Sentiment Analysis Use in the Satisfaction Evaluation for Maritime Education

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\textbf{Abstract} — The paper argues for the necessity of a mixed approach to satisfaction analysis at the maritime education and proposes a generic, but practical research framework for this purpose. The proposed framework concerns the satisfaction evaluation of marine e-learning systems and combines the speech recording (sentiment/opinion analysis) for measuring emotional user responses with usability testing (SUS tool). The ultimate goal of this research is to find and test the relations between the satisfaction of students and usability acceptance for e-learning environments in maritime education & training. The experimental procedure presented here is a primary effort to research the emotion analysis (satisfaction) of the users-students in maritime e-navigation environments (ECDIS).

\textbf{Index Terms} —evaluation, satisfaction, sentiment analysis, maritime education.

I. INTRODUCTION

In the maritime education and training, in particular, the user’s satisfaction based on objective criteria poses an important research subject because via this we can determine the background that explains the satisfaction phenomena, recommending at the same time new considerations that will expand the up-to-date educational conclusions on the adult education in educational programs and software.

The development of an evaluation framework of the student’s satisfaction – happiness via e-learning environment use in maritime education (Information Technologies Laboratory of the National Marine Training Centre of Piraeus) is an important research subject. That can result via data translation recorded with the use of sentiment/opinion analysis method. The research methodology connects the behavioral evaluation with the text data (sentiment analysis) and traditional methods (interview, questionnaire).

The samples consisted of 31 maritime students that were subjected to a specific experimental procedure (ECDIS). The ultimate goal would be the use of her research results from the marine education and training sector (IMO), the adult education sector scientists, as well as the learning systems developers in order to improve their work in the educational projects.

II. REVIEW AND SCOPE

In the investigative field of psychology science, the use of the English word \textit{affect} is very popular, which usually covers a plethora of concepts such as emotions, moods and preferences. 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. 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 ([1],[2]).

Modern scientific community suggests different views concerning understanding emotional mechanism. There is the view that emotion is defined by the natural reactions caused in the body (sweating, pulse increase, etc.), while other researchers believe that it is a purely mind process, while there are also hybrid views that define, each one in a varying degree, the participation and the manner where the human functions are involved in the emotional experience [2].

An important factor that can be investigated in relation to the emotional experience is the language process. The psychological research in the language production, comprehension and development is developed mainly after 1960 as a result of linguist’s N. Chomsky research on generative grammar [3]. 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 [4].

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., 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

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expressions, (d) action tendencies, (e) subjective feelings, and (f) emotion regulation [5].

This research is interesting by stating a strong argument pro the position that at least two dimensions are required for a satisfactory depiction of the semantic space of emotions (valence, potency, unpredictability). The general conclusion of the authors of that particular research is that the optimal amount of dimensions to be taken under consideration depends directly on the question posed by the. 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 ([6],[7],[8]). 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 [9].

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”. Effectiveness means accuracy and completeness with which users achieve specified goals. Efficiency means resources expended in relation to the accuracy and completeness with which users achieve goals. Satisfaction means freedom from discomfort and positive attitudes towards the use on the product. It is widely acknowledged that the first two goals of usability (efficiency and effectiveness) can be measured in an objective manner (usability tests), but he third goal (personal satisfaction) is subjective in nature and depends on the characteristics of the user groups addressed [10].

The usability evaluation of ship manipulation systems is an essential step in any process related to the design of related interactive technologies and their ergonomic arrangement to the ship’s system. There is considerable work on the ergonomic assessment of the human strain and the design and arrangement of ship equipment. This work has few applications in industry and not yet resulted to well-established evaluation methods and cases [10].

Usability testing procedures used in user-centered interaction design to evaluate a product by testing it on users. Usability testing focuses on measuring a human-made product’s capacity to meet its intended purpose ([11],[12]). A number of usability methods have been developed and promoted by different researchers [13]. Usability testing has a number of possible goals and purposes. Certainly one of the most important is to discover major problems in the user interface that could result in human error, terminate the interaction, and lead to frustration on the part of the user. Other goals might be to reduce training time, increase performance and efficiency, and increase user satisfaction [14].

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. The study of usability itself is extended to include other aspects of the user experience like accessibility, aesthetics, emotion and affect and ergonomics ([10],[15]).

Qualitative research methods were developed in the social sciences to enable researchers to study social and cultural phenomena. Qualitative data sources include observation and participant observation (fieldwork), interviews and questionnaires, documents and texts, and the researcher’s impressions and reactions. Although most researchers do either quantitative or qualitative research work, some researchers have suggested combining one or more research methods in the one study (called triangulation) [16]. Much qualitative research is interview based. Qualitative interviewing is a flexible and powerful tool which can open up many new areas for research. The interview used in usability research for understanding of the goals, needs, an activities of people who use the products [17].

Investigation and analysis of the emotional state of an e-learning maritime systems’ user (simulator etc.) is a subject attached to many knowledge fields. More specifically it’s related to psychology, pedagogies, man-machine interaction, linguistics and affect computing. The present analysis focuses in a linguistic approach. The focus of the research is in two sectors: language communication (oral text), and in registering preferences, opinions and user stances [2].

The main purpose of this research activity is the analysis of emotional state (personal satisfaction) and the investigation of the standards that connect the user’s Satisfaction by use of oral text (as the basis for the situation) in the basic dipole (Fig.1):

![Figure 1. Dipole of research activities](image)

Personal (subjective) satisfaction is a difficult measuring factor. Usability dimension gains significant importance in educational learning environments where the participation motive is a given. For these reasons, we use a mixed technique by using a language dimension (sentiment analysis) with traditional methods (qualitative, quantitative), verifying measurements can be accomplished in order to extract safer conclusions.
III. PROPOSED RESEARCH FRAMEWORK

A. Methodology

The suggested research framework is a combination of qualitative – quantitative methodology on one hand and use of sentiment/opinion analysis (Natural Language Processing-NLP) on the other. The main elements of the proposed research framework include:

(a) Registration and interpretation of user emotional states,
(b) Speech recording and lexical analysis (sentiment/opinion analysis),
(c) Usability testing procedures and
(d) Wrap-up interviews.

The proposed participants are officers in the Merchant Navy (university graduates), and the rest crew of ship they have been certified in short training (by standard STCW).

The research purpose is defined in detecting, recognizing and interpreting the emotional information (satisfaction) in conjunction with other information (usability assessment) created during the execution of a scenario in an e-learning marine system (simulators or training software).

The experiment research process will include the following stages (Fig.2):

- **Stage 1**: Information about the experiment, Presentation of the acceptance document by the user-trainee.
- **Stage 2**: Completion of a user’s profile and of the assessment survey concerning educational and technical characteristics (questionnaire) by the trainee.
- **Stage 3**: Scenario execution in software.
- **Stage 4**: Completion of the process (Scenario) through a semi structured interview & questionnaire with the user.

![Figure 2. The Experiment research process](image)

B. Data Collection Tools

The detection of suggested research framework information will be realized using the questionnaires, interview and speech recording and tested tool ([10],[18],[19],[20],[21])(Fig. 3):

- **QUP-Questionnaire User Profile**: it contains: a personal profile (gender, age), personal background (education, experience and place of work) etc.
- **ST-Speech Tool**: Use of a microphone for speech recording of spoken words (speech-text). This executes the speech recording (1 file) of the user where the user explains how he/she feels (satisfaction) and why (.WAV type file).
- **AQ – Appraisal Questionnaire**: it registration view/viewpoint/ attitude data by using a questionnaire.
- **SUS-System Usability Scale tool**: The System Usability Scale (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. The SU scale is generally used after the respondent has had an opportunity to use the system being evaluated, but before any debriefing or discussion takes place. Respondents should be asked to record their immediate response to each item, rather than thinking about items for a long time. The SUS scores have a range of 0 to 100 (Tab. I).

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

TABLE I.

**SYSTEM USABILITY SCALE – (DEC. 1986)**
C. Satisfaction Levels

The phenomenon of the subjective satisfaction of the user is the ultimate goal (Fig.4).

![Diagram](image)

**Figure 3. Research procedure by using the Data Collections Tools**

**Figure 4. Structural vision of the users-students “subjective satisfaction” phenomenon**

It is complicated in its nature as it is affected by many factors varying from situation to situation and from individual to individual. The ultimate goal is to find an average, concerning the maritime education and training and any special factors concerning: the education suitability (maritime education models), the ability to simulate the functional abilities regarding the actual marine environment, the realism of situations in correspondence with the real-time situations, the controlled functional environment, the satisfactory interface for the users and the ability to conduct full-time system control by the educator-trainer. The proposed satisfaction scale shows the next figure:

![Table](image)

**Figure 5. Satisfaction Scale**

From this climax, we develop the next satisfaction levels (Fig.6):

![Diagram](image)

**Figure 6. The Satisfaction Levels**

D. Lexical Data Collection

Before data processing and analysis are initiated, we proceed with the data storing and cleansing process in the following three steps:

- **1st**: manually store the data’s interview (satisfaction view every user).
- **2nd**: manually create table SAT_DATA REGISTRATION (Fig.7).
- **3rd**: manually follow the data cleansing methodology (throw out noise data from the data’s interview: text without semantic load with sentiment or opinion content).

<table>
<thead>
<tr>
<th>Int No.</th>
<th>P+ (mdf)</th>
<th>Vol1 (comp)</th>
<th>Pol+</th>
<th>Pol-</th>
<th>P_r (mdf)</th>
<th>Tot Nw</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Interview No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Interview Point (Scenario user view, Software user view)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Volume of sentiment load by using modifier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Volume of sentiment load by using comparison degree (Positive, Comparative, Superlative)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Lexical phrase or word with sentiment load (positive or negative polarity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Topology of sentiment phrases in text: 1 in first ½ of text, 2 in second ½ of text, 0 homogeneity in all text (interview)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Total Words</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 7. Structure of SAT_DATA REGISTRATION table**

E. Text Sentiment/Opinion Process

The semantic orientation based in a Lexicon Base (LB) (Fig.8). This approach based a Greek Lexicon of Emotions (“ANTILEXICON”) [22]. Suppose the follow parameters for sentiment/opinion processing:

\[
\text{IndW}_+ = \frac{\sum W_{S+}}{\text{TotNw}}
\]

\[
\text{IndW}_- = \frac{\sum W_{S-}}{\text{TotNw}}
\]

\[
W_{S+} = \sum W
\]

\[
W_{S-} = \sum W
\]

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

![Diagram](image)

**Figure 8. Sentiment process**
IV. CASE STUDY

A. Objects

The experimental procedure presented here is a primary effort to research the satisfaction phenomenon of the users-students in e-navigation ship’s bridge environment ECDIS by using a combination of qualitative – quantitative techniques with sentiment/opinion analysis. Especially the case study aims the following:

- the evaluation of the user satisfaction from using the ECDIS and scenario and
- educational evaluation of ECDIS from the user’s point of view (opinions).

The “Goals” of ECDIS are set as “to plan and display the ship’s route for the intended voyage and to plot and monitor positions throughout voyage” based on SOLAS V/19.2.1.4 [23].

B. Participants

The first (random) sampling was carried out on the January 2012 until May 2012, in the Information Technologies Laboratory of the National Marine Training Centre of Piraeus. 31 Marine officers were used as the experiment subjects; they underwent a specific procedure in the ECDIS Lab room with video recording of ~23 minutes per student. They then completed the questionnaires and were interviewed following the research methodology framework.

C. Data Analysis

The data of experiment (ECDIS) come from three sources (by using SPSS, Excel):

- questionnaires,
- SUS Tool and
- Interview (speech recording).

The sample’s profile as shown in Table II, prevail the younger, and the C’ Officer order.

<table>
<thead>
<tr>
<th>Marine Officers</th>
<th>Male (29)</th>
<th>Female (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age’s scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-35 years</td>
<td>16 (51.6%)</td>
<td>2 (6.45%)</td>
</tr>
<tr>
<td>36-45 years</td>
<td>6 (19.3%)</td>
<td>0</td>
</tr>
<tr>
<td>&gt;45 years</td>
<td>7 (22.5%)</td>
<td>0</td>
</tr>
<tr>
<td>Officer order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A’</td>
<td>13 (41.9%)</td>
<td>0</td>
</tr>
<tr>
<td>B’</td>
<td>4 (12.9%)</td>
<td>0</td>
</tr>
<tr>
<td>C’</td>
<td>12 (38.7%)</td>
<td>2 (6.45%)</td>
</tr>
</tbody>
</table>

The next tables show the results of training program evaluation (Tab.III) and ECDIS as software educational tool (Tab.IV).

The next table shows the allocation of the satisfaction (31 users responded to the interview) in a 5th scale about the Scenario & ECDIS software used by the users in their answers (extensive breadth scale in order to cover all possible user choices – breadth of choices). The majority of answers is in the top (2-1) of the scale (87.1% scenario, 90.3% ECDIS software).

<table>
<thead>
<tr>
<th>Marine Officers</th>
<th>Total Assessment</th>
<th>Time Schedule</th>
<th>Educational Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation scale</td>
<td>Very high</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>15 (48.3%)</td>
<td>7 (22.6%)</td>
<td>6 (19.3%)</td>
</tr>
<tr>
<td></td>
<td>(58.06%)</td>
<td>(22.6%)</td>
<td>(12.9%)</td>
</tr>
<tr>
<td></td>
<td>(61.25%)</td>
<td>(3.22%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31 (100%)</td>
<td>31 (100%)</td>
<td>31 (100%)</td>
</tr>
</tbody>
</table>

The following table and figure show the allocation of the satisfaction in Satisfaction levels (proposed research framework) for Scenario and ECDIS software.

<table>
<thead>
<tr>
<th>Marine Officers</th>
<th>ECDIS Software</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction scale</td>
<td>Very high</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>13 (41.9%)</td>
<td>15 (48.4%)</td>
</tr>
<tr>
<td></td>
<td>(38.7%)</td>
<td>(48.4%)</td>
</tr>
<tr>
<td></td>
<td>31 (100%)</td>
<td>31 (100%)</td>
</tr>
</tbody>
</table>

TABLE II. STRUCTURE OF STUDENT’S SAMPLE

TABLE III. TRAINING PROGRAM EVALUATION

<table>
<thead>
<tr>
<th>Marine Officers</th>
<th>ECDIS</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction scale</td>
<td>Very high</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>13 (41.9%)</td>
<td>15 (48.4%)</td>
</tr>
<tr>
<td></td>
<td>(38.7%)</td>
<td>(48.4%)</td>
</tr>
<tr>
<td></td>
<td>31 (100%)</td>
<td>31 (100%)</td>
</tr>
</tbody>
</table>

TABLE IV. ECDIS SOFTWARE EVALUATION

TABLE V. SATISFACTION SCALE EVALUATION

TABLE VI. SATISFACTION LEVEL EVALUATION
The following table is observed the results from usability assessment Tool (SUS):

<table>
<thead>
<tr>
<th>SUS score</th>
<th>ECDIS Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUS Level</td>
<td>(80-100 score)</td>
</tr>
<tr>
<td>High</td>
<td>12 (38.7%)</td>
</tr>
<tr>
<td>Satisfactory rating (60-79 score)</td>
<td>13 (41.9%)</td>
</tr>
<tr>
<td>Low usability (&lt;60 score)</td>
<td>6 (19.3%)</td>
</tr>
<tr>
<td>Total</td>
<td>31 (100%)</td>
</tr>
</tbody>
</table>
The most used phrase in user’s answers has this format:

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

We used Spearman correlation and found **negative correlation** (moderate, with strong significance) between IndW[scenario], \( P_{TOP} \) ECDIS, **positive correlation** (moderate, with strong significance) \( P_{TOP} \) ECDIS -- \( P_{TOP} \) Scenario & **negative weak correlation** between \( P_{TOP} \) Scenario -- IndW[scenario].\( _s \) (Tab. XII).

### TABLE XII. LEXICAL VARIABLES CORRELATION

<table>
<thead>
<tr>
<th>Variables correlation</th>
<th>Spearman’s ( \rho )</th>
<th>Stg. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( IndW_s ), (scenario) - ( P_{TOP} ) Scenario</td>
<td>-.371</td>
<td>.04</td>
</tr>
<tr>
<td>( IndW_s ), (scenario) - ( P_{TOP} ) ECDIS</td>
<td>-.559</td>
<td>.001</td>
</tr>
<tr>
<td>( P_{TOP} ) ECDIS - ( P_{TOP} ) Scenario</td>
<td>.404</td>
<td>.024</td>
</tr>
</tbody>
</table>

The main purpose of this research, is the investigation of satisfaction of a user of maritime education equipment (ECDIS, EMS, etc.) via the assistance of linguistic techniques but also other traditional methods (questionnaires-interviews).

More specifically in Maritime Education (ME) follow certain education standards (STCW’95) 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, management the engine etc.) as well as protecting the ship and crew (safety issues and environment protection issues). Specifically, the STCW’95 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 ([24],[25]).

The paper argues for the necessity of a mixed framework to usability & educational evaluation at the maritime interactive systems and proposes a generic, but practical framework for this purpose. The main elements of the proposed framework include: speech recording for sentiment/opinion analysis, Usability testing procedure (SUS), Attitudes/views questionnaires. The results are shows:

- In sentiment/opinion analysis, we observe the total word of answer’s users depending from satisfaction (growing the sum of Total words from low \( \rightarrow \) very high satisfaction) in Scenario & ECDIS satisfaction.
- The Mdf words (Mean Mdf, using Mdf) depending from satisfaction (growing from low \( \rightarrow \) very high satisfaction) in Scenario & ECDIS satisfaction.
- The Topology (\( P_{TOP} \)) for sentiment phrases in user’s answers has value 0 (extending all the answer).
- The most used word in sentiment phrases is "αρκετά (enough)" (ECDIS & Scenario satisfaction form user’s answers) and the most used phrase in user’s answers has this format: (mdf | auxiliary verb) + satisfied (verb).
- Relation (positive or negative) between lexical parameters (IndW[scenario], \( P_{TOP} \) ECDIS,\( _s \) \( P_{TOP} \) Scenario). |


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