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# INTEGRATING FITT'S LAW IN HEURISTICAL EVALUATION CHECKLIST

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The Learner Centered Design (LCD) guarantees efficiency, effectiveness and customer satisfaction avoiding that the learning environment becomes frustrating and offering quality to the IT support together with low cost evaluation parameters. In the academic and industrial environments the heuristic analysis based upon checklist is a diffused method to analyze the LCD adequacy to the quality criteria.
The usability of the interfaces has a relevant role. Fitts' law is a model of the human behavior of the prediction of the times for the pointing of a target. It can be used for the design of usable interfaces, as well.
In literature, the empirical evidence shows the effectiveness of Fitts' law in the interactions between humans and control equipment for the military and aeronautics field. Nevertheless there are still few experiments in web usability. In this paper we present an experiment which shows a significant improvement of the indices used to measure usability.

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The advantages of the integration of Fitts' law within the heuristic based upon checklist will be analyzed after an adequate presentation of the literature. A usability test on two samples of users of the Jonian Department at the University of Bari will be adopted.

## 1 Introduction

A valid research project in the e-learning environment should focus on the tutorship and on the ways to personalize the learning process through the analysis of the learning needs. The greater expectations are those of organizations, University and Public Administrations that need the development and the maintenance of up-to-date and competitive human resources (the so-called long-life learning) and different Research Institutes, above all the American ones, offer the analysis and the e-learning market forecast, examinating the diffusion and the development trends of this approach above all within the professional training sphere.

The quantity of sources that show the advantages of the e-learning in economic and formative terms, is always greater, as for instance the accessibility, the flexibility and the extension of the times and methods of the learning, the reduction of direct and indirect costs, and so on and so forth (Ardimento *et al.*, 2011; Cimitile *et al.*, 2011). Often the financial analysis overcomes the formative efficacy but there are different phases in the planning and the development of e-learning systems that could be evaluated: the analysis of the needs (diagnostic evaluation), the development (formative evaluation), the final monitoring (assessment), the usability of the system, the conformity to the W3C accessibility standards (W3c, 2015).

According to Hughes and Attwell (Hughes & Attwell, 2003), it is possible to outline briefly the actual evaluation scenario as follows:

1. Descriptive analysis of different specific e-learning programs, focusing on the higher and on the academic education in the "virtual communities" (Thor & Scarafiotti, 2004).
2. Comparative studies on the systematic evaluation of the differences between the traditional learning and the learning based upon the IT;
3. Tools for the evaluation of the characteristics of the interface of the system used or the user's activity while web surfing (Riddy & Fill, 2004).
4. Report for return on investments, ROI that measures the relation between the investments on the learning and the benefits obtained, so to understand if the adoption of an e-learning program is convenient.
5. Analysis of the reference models for the e-learning quality that are intended to find the standards of quality for software and e-learning systems.

6. Papers on particular educational software.
7. Evaluation of the user's performance in terms of learning.

In this case it seems to emerge an evaluation centered upon the IT system adopted for the teaching/learning process or upon the peculiar experience of an organization, whereas in the most recent works the interaction of the user with the learning tools is better highlighted.

Following this trend several studies propose a checklist for the experimental evaluation of "quality factors" of e-learning. The present work is upon the integration of Fitt's law in the abovementioned checklist, starting from the results of a usability test made on a sample of students of the e-learning platform from the Jonian Department at University of Bari.

## 2 LCD principles

The Learner Centered Design (LCD) is a design strategy whose aim is to put the student at the center of the project. It is then fundamental to center on the "human factor" to better exploit the great opportunities that the distance learning of the third generation offers and to overcome the difficulties emerged so far. The planning of a course gives a prove to this, as it has a direct influence both on the motivation and on the learning, (O'Regan, 2003).

The history of the LCD begins in 1994 when Soloway (Soloway *et al.*, 1994) applied the philosophy of the usability of the IT to the e-learning world taking inspiration from the usable design of the websites better known as User Centered Design. The user interacting with the system was put at the center of the design.

The user was studied and interviewed at every planning stage and on each cognitive process (attention, perception, memory, problem solving, learning and motivation) as the main player to find the guidelines for the building of a system that could suit the user in the most efficient, effective, and satisfying way.

The main points were defined as follows: the aim is to understand, the motivation is the basis, the diversity of the users is the standard, and finally the growth of the knowledge of the user is the challenge. In this way the evolution of the LCD has allowed to consider technology as a whole, the so-called Instructional Methods and the human cognitive process integrating in a holistic perspective both cognitive and design factors (O'Regan, *op. cit.*).

An evaluation contemplating only the technological aspects or the economic ones is not sufficient to guarantee an objective vision of the impact that the online learning has generated in the learning environment. The evaluation of the impact in the process of teaching and of learning, the advantages compared with the traditional methods and the analysis of the critic points are all activities that

cannot be underestimated if a partial vision of the phenomena is to be avoided.

It is important then not to neglect the aspects concerning the relationships between the user and the technological apparatus, as well as the interaction with the platform and the psychological impact that it involves.

The conquests in terms of understanding of the policies of approach to the system by the user are steady knowledge and they are not influenced by the evolution of the technological context (Nielsen & Loranger, 2006) by the persistence and the relevance of Fitts' law.

To build a learner-centered formative experience means also to adapt the didactic design to the learner needs through the Instructional Design (ID).

There are more than one hundred ID models, but they almost are based upon the ADDIE methodology (Analysis, Design, Development, Implementation, Evaluation) that encounters five steps:

1. Analysis: the process starts with the analysis of the learner's needs, whose profile will contain information about the learning style, the level of IT competence, the social and economic status, the level of competence achieved and the desired one.
2. Design: the targets of the course are defined, that must correspond to the valuable performances of the learners, the resources, the didactic strategies, the assessment strategies that better suit the learners' needs.
3. Development: the didactic materials and the operational environment are developed. Also the development of the learning objects is calibrated according to the learners' exigencies. To test the effective usability of the materials many guide-tests are recommended.
4. Implementation: the formative actions are performed. The online tutor has an important role, to monitor and evaluate the constant correspondence of the materials and the didactic activities to the learner's need.
5. Evaluation: the learner's feedbacks are constantly evaluated so to make sure that every need is fulfilled. Through the evaluations it is possible to re-shape the formative process in an interactive way, to ameliorate the alignment with the learner's need. The results of the evaluation become inputs for a methodological structure that turns from sequential to interaction – oriented, thus toward the continuous increase of the quality.

## 3 LCD models

The LCD approach is used in certain models that offer methodologies oriented toward the implementation of the interaction man-machine.

Among them, the Holzinger and Motschig-Pitrik (Holzinger & Motschig-Pitrik, 2005) and Mehlenbacher (Mehlenbacher *et al.*, 2005) models are the

most relevant.

Holzinger and Motschig-Pitrik propose a three-levels model:

1. A prime research to know the user through the five wh-questions (Who? What? Why? Where? When?).
2. The individuation of a design coherent with the didactic model, the instructional design, the information design and the interaction design.
3. The development of a prototype.

Mehlenbacher propose five dimensions valuable in any formative situation: user's background, user's activities and tasks, social dynamics, formative activities, learning environment and apparatus.

Starting from these dimensions, this approach leads to the formalization of heuristics for the e-learning design, as follows:

- Respect of the standards of accessibility, possibility to customize the functions of the system, feedback and prevention of the error, clear and effective web surfing, user's control, flexibility of the system.
- Possibility to use technologies for the collaboration among users.
- Clear, highly legible and high quality contents.
- User-friendly environment and apparatus.
- Whereas (Penna & Stara, 2004) considers the LCD in the following way:
- To define the target characteristics so to orient the design toward them.
- To understand the targets and the cognitive styles of the targets through a task analysis, to develop a basic prototype of the system and to test its functioning from the user's point of view.
- To test the prototype on real users.
- To develop a beta version of the system within which all functions of the final version are active, and to make evaluation tests.

The LCD process is a circular process until the launch of the final product.

These models can be useful for the creation of effective tools for the evaluation of the e-learning quality when standards of reference and evaluation methodologies are lacking.

## 4 Fitts' law

Fitts' law was firstly enunciated in 1954 (Fitts, 1954) in an article signed by Paul Morris Fitts, researcher of the Human Engineering Division of the US Air Force, and professor at Ohio State University and at Michigan University.

His study, P. Fitts has shown the mathematical model hereafter reported in its original version:

$$T = a + b \log_2 \left(1 + \frac{D}{W}\right)$$

Where:

- The variables a and b can derive from the experimental observation and are functional to the situation.
- T is the acquisition time of the target (also called by certain authors MT, movement time to a target).
- D is the distance between the pointer and the target.
- W is the size of the target area.

According to the Law, the time necessary to reach a target with a pointing device is proportional to the logarithm of the distance to cover all divided by the dimension of the detail. Notice that the time grows according to a logarithmic function deriving from the increase of the speed of pointing at the growth of the distance of the target.

The law has been confirmed for a great variety of pointing devices and even for the eye movements.

The research activity and the literature shown so far put Fitt's Law into the heuristic of the "Feedback and prevention of the error" context of Mehlenbacher model and the "What" model by Holzinger. Murphy instead, comes into the implicit parameters that have to be considered to create the prototype for the learning model-platform.

Fitts' law is conceived for a monodimensional space but it has been extended also to bidirectional movements and to tridimensional ones (Rachael *et al.*, 2015). It illustrates the longevity of the results in terms of usability, which are depending principally upon human characteristics and not technological ones.

In literature are present evaluation about fitt's interaction dipendent by age and objective evaluation of fitt's law using fingertips (Nishiuchi & Takahashi, 2015); otherwise tools as the klm form analyzer are used to analyze the efficacy of fitt's law in a specifical context (C.Katsanos *et al.*, 2015). In this work we examin the efficacy of fitt's law in an e-learning web interface.

## 5 Case study

Since the academic year 2008/2009 the Jonian Department of the University of Bari, has been officially adopting an e-learning service to offer didactic blended learning courses. The web environment based upon an open source platform designed and implemented by the promoters and experimented by

them during the academic year 2015/2016, had reached fifty courses and 8650 users in February 2016. The activity of evaluation that is the object if this work was carried on from September to December 2015 together with the traditional course of Informatica of the Prof. Michele Scalera, scheduled at the second year of the "Laurea" degree.

### *5.1 Usability test*

A project was been carried on to verify and to test the variation of the usability level of an e-learning application, when the standards of Fitts' law are applied to it, whereas a test of usability was used as method to discover the user-friendliness of the interface that had been designed. The observation of the users' behaviour has helped to analyse in detail the performances and the reactions in the interaction with the interface, thus verifying the level of usability achieved.

The test involved 24 students that had never used the e-learning system but having a satisfying level in IT competence tested through a selection.

The test was carried out in a controlled environment, that is to say the Laboratory of the Faculty, an environment which was familiar to all the users that had been selected. Each computer was equipped with Microsoft Windows 7 and browser, chosen by the users between Microsoft Internet Explorer, Google Chrome or Mozilla Firefox. The video and the audio of each test were recorded in background by a software for the exact analysis of the times, as a manual measuring of the time would have certainly involved a relevant error factor.

The first group of students tested the platform to which it had previously been applied the theme named Experience 24/7, that is to say the default Moodle's theme having flash contents, a three columns layout, centered in the page. Within this theme the principal navigation menu is distant from the borders and the angles of the web page, it cannot be re-dimensioned and has submenus that need the refresh to be viewed.

The second group of students, instead, used the same web platform having a different theme named Standardblue that had elements conformed to Fitts' Law standards. This theme is characterized by a liquid layout on three columns, with lateral menu next to the page border, with Ajax support for the refresh only of certain parts of the menu.

The whole test through, the order of the contents was not changed, and during the second stage the dimension of the graphic elements has been increased of the 10%, and the dimension of the font used increased of two pixels.

# 6 Test

## *6.1 The element of the test*

The elements that participated to the test are:

- The users' representative panel.
  The reference point of the whole process. They had been selected among the students in the course of Computer Science by Prof. Michele Scalera. The number of users selected was 24. A half of them worked on the platform having Experience 24/7 as theme[1], the other half the one having Formal_white[2] theme modified as previously specified. The research team decided to select the users through a questionnaire to collect information about their IT competence, their personal data and their education. This was necessary in order to save the results of the test from uncertainties deriving from a low IT competence and to obtain homogeneous groups of users.
  120 candidates carried out the test. Each candidate was given an id. To participate in the test a score of at least 18/30 was necessary; 78 passed the test and at the end 24 final users were chosen by a random of their id values:

```
<?php for ( $i = 1; $i < = 24; $i++) echo $i.” -
          “.$user[rand(1,78)].”\n”; ?>
```

- Usability experts.
  A team made up of four elements having the task to collect the data and to analyze them. They were also the designers and the responsible for the project.

## *6.2 Test planning*

The aims of the test were divided into general and specific. The general aims: to evaluate the easiness of use, the satisfaction and the perception of the utility of the service as a whole (for instance to increase the value of the contents or to identify new needs) through the measuring of the principal aspects that are responsible for the usability of the interaction (perception, consistency, user-friendliness. For this aim the conductors invited the users to express their opinions about the feedback given by the new graphic interface ("thinking aloud" method).

Specific aim of the test was to record the times for the achievement of a few tasks (task analysis) as in particular:

[1] http://www.ncwdesign.it/experience24.png

[2] http://www.ncwdesign.it/formalwhite.png

1. To enter "Corso di Informatica".
2. To enter the forum of the community of the students of the Jonian Department and the opening of a new thread.
3. To download the pdf file named "Il processore didattico".
4. To consult the FAQ.

Each operation was started from the homepage of the platform and at the end of the test the participants were given a brief questionnaire.

## 7 Test results

### *7.1 Data analysis and recommendations*

The results of the test are reported in the schedules that follow. The first two represent a qualitative synthesis of the interfaces of the platforms, gathered from the participants and on the basis of the personal opinions they expressed (think aloud method). During the test the importance of the opinions about the usability of the platform was highlighted more than the aesthetic one. The qualitative rank is graduated in the following way:

Excellent = score 5, Good = score 4, Fairly good = score 3, Poor = score 2, Insufficient = score 1

Table 1
QUALITY OF THE PLATFORM PERCEIVED BY THE FIRST GROUP OF USERS WITH EXPERIENCE 24/7 PLATFORM

| | | | | | |
|---|---|---|---|---|---|
| User 1:4 | User 2:3 | User 3:2 | User 4:3 | User 5:4 | User 6:3 |
| User 7:2 | User 8:3 | User 9:3 | User 10:3 | User 11:3 | User 12:3 |

Average quality for experience 24/7 platform: 3

Table 2
QUALITY OF THE PLATFORM PERCEIVED BY THE SECOND GROUP OF USERS WITH FORMAL_WHITE PLATFORM

| | | | | | |
|---|---|---|---|---|---|
| User 13:3 | User 14:4 | User 15:4 | User 16:3 | User 17:4 | User 18:5 |
| User 19:3 | User 20:4 | User 21:4 | User 22:3 | User 23:3 | User 24:3 |

Average quality for formail_white platform: 3,58

The non–parametric test of the sum of the ranges of Wilcoxon was applied to the values gathered. This test calculates the absolute differences among paired observations, put them in order of magnitude, assigns them the original signs of difference to the ranges obtained, and calculates the sum of the ranges having

plus sign. The significance of the value obtained comes from the Wilcoxon Rank-Sum Table.

The test applied to tables 1 and 2 gives the following values:

W = 41, p-value = 0.04236;

Alternative hypothesis: the users' judgement about the platforms is different from 0;

As $p<0.05$ there is a little evidence in favour of the alternative hypothesis, that is to say that the average judgement about the two platforms is different (in particular the average judgement of the usability of the second platform is highly superior than the one of the first platform).

Hereafter the times recorded, rounding off of the values to the first decimal place.

Table 3
TIMES RECORDED BY THE USERS FOR THE ACHIEVEMENT OF THE TASKS WITH EXPERIENCE 24/7 THEME

| | Time task 1 | Time task 2 | Time task 3 | Time task 4 |
|---|---|---|---|---|
| User 1 | 7,8 | 31,7 | 22,8 | 35,3 |
| User 2 | 6,2 | 28,8 | 13,5 | 25,4 |
| User 3 | 11,0 | 19,8 | 16,0 | 45,7 |
| User 4 | 14,7 | 23,7 | 23,4 | 39,9 |
| User 5 | 8,4 | 22,5 | 14,7 | 24,2 |
| User 6 | 10,4 | 18,7 | 19,9 | 34,1 |
| User 7 | 17,0 | 41,4 | 42,7 | 25,6 |
| User 8 | 10,7 | 21,3 | 38,4 | 25,2 |
| User 9 | 13,2 | 29,2 | 21,5 | 43,9 |
| User 10 | 23,2 | 21,6 | 18,7 | 41,0 |
| User 11 | 6,8 | 17,4 | 13,5 | 33,1 |
| User 12 | 9,8 | 25,4 | 19,2 | 27,4 |
| Average | 11,6 | 25,1 | 22,0 | 33,4 |

Table 4
TIMES RECORDED BY THE USERS FOR THE ACHIEVEMENT OF THE TASKS WITH FORMAL_WHITE THEME

| | Time task 1 | Time task 2 | Time task 3 | Time task 4 |
|---|---|---|---|---|
| User 13 | 9,7 | 22,4 | 23,8 | 38,3 |
| User 14 | 7,4 | 17,4 | 14,5 | 27,4 |
| User 15 | 9,2 | 20,6 | 18,0 | 21,7 |
| User 16 | 7,4 | 23,7 | 19,0 | 39,9 |
| User 17 | 19,7 | 28,1 | 15,7 | 18,7 |
| User 18 | 10,4 | 34,7 | 16,9 | 26,3 |
| User 19 | 8,5 | 16,4 | 41,7 | 23,1 |
| User 20 | 15,2 | 21,3 | 27,5 | 11,2 |
| User 21 | 10,1 | 21,5 | 14,6 | 28,6 |
| User 22 | 13,9 | 30,8 | 14,7 | 33,5 |
| User 23 | 13,5 | 25,8 | 12,5 | 23,1 |
| User 24 | 12,1 | 23,5 | 15,8 | 19,4 |
| Average | 11,4 | 23,8 | 19,6 | 25,9 |

From the application of Wilcoxon's test:

**task 1**: W = 70.5, p-value = 0.931;
alternative hypothesis: the judgement of the users about the platforms is different from 0. There are no statistically relevant differences in the elaboration times depending upon the application of Fitts' law to the platform.

**task 2**: W = 78.5, p-value = 0.7073;
alternative hypothesis: the judgement of the users about the platforms is different from 0. Also for this second task, there are no statistically relevant differences in the elaboration times as the themes changed.

**task 3**: W = 87.5, p-value = 0.3706;
alternative hypothesis: the judgement of the users about the platforms is different from 0. There are no statistically relevant differences in the elaboration times as the themes changed.

**task 4**: W = 108, p-value = 0.03754;
alternative hypothesis: the judgement of the users about the platforms is different from 0. This time there is a statistically relevant difference ($p<0.05$): the elaboration times are on average shorter with the use of the

second theme.

From the analysis of the results the scenario is interesting. The growth of the area of the target and of the readability of the texts, in this case, do not reduce the times of access during the tasks which are complex (1,2,3), whereas this does not happen for the simplest task (4). At the same time, in no case the application of Fitts' law seems to increase the interaction times. Tasks 1,2,3 need the selection of targets within lists. The increase of their dimension, and of the font of the page, space the target out from the pointing device. The increase of the distance of the target from the pointing device compensate for the increase of the area of the target. This argument deserves a deeper analysis, as it would be interesting to individuate the elements within the web layout that benefit more from the application of Fitt's law standards.

## Conclusion

The fast development of the e-learning has not yet allowed an harmonious growth and it has been characterized by the lack of shared and consolidated guidelines. Sometimes the emphasis put on the use of multimedia and on the intense use of the web has limited the evaluation of the quality of the products.

Although certain researches have let the problem of the evaluation emerge, the e-learning community needs to define precise strategies for the evaluation of its applications and only accurate experimental researches can show operators the right way toward design guidelines.

To offer its advantages the e-learning must become at the same time an efficient, ergonomic, formative tool, accessible by any user (Mehlenbacher *et al.*, 2005), but all the operators should join their efforts to conceive the distance learning as learner centered.

The LCD approach is nowadays a design method able to fulfill this task, and thanks to the knowledge already offered by the literature it is already possible to define the quality factors to use not only during the implementation phase, but also during the evaluation one, that mostly needs to be powered in the distance learning.

The integration of these factors within checklists ad hoc for the design of any e-learning experience could offer advantages to the scientific community, to gather the impact in terms of quality of the product, with no extra costs.

The experiment described in this paper highlights that the integration of the standards of Fitts' law can be possible and even desirable. The distance learning still needs to be scientifically studied, and although its evolution rhythms are accelerating, it is necessary to evaluate its dynamics with functional methodologies.

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