (>=0,70)
Perceived Ease of USE (PEOU)	5	0,89
Perceived Usefulness (PU)	4	0,75
Self-Efficacy (SE)	3	0,81
Will. to Learn (WTL)	4	0,85
Satisfaction (SA)	3	0,82

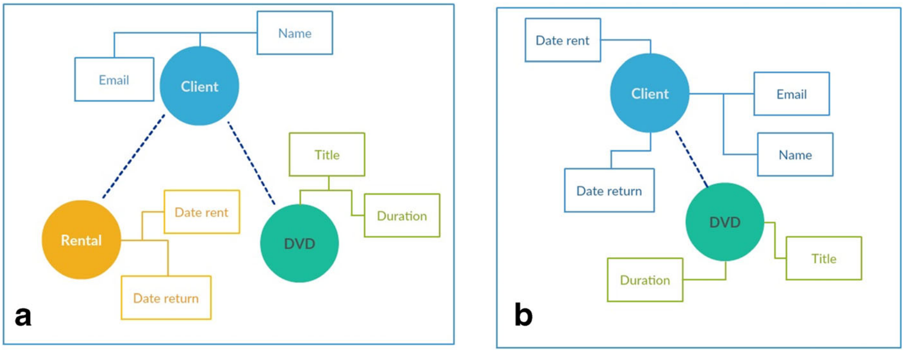

Fig. 3 Learning tasks graph solutions

*for solution version 1 (*Fig. 3*), or*

$$\boldsymbol{Pe} = 0.5{*}N + 0.5{*}P + 0.35{*}E \tag{2}$$

*for solution version 2 (*Fig. 3*).*

Where,

Pe Performance
N Nodes
P Property
E Edge.

Performance score could be calculated, using PHP algorithms, based on students' actions stored in a database learner-history entity.

2.4 Participants and procedure

A population of 80 university students voluntarily participated in the experiment. Of those, 54 successfully completed the tasks and 26 were excluded for providing non appropriate or uncompleted data.

The experiment was conducted during two under-graduate e-Commerce and Finance courses, and one post-graduate e-Commerce course. There were no significant gender differences (46.6% females, 51.7% males). The average database expertise level of the whole sample was 1, 94 (range (Alenezia and Shahib 2015; Budd et al. 2016)), revealing that all students had low to medium experience on database application development. As depicted in Table 2, experience in web development was higher (3,83; range (Alenezia and Shahib 2015; Budd et al. 2016)) and experience in programming was at low level (2.14; range (Alenezia and Shahib 2015; Budd et al. 2016)).

In the beginning of the experimental process the participants were provided with the IP address to access the prototype platform and some oral instructions were given by the researchers. When accessing the platform, the participants needed to register their data and rank their expertise level on database knowledge, web development, programming, and generic computer (PC) experience. After successful login the first wizard step was shown. The learning task and some brief explanation on the database

Table 2 Participants' experience levels ($N = 54$)

	Minimum	Maximum	Mean	Std. Deviation
Web Experience	1,00	5,00	3,83	1,17
Database Experience	1,00	5,00	1,94	0,95
Programming Experience	1,00	4,00	2,14	0,93
Computer Experience	1,00	5,00	3,64	1,08

components (entities/nodes, attributes/properties, forms/relationships) and the experimental process steps was provided in a separate window tab, accessed via a button-link. After completing the task, the survey model was shown as an online questionnaire, embedded in the last page of the prototype interface. The students' unique code (student identity number) was retrieved in the questionnaire form to associate their distinct actions and performance scores to their self-report responses.

2.5 Data analysis

A Shapiro-Wilk test (Shapiro and Wilk 1965) for normality was conducted on the whole sample. As depicted in Table 3, non-normal distributed data was found in Performance (Pe), Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Satisfaction (SA), and Willingness to Learn (WL). Only Self-Efficacy data showed normal distribution. The Shapiro-Wilk results can be visually confirmed by the distribution histograms presented in Appendix 1.

Since data do not follow a normal (or approximately normal) distribution throughout all the variables, it is preferred to use non parametric statistical methods. In particular, Spearman's rank correlation coefficient will be used to examine the bivariate correlations between variables and Mann-Whitney test (Wilcoxon test for independent samples) will be conducted to examine potential differences between gender related groups. Descriptive statistics will demonstrate the mean scores and standard deviations of the measured variables, both for the whole sample size as well for the gender related groups.

Table 3 Shapiro-Wilk's normal distribution test

Variable	Shapiro-Wilk		
	Statistic	df	Sig.
PU	0,90	54	0,00
PEOU	0,85	54	0,00
SA	0,94	54	0,02
SE	0,96	54	0,11
WL	0,95	54	0,04
PE	0,85	54	0,00

3 Results

3.1 Descriptive statistics

Table 4 presents the descriptive statistics results of the examined variables for the whole sample. Tables 5 demonstrates the descriptive statistic results for the defined gender groups. As depicted, all acceptance and perception items have been ranked above medium (higher than 3,00/5,00). Performance score follows similarly high levels, implying the usefulness of the proposed learning approach.

3.2 Gender-group comparisons

Table 6 presents the Mann-Whitney results for comparing gender related groups. As depicted, no gender differences have been detected.

3.3 Bivariate correlations

Table 7 presents the Spearman correlation coefficients among the examined variables. As depicted, most of variables are closely related to each other, except performance which does not seem to be affected by any acceptance or perception variables.

4 Discussion

The correlation analysis in Table 7 revealed several significant correlations between the measured variables. The interesting finding is that most variables are strongly associated to each other. In particular:

- Perceived usefulness, ease of use and willingness to learn are strongly associated to all other variables, but performance;
- Self-efficacy is strongly associated to perceived usefulness and willingness to learn,
- Satisfaction is strongly associated to perceived usefulness, ease of use and willingness to learn.

Table 4 Descriptive Statistics ($N = 54$)

	Minimum	Maximum	Mean	Std. Deviation
PEOU	1,00	5,00	3,29	0,76
PU	1,00	5,00	3,25	0,95
WL	1,75	5,00	3,72	0,85
SE	1,67	5,00	3,35	0,80
SA	2,00	5,00	3,53	0,68
PE	1,00	5,00	3,70	1,34

Table 5 Descriptive statistics for male and female participants

	Minimum	Maximum	Mean	Std. Deviation
Gender = Female ($N = 25$)				
PU	2,00	5,00	3,56	0,99
PEOU	2,00	5,00	3,43	0,84
WL	2,25	5,00	3,89	0,82
SE	2,00	5,00	3,28	0,81
SA	2,00	5,00	3,56	0,76
PE	1,00	5,00	3,60	1,30
Gender = Male ($N = 29$)				
PU	2,00	5,00	3,75	1,03
PEOU	2,00	5,00	3,37	0,91
WL	1,75	5,00	3,57	0,87
SE	1,67	5,00	3,42	0,80
SA	2,00	4,67	3,50	0,62
PE	1,00	5,00	3,75	1,4

As noticed, self-efficacy and satisfaction are not correlated to each other. Performance is not correlated to any of the acceptance and perception variables, contrary to previous research suggesting that users' performance is associated with perception and acceptance items (e.g. Tzafilkou et al. 2017). Hence, further research needs to be conducted on learners' behavioral and/or affective states in association to performance and learning achievement scores.

Another important finding is that no gender-related differences have been detected in perception and acceptance items. Although previous studies have declared gender differences in developing tasks, especially regarding self-efficacy (e.g. Beckwith et al. 2007; Burnett et al. 2011), this study reveals equal levels of self-efficacy between male and female participants, implying that experiential learning methodologies for web development courses are equally perceived by male and female students. However, previous experimental studies on developing tasks were not conducted via experiential learning tools and approaches. Hence, future research might bring different results, closely to the current study. What is most important is that no performance differences have been detected between gender groups. This result comes to agreement with the conclusion of Huang et al. (2017) who declare that experiential learning approaches equally affect male and female learners' achievement.

Table 6 Mann-Whitney Comparison (Grouping Variable: Gender)

	PU	PEOU	WL	SE	SA	PE
Mann-Whitney U	345,50	318,50	289,00	315,00	336,50	335,00
Wilcoxon W	780,50	643,50	724,00	640,00	771,50	660,50
Z	−0,30	−0,83	−1,28	−0,83	−0,45	−0,48
Asymp. Sig. (2-tailed)	0,75	0,40	0,20	0,40	0,64	0,63

Table 7 Spearman's rho Correlation Matrix

		PU	PEOU	WL	SE	SA	PE
PU	Correlation Coefficient	1,00	**0,60****	**0,49****	**0,31***	**0,69****	0,56
	Sig. (2-tailed)	.	0,00	0,00	0,02	0,00	0,69
	N	54	54	54	54	54	54
PEOU	Correlation Coefficient	**0,60****	1,00	**0,32***	0,21	**0,48****	0,10
	Sig. (2-tailed)	0,00	.	0,01	0,11	0,00	0,47
	N	54	54	54	54	54	54
WL	Correlation Coefficient	**0,49****	**0,32***	1,00	**0,47****	**0,56****	−0,34
	Sig. (2-tailed)	0,00	,015	.	0,00	0,00	0,80
	N	54	54	54	54	54	54
SE	Correlation Coefficient	**0,31***	0,21	**0,47****	1,00	0,25	−0,21
	Sig. (2-tailed)	0,02	0,11	0,00	.	0,06	0,90
	N	54	54	54	54	54	54
SA	Correlation Coefficient	**0,69****	**0,48****	**0,56****	0,25	1,00	0,14
	Sig. (2-tailed)	0,00	0,00	0,00	0,06	.	0,30
	N	54	54	54	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

Finally, we can make a positive conclusion on the validity and usefulness of the proposed learning methodology, because of the high or above medium sores (i.e. higher than 3,00/5,00) in measured satisfaction and perceived usefulness.

5 Conclusions and future work

The proposed experiential learning approach for web developing courses attempts to develop and evaluate the idea to assist students in learning graph database concepts and construct a web application, via using simple words and real-world examples. Our suggested learning model is based on principal experiential learning features and provides learners with a wizard-like environment in order to progressively guide them develop a database-centric application. The experimental results are encouraging and show a high score in performance and acceptance for students who participated in the experiment, which means that they averagely managed to satisfyingly respond to the learning tasks.

Despite its efficiency, the proposed learning approach is a preliminary version and possibly meets certain limitations. A further optimized interface, integrating more features that comply with user-centered and learning design theories is planned to be developed and re-evaluated in the future. Also, experimental evaluation shall be conducted in larger sample sizes encompassing more variables to be examined like learners' affective states.

Overall, the suggested approach significantly contributes in the effort of designing efficient learning tools and approaches based on experiential learning theories to assist learners in enhancing their web developing knowledge and skills.

Availability of data and material All data can be available after request.

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Compliance with ethical standards

Conflict of interest The authors state that there is not any conflict of interest.

APPENDIX A - Distribution Histograms

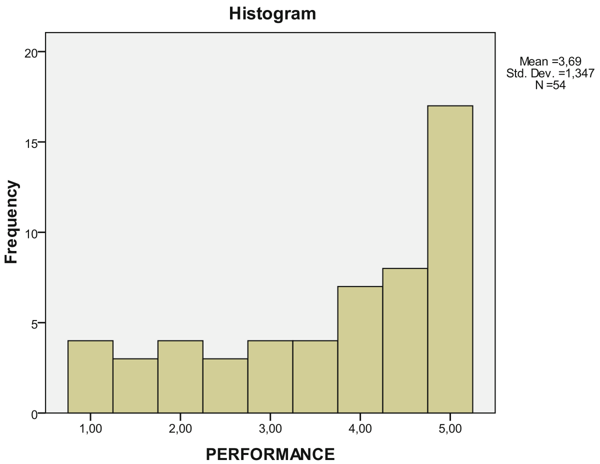

Fig. 4 Performance distribution histogram

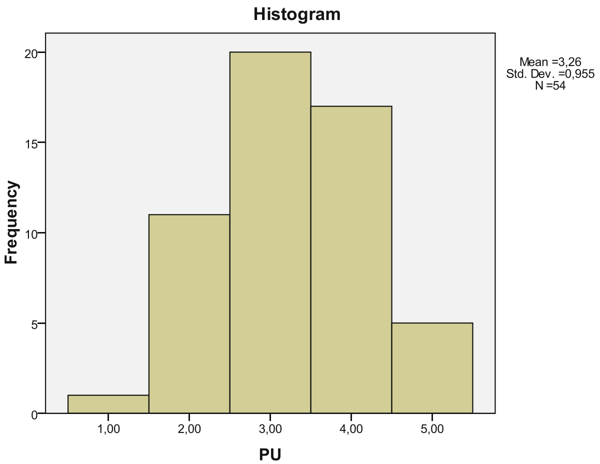

Fig. 5 Perceived Usefulness distribution histogram

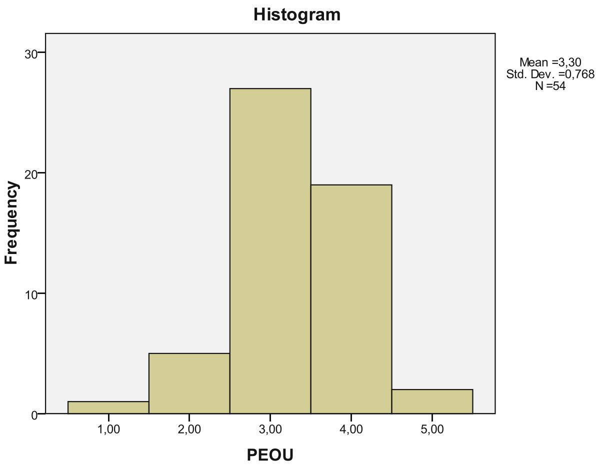

Fig. 6 Perceived Ease of Use distribution histogram

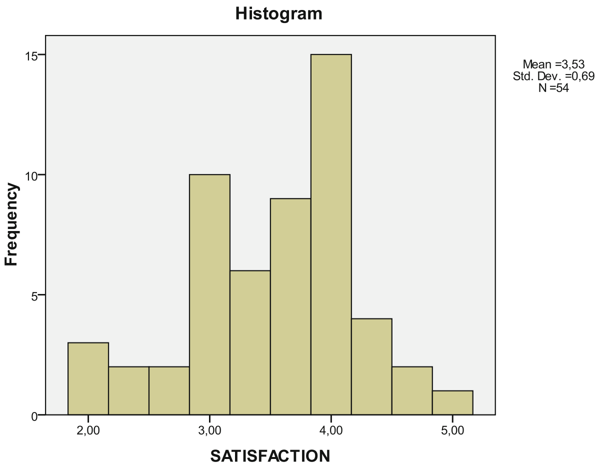

Fig. 7 Satisfaction distribution histogram

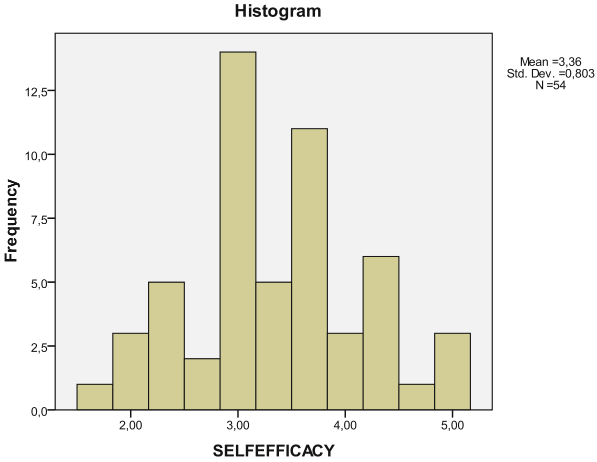

Fig. 8 Self-Efficacy distribution histogram

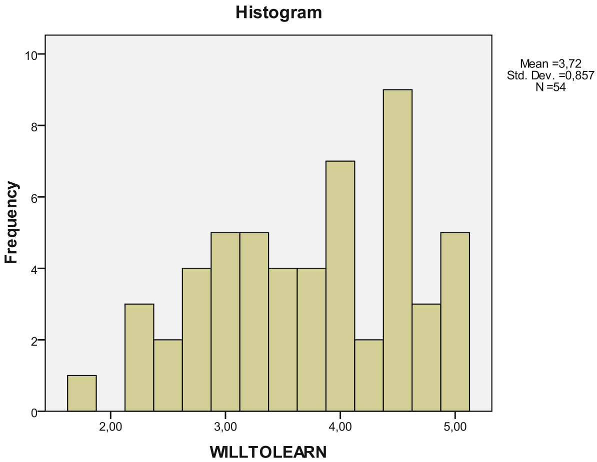

Fig. 9 Willingness to Learn distribution histogram

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