TRANSNAV
http://www.transnav.eu
the International Journal
on Marine Navigation
and Safety of Sea Transportation
Volume 8
Number 4
December 2014

DOI: 10.12716/1001.08.04.17

Experimental Research in Operation Management in Engine Room by using Language Sentiment/Opinion Analysis

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ABSTRACT: The paper argues for the necessity of a combination MMR methods (questionnaire, interview) and sentiment/opinion techniques to personal satisfaction analysis at the maritime and training education and proposes a generic, but practical research approach for this purpose. The proposed approach concerns the personal satisfaction evaluation of Engine Room simulator systems and combines the speech recording (sentiment/opinion analysis) for measuring emotional user responses with usability testing (SUS tool). The experimental procedure presented here is a primary effort to research the emotion analysis (satisfaction) of the users-students in Engine Room Simulators. Finally, the ultimate goal of this research is to find and test the critical factors that influence the educational practice and user's satisfaction of Engine Room Simulator Systems and the ability to conduct full-time system control by the marine crew.

1 INTRODUCTION

In the shipping industry, several serious accidents including the capsize of the *Herald of Free Enterprise*, the *Exxon Valdes* tragedy, the capsize of the *Estonia* and others, have happened. The accidents have shocked the public and attracted great attention to ship safety. As serious concern is raised over the safety of ships all over the world, the International Maritime Organisation (IMO) has continuously dealt with safety problems in the context of operation, management, survey, ship registration and the role of administration. The improvement of safety at sea has been highly stressed. The international safety-related marine regulations and rules were produced to prevent similar accidents from occurring (Wang, 2001). The *Herald of Free Enterprise* in 1987, for example, greatly affected the rule developing activities of the IMO (Cowley, 1995, Sekimizou, 1997). This finally resulted in the adoption of the International Safety Management (ISM) Code. All such accidents (i.e. *Scandinavian Star* in 1990, *Estonia* in 1994 etc.) highlighted the role of human error in marine casualities and, as a result, the new Standards for Training, Certificates and Watckeeping for seafers were subsequently introduced (Sekimizou, 1997, Wang, 2001).

In Marine Education & Training (MET), the use of simulators (engine or ship's bridge) is fact. Various maritime educational standards (i.e. STCW, 95, Manila 2011) allow the simulators using in educational practice. The aim for the application of simulators in MET is the transport of capacity which is the possibility to adopt the dexterities that are learned in a frame of training one in the operation of a vessel. Because no situation is always the same with a previous experience, the fact that an individual becomes more specialized with each repetition of similar objective lies in the fact of transport. Indeed a faith in the "make of" transport constitutes the basic justification for all programs of

education. We assume that the dexterities and the knowledge that is learned in a classroom can be applied effectively in similar situations outside it (Tsoumas et al., 2004).

MET follows certain education standards (STCW'95/Manila 2011) for each specialty (Captain, Engineer) and for each level (A', B', C'). Its scope is the acquisition of basic scientific knowledge, dexterities on execution (navigation, route plotting, administering the engine etc) as well as protecting the ship and crew (safety issues and environment protection issues). Specifically, the maritime education standard defines three competency levels: Management, function and support while at the same time it defines related dexterities. Every dexterity level suggests the totality of the learning goals and the goal definition is the basic characteristic of training. The simpler competence make up the more complex ones. This hierarchical increase in the level of dexterity places an austere framework for the educator designer of lessons in each marine school. The introduction of simulators and other modern training tools constitutes an important research question on what degree it can fulfil all the expectations set forth by the STCW'95 (IMO, 2003, Papachristos et al., 2012a, Tsoukalas et al., 2008).

The paper argues for the necessity of a mixed approach to usability and educational evaluation at the engine room and proposes a generic, but practical framework for this purpose. In particular, we present a multi-method approach for the usability and educational evaluation of maritime engine simulators that combines the physiological data generated from speech recording by using sentiment analysis and questionnaires and interviews. This combination of these methods aims at the generation of measurable results of complementary assessments of the user experience (Papachristos et al., 2012a, Papachristos et al., 2012b).

The proposed approach is generic, in the sense that it can be the starting point for an integrated usability & educational evaluation of the interactive technologies during in-situ education, simulation and pragmatic ship operation management. The approach is currently applied to assess the usability & educational practice of ship engine room in educational scenarios.

2 THEORETICAL BACKGROUND

Research in HCI (Human-Computer Interaction) has created many methods for improving usability during the design process as well as at the evaluation of interactive products (Koutsabasis, 2011). Usability has been defined by ISO 9241 as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use". It is widely acknowledged that the efficiency and effectiveness can be measured in an objective manner, i.e. in specific contexts of use and with the participation of representative user groups, and they are usually defined in terms of metrics like: task success, time-to-task, errors, learnability (in repetitive use tests), etc.; while the personal satisfaction is subjective in nature and depends on the characteristics of the user groups addressed (Tullis and Albert, 2008).

The simulators constitute a category of educational software and follow a methodology of application in instructive practice. The user is prompted by the software to undertake active action for the making of personal work in the computer (simulator) or in practicing the system (adjustment) (Crook, 1994, Solomonidou, 2001, Tsoumas et al., 2004). Maritime Engine simulation allows the creation of real, dynamic situations that take place on a ship at sea in a controlled surrounding where naval machine officers can (Kluj, 2002; Tsoumas et al., 2004):

1 practice new techniques and dexterities
2 shape opinions from teachers and colleagues
3 transport the theory of a real situations in a safe operation
4 face several problems simultaneously rather than successively, can learn by giving priority to multiple objectives under high pressure situations and change situations accordingly.

It is difficult to expect that a simulator will be in place to achieve all the previously mentioned expectations. The higher requirements of a user leads to the increasing complexity of engine room simulators, higher cost and their longest-lasting time of growth. On the other hand the fast changes in the Engine room equipment and the control techniques require a lot of flexibility in the architecture of simulators. The *model Det Norske Veritas* for the Certification of Naval Systems of Simulators proposes the following four classification of simulators (Kluj, 2002; Tsoumas et al., 2004):

- *Category A (ENG).* A complete mission simulator imitates all the processes of the instruments in the control room, with the use of functional stations in the instrument room.
- *Category B (ENG).* An objective simulator, capable of imitating various instrument processes in the control room, but with the limited use of functional stations in the control room.
- *Category C (ENG).* A limited objective simulator capable of imitating certain instrument processes in the control room for the training procedure.
- *Category H (ENG).* A special objective simulator capable of imitating an operation and/or maintenance of particular equipment of instruments and/or determined scripts of applied mechanics.

The psychological research in the language production, comprehension and development is developed mainly after 1960 as a result of linguist's N. Chomsky (1957), research on generative grammar. The psycholinguistic research showed that language comprehension and production is not influenced only from factors not related to their linguistic complexity but also from the speaker's/ listener's existing knowledge for the world around him/her, as well as by the information included in the extra linguistic environment (Pinker and Jackendorff, 2005, Vosniadou, 2001).

In psychology, the term emotion tends to be used for the characterization of rather short but intense experiences, while moods and preferences refer to lower intensity but greater duration experiences.

Modern scientific community suggests different views concerning understanding emotional mechanism like natural reactions, purely mind process, or hybrid combination (Lazarous, 1982, Zajonc, 1984; Vosniadou, 2001). In general, we could note that psychology considers the emotional mechanism as a determinist mechanism that pre-requires a stimulus – cause incited in the brain by use of the neural and endocrine system (hormonal), the response – emotion (Malatesta, 2009, Papachristos et al., 2012b).

Investigating the emotional gravity of words spoken by a speaker and defined its emotional state (current or past) constitutes a state of the art issue. Most of the emotional state categorization suggested concern the English language. To overcome this problem, studies have been conducted that approach the matter cross-culturally and study the assignment of the categories to various languages. This assignment has conceptual traps since the manner in which an emotional state is apprehensible; an emotional state is influenced by cultural factors as well. In a rather recent cross-cultural study done by Fontaine et al., (2007), 144 emotional experiences' characteristics were examined, which were then categorized according to the following emotional "components": (a) event assessment (arousal), (b) psycho physiological changes, (c) motor expressions, (d) action tendencies, (e) subjective feelings, and (f) emotion regulation.

International bibliography contains various approaches – techniques (sorting algorithms) concerning linguistic emotional analyses, which are followed and are based mainly in the existence of word lists or dictionaries with labels of emotional gravity along with applications in marketing, cinema, internet, political discourse etc (Lambov et al., 2011, Fotopoulou et al., 2009). There are studies also concerning sorting English verbs and French verbs that state emotions based on conceptual and structural-syntactical characteristics. For the Greek language there is a study on verbs of Greek that state emotions based on the theoretical framework "Lexicon-Grammar" that is quite old and doesn't contain data from real language use; there are also some studies concerning Greek adjectives and verbs that state emotions and comparison with other languages (French – Turkish) under the viewpoint: Structural-syntactical + conceptual characteristics. More recent studies in Greek conducted systematically the noun structures based on the theoretical framework of "Lexicon-Grammar" and the establishment of conceptual & syntactical criteria for the distinction and sorting of nouns based on conceptual-syntactical characteristics of the structures in which they appear (Papachristos et al., 2012b).

Specifically, as sentiment analysis and opinion mining applications tend to utilize more and more the composition of sentences and to use the value and properties of the words expressed by its dependency trees, there is a need for specialized lexicons where this information can be found. For the analysis of more complex opinionated text like news, political documents, and (online) debates the identification of the attitude holder and topic are of crucial importance (Choi and Cardie, 2008, Jia et al., 2009, Moilanen and Pulman, 2007). Applications that exploit the relations between the word meaning and its arguments can better determine sentiment at sentence-level and trace emotions and opinions to their holders (Maks and Vossen, 2012).

3 RELATED WORK AND SCOPE

The effectiveness evaluation of the educational software in the educational practice was mainly based on the experience & analysis (pos-itivistic) methods, which accept that knowledge may be attributed only to the objective reality existing re-gardless of the values and beliefs the ones seeking to discover her. As it shown in the international bibliography, the use of multiple methods of evaluation is more effective and the combinatorial use of quantitative and qualitative approaches confines their weaknesses (Brannen, 1995, Bryman, 1995, Patton, 1990, Retalis et al., 2005, Tsianos et al., 2009).

Specifically, the Mixed Methods Research (MMR) employs a combination of qualitative and quantitative methods. It has been used as a distinct approach in the social and behavioral sciences for more than three decades. MMR is still generating discussions and debates about its definition, the method involved, and the standards for the quality. Although still evolving, MMR has become an establish approach. It is already considered the 3rd research approach, along with the quantitative and qualitative approaches, and has its own emerging world view, vocabulary, and techniques (Fidel, 2008).

Usability testing procedures used in user-centered interaction design to evaluate a product by testing it on users. This can be seen as an irreplaceable usability practice, since it gives direct input on how real users use the system. Usability testing focuses on measuring a human-made product's capacity to meet its intended purpose (Dix et al., 2004, Nielsen, 1994). A number of usability methods have been developed and promoted by different researchers (Neilson and Mark, 1994).

In literature we meet as usability requirements or goals: (i) Performance, (ii) Accuracy, (iii) Recall, (iv) Stickiness and (v) Emotional response. Some usability testing can be accomplished through the use of checklists, guidelines, and principles. Most usability testing methods involve tests on real users and require human observers to evaluate the outcomes of the test. Consequently, usability testing tends to be rather labor intensive (Norman, 2006). Several studies have attempted to compare usability-testing methods in terms of their ability to identify types of usability problems and their influence on designers (John and Marks, 1997). Questionnaires are often regarded as an inexpensive and convenient way to gather data from a large number of participants. As adopted by many HCI (Human-Computer Interaction) and usability engineering practitioners, the attitude questionnaire can be transformed into a socalled satisfaction questionnaire (Czaja and Blair, 1996, Ryu, 2005). On other hand, Qualitative research methods were developed in the social sciences to enable researchers to study social

and cultural phenomena. Much qualitative research is interview based. The interview used in usability research for understanding of the goals, needs, an activities of people who use the products (Kantner et al., 2003). Until recently, field usability research has not gained wide acceptance among usability practitioners.

There is considerable work on the ergonomic & usability assessment of the human strain (Torner et al., 1994) and the design and arrangement of ship equipment. This work has few applications in industry (Petersen et al., 2010) and not yet resulted to well established evaluation methods and cases. According to Osterman et al. (2010) "*several models and methods have been developed to estimate costs and benefits of ergonomics in other industries, but no studies were found from the shipping industry*". More specifically, these studies tend to report on usage effects on health, safety and mental workload; however they offer little guidance on the evaluation methods and/or the design of the respective technology and equipment (devices) with respect to usability (Papachristos et al., 2012b).

In recent years many sentiment analysis and opinion mining applications have been developed to analyze opinions, feelings and attitudes about products, brands, and news, and the like. These applications

mine opinions from different sources like online forums and news sites and from movie, product and hotel reviews. Many of these tools rely on manually built or automatically derived polarity and subjectivity lexicons and, in particular for English, a couple of smaller and larger lexicons are available (Maks and Vossen, 2012).

These lexicons are lists of words senses annotated for negative or positive polarity like as (Hatzivassiloglou and McKeown, 1997, Maks and Vossen, 2012):

- (Subjective:negative) angry — feeling or showing anger;"angry at the weather; angry customers; an angry silence",
- (Subjective:positive) beautiful — esthetically pleasing,
- (Objective:no polarity) alarm clock, alarm — a clock that wakes the sleeper at a preset time, and
- (Objective:negative) war,warfare—thewaging of armed conflict against an enemy; "thousands of people were killed in the war".

Many interesting works exist that focus on extracting the opinions from the customer reviews. Some works focus on performing opinion mining to identify the semantic orientation of a review overall, whereas others focus on identifying and extracting the opinion words that will determine the semantic orientation. A few works exist that perform sentence-level sentiment analysis (i.e. sentiment analysis that is using words but is not extracting representative features). The opinion words are classified individually and then the polarity of the opinion sentence is calculated by combining the individual opinion word polarity while in the sentiment of each sentence is analyzed by identifying the sentiment expressions and subject terms. Sometimes the opinions regarding the products may not be explicitly mentioned on the customer review sites but they exist in web blogs. Finally there exist a few product-ranking techniques based on opinion mining of product reviews for specific languages, such as Chinese (Eirinaki et al., 2012, Meena and Prabhakar, 2007, Kim and Hovy, 2004, Zhang et al., 2007).

We propose a research approach for educational and usability evaluation of marine simulators with emphasis in personal satisfaction (usability view) that combines speech recording for measuring emotional user responses-lexical analysis with usability assessment. Certainly, the proposed approach may require further adaptations to accommodate evaluation of particular interactive simulation systems. The main elements of the proposed approach include (Papachristos et al., 2013):

1 Registration and interpretation of user emotional states
2 (Speech recording and lexical analysis (sentiment processing)
3 (Usability/Satisfaction & Educational assessment questionnaires
4 Wrap-up interviews (emotional assessments).

The Personal (subjective) Satisfaction is a difficult measuring factor. For that, we use a mixed technique by using a language dimension (sentiment analysis) with MMR methods (questionnaire & interview), verifying measurements can be accomplish in order to extract safer conclusions (Papachristos et al., 2013).

4 APPROACH

The main purpose of this approach is the analysis of emotional state and the investigation of the standards that connect the user's Satisfaction-Happiness by use oral text (as the basis for the situation) in the basic dipole: *happiness* (*satisfaction*) – *sad* (*non satisfaction*). We used two methodological tools:

- Sentiment /opinion analysis (Natural Language Processing)
- MMR methodology (Qualitative-quantitative techniques)

The approach contains:

- Process
- Research tools
- Personal Satisfaction Modeling, and
- Sentiment/Opinion Analysis

1 Process

The experimental process will include four (4) phases (Fig.1):

- Phase 1: Presentation of the acceptance document by the user-trainee.
- Phase 2: Questionnaire Completion (user's profile and assessment educational and technical characteristics) by the trainee.
- Phase 3: a semi structured interview about the emotional state
- Phase 4: Simulation Scenario (run)
- Phase 5: Completion the simulation (scenario) through a semi structured interview & usability questionnaire (SUS Tool)

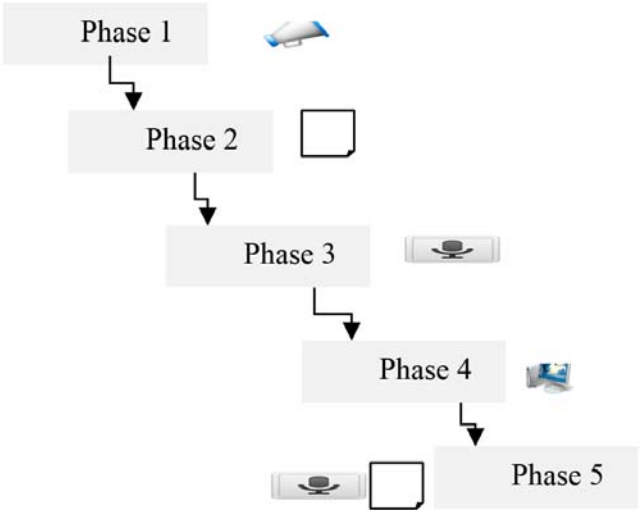

Figure 1. The Experimental research process (as rich picture)

2 Research Tools

We used four (4) tools:

- *User Profile Questionnaire (*UPQ*):* it contains: a personal profile (gender, age), personal background (education, experience and work experience) etc.
- R*ecording Speech Tool (*RST*)*: Use of a microphone for speech recording of spoken words (speech-text).
- *Evaluation Questionnaire*: (EQ) it registration view/viewpoint/attitude data by using a questionnaire.
- *System Usability Scale Tool (SUST)*: The SUS is a simple, ten-item scale giving a global view of subjective assessments of usability. It is often assumed that a Likert scale is simply one based on forced-choice questions, where a statement is made and the respondent then indicates the degree of agreement or disagreement with the statement on a 5 (or 7) point scale (Brooke, 1996). The SUS scores have a range of 0 to 100 (see Tab. I)

Table 1. SUS scale

No	Question	Coefficient
1	I think that I would like to use this system frequently	4
2	I found the system unnecessarily complex	1
3	I thought the system was easy to use	1
4	I think that I would need the support of a technical person to be able to use this system	4
5	I found the various functions in this system were well integrated	1
6	I thought there was too much inconsistency in this system	2
7	I would imagine that most people would learn to use this system very quickly	1
8	I found the system very cumbersome to use	1
9	I felt very confident using the system	4
10	I needed to learn a lot of things before I could get going with this system	3

3 Personal Satisfaction modeling

The personal satisfaction modeling contains 5 levels:

Very dissatisfied	dissatisfied	neutral	Somewhat satisfied	Very satisfied
1	*2*	*3*	*4*	*5*

Figure 2. The Satisfaction levels

From these levels, we design the Research Personal Satisfaction Framework (RPSF) (Papachristos et al., 2013):

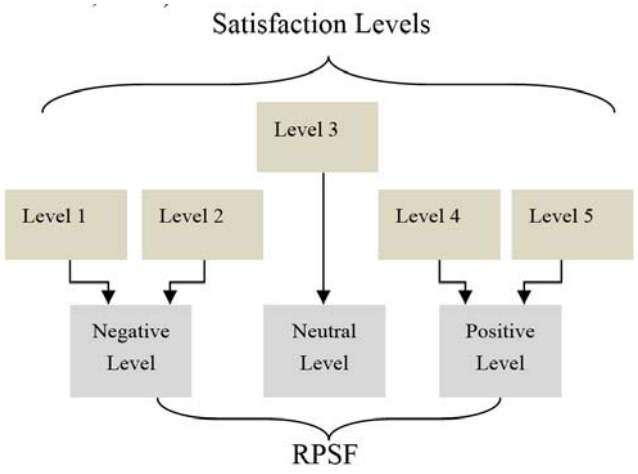

Figure 3. The RPSF

4 Sentiment/Opinion Analysis

The semantic orientation based in a Lexicon Base (LB). This approach based a Greek Lexicon of Emotions ("ANTILEXICON") [22]. Suppose the follow parameters for sentiment/opinion processing:

$$\mathrm{IndW}_{+} = \left(\sum \mathrm{W}_{S+}\right) / \mathrm{TotN}_{w} \quad (1)$$

$$\mathrm{IndW}_{-} = \left(\sum \mathrm{W}_{S-}\right) / \mathrm{TotN}_{w} \quad (2)$$

$$\mathrm{W}_{S+} \mid \mathrm{W}_{op+} = \sum \mathrm{W} \quad (3)$$

$$\mathrm{W}_{S-} \mid \mathrm{W}_{op-} = \sum \mathrm{W} \quad (4)$$

where
W: number words with sentiment or opinion load per text (positive polarity+ or negative polarity-)

5 FIRST RESULTS

This experimental procedure is a primary effort to research the educational and usability evaluation with emotion analysis (satisfaction) of the users-students in maritime simulators.

1 Object

The engine room simulator of Norcontrol Kongsberg was selected for the experiment. It belong the Merchant Faculty of Maritime Academy of Aspropyrgos for the education of merchant engineers on management issues, operation and re-establishment of damages in a typical engine room of

a vessel. It is constituted by the following areas-parts: (i) instructional Room Workstation, (ii) Engine Control Room Workstation, (iii) Exercise Room Workstation and (iv) Sound System. The engine room simulator allocates special software on monitoring the operations of the system as well as growth of instructive scripts (PPT 2000- MC 90- III simulator). The material (hardware) that is used for the support of software is constituted of 6 HP workstations that run on functional system HP-UX. It also allocates a number of terminals for the concretisation of the adjustment (7 PCs). Moreover printers are used for the printing of operating parameters of the simulation and the evaluation of the students (Tsoumas et al., 2004).

2 Participants

The sampling was carried out between January and February 2013. The samples consisted of 6 students-users. They were subjected to a specific experimental procedure (Diesel generator operation) in engine room simulator and completed the questionnaires and gave interviews (research approach).

3 Data Analysis

The data of experiment (Engine Simulator) come from three sources:

- questionnaires,
- SUS tool, and
- Interviews (voice recording).

Specifically, we have

Table 2. Data Profile

Variables	Results
Sex	6 men
Medical profile	4 people (glasses) 4 people (myopia)
Educational background	3 people (general High School) 2 people (Technical High School) 1 People (other)
Year of study	First year (5 people) Forth year (1 people)
English language	1 people Excellent level 2 people Very good level 3 people Good level
Computer knowledge level	5 people basic level (MS office / Internet using) 1 people advanced level (computer programming, web site design etc.)
Simulation Experience	2 people

The educational evaluation is show the next Table:

Table 3. Educational Evaluation

	very satisfied	satisfied	Neutral	Dissatisfied	very dissatisfied
infrastructure	0	3	1	1	1
Courses	0	2	3	1	0
Teaching	2	2	2	0	0

And the satisfaction about the experimental procedure is:

Table 4. Satisfaction Evaluation

	very satisfied	satisfied	Neutral	Dissatisfied	very dissatisfied
Scenario	1	5	0	0	0
Simulator	4	2	0	0	0

4 Sentiment/Opinion Analysis

The next tables display the measures of lexical data from sentiment processing:

Table 4. Lexical Analysis for Scenario Satisfaction

	Very satisfied	Satisfied
Total N (words)	*53*	*236*
Using Mdf (modifiers)	*Yes*	*Yes*
Sum Mdf [$\sum W_{mdf}$]	*2*	*10*
Mean Mdf [$\sum W_{mdf}$]	*2*	*2*
Total N / Sum Mdf	*26,5*	*23,6*
$\sum W_{s/op+}$	*8*	*31*
$\sum W_{s/op-}$	*0*	*0*
Total N /$\sum W_{s/op+}$	*6,62*	*7,61*
Total N /$\sum W_{s/op-}$	*0*	*0*

Table 5. Lexical Analysis for Simulation Satisfaction

	Very satisfied	Satisfied
Total N (words)	*199*	*90*
Using Mdf (modifiers)	*Yes*	*Yes*
Sum Mdf [$\sum W_{mdf}$]	*7*	*5*
Mean Mdf [$\sum W_{mdf}$]	*1,75*	*2,5*
Total N / Sum Mdf	*28,4*	*18*
$\sum W_{s/op+}$	*23*	*12*
$\sum W_{s/op-}$	*0*	*0*
Total N /$\sum W_{s/op+}$	*8,65*	*7,5*
Total N /$\sum W_{s/op-}$	*0*	*0*

Table 5. MDF word Analysis

Satisfaction			
Most used words	Scenario Frequency	Simulator Frequency	Total Frequency
"πολύ (a lot/very)"	3	4	7
"αρκετά (enough)"	4	3	7

The most used phrase in user's answers in sentiment analysis has this format:

Phrase: (mdf | auxiliary verb) + satisfied (5)

and opinion analysis:

Phrase: mdf +adjective| noun | verb (6)

And finally, the Topology (P_{TOP}) for sentiment/opinion phrases in user's answers extending all the answer due to the small size of the answers (average: 48,2words):

Total N / people of sample = 289 / 6 = 48,16 (7)

6 CONCLUSIONS

The main purpose of this research, is the investigation of personal satisfaction of a user of MET equipment (Engine room simulator) via the assistance of language techniques but also other methods like MMR (questionnaires-interviews).

The main elements of the proposed approach include: speech recording for sentiment/opinion analysis, Usability testing procedure (SUS), Attitudes/views questionnaires. The first results are shows:

- The Total N / Sum Mdf Index depending from personal satisfaction (growing from very high → high satisfaction) in Scenario & Simulator satisfaction.
- The Topology (P_{TOP}) for sentiment/opinion phrases in user's answers extending all the answer.
- The most used words in sentiment phrases is *"αρκετά (enough)"& πολύ (a lot/very)* (simulator & Scenario satisfaction form users answers) and the most used phrase in user's answers has this format: (mdf | auxiliary verb) + satisfied (verb) & mdf +adjective| noun | verb.
- Very High personal satisfaction for simulator (majority) and high personal satisfaction for simulator (majority).
- In sentiment/opinion analysis, we observe the Mean Mdf Index is 2 approximately for all cases.

The research continues with the numeral increase of the sample and the total processing and evaluation of the research findings (qualitative and quantitative data). The proposed approach may require further adaptations to accommodate evaluation of particular interactive systems.

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