Emotion Evaluation of Simulation Systems in Educational Practice

D. Papachristos¹, K. Alafodimos¹ and N. Nikitakos²
¹ TEI of Piraeus, Department of Automation, Aigaleo, Greece
² University of Aegean, Department Shipping, Trade and Transport, Chios, Greece

Abstract—The paper argues for the necessity of a mixed approach (biometric tools, sentiment analysis, qualitative techniques) to satisfaction evaluation of the users-students in the Marine Education and proposes a generic, but practical research protocol for this purpose. The proposed approach concerns the satisfaction evaluation of marine simulation systems and combines the biometric tools of gaze tracking & speech recording for measuring emotional user responses with usability testing. The ultimate goal of this research is to find and test the critical factors that influence the satisfaction of students and usability acceptance. The experimental procedure presented here is a primary effort to research the emotion analysis (satisfaction) of the users-students in marine simulating environments.

Index Terms—evaluation, satisfaction, gaze tracking, marine education.

I. INTRODUCTION

Investigation and analysis of the emotional state of an electronic learning marine 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 emotional computation. The present analysis focuses in the presentation of a specialized research protocol. The focus of the protocol is in three sectors: head movement & eye/gaze tracking, language communication (oral text), and in registering preferences, opinions and user stances.

The main purpose of this research activity is the analysis of emotional state and the investigation of the standards that connect the user’s Satisfaction-Happiness by use of the eye-head movement & oral text (as the basis for the situation) in the basic dipole:

![Dipole of research activities](Image)

Moreover, it’s also the user satisfaction evaluation as far as the electronic learning marine systems and the scenario-exercises (benefits, usability). The information and conclusions from such an investigational process, we suppose, can offer new investigative data in the fields it crosses by connecting morphological characteristics, visual system and language center, as far as the human brain is concerned, with learning processes and especially new educational frameworks as are those for the application of Information and Communication Technologies (ICT) in the sphere of human emotions.

II. REVIEW

International bibliography provides many sources on the Eye-tracking research in education [1]. For instance, Schiessl et al., used an eye-tracker to investigate gender interfaces in attention behavior for textual vs. pretorial stimuli on websites [2]. An investigate outcome was that, when the participants were asked where in the interface they thought they looked their perceptions often differed from reality, showing that accurate attention patterns could only be found with an eye-tracker. Salvucci and Anderson applied these ideas to design IGO (Intelligent Gaze-added Operating system), a system that allows users to use their eyes to perform interface operations such as opening, closing and dragging windows [3]. Sibert et al., describe the use of gaze trucking to assess reading performance in the Reading Assistant, a system for automated reading remediation that provides visual and auditory cues if user gaze patterns indicate difficulties in reading a word [4]. Gluck and Anderson studied the use of eye-tracking to assess student problem-solving behaviors within the PAT Algebra I tutor, including attention shifts, disambiguation of problem statements and errors, processing of error messages and other information critical to problem solving [5].

In the field of learning and instruction, eye tracking used to be applied primarily in reading research with only a few exceptions in other areas such as text and picture comprehension and problem solving. However, this has changed over the last years, eye-tracking is starting to be applied more often, especially in studies on multimedia learning. Because eye tracking provides insights in the allocation of visual attention, it is very suited to study differences in intentional processes evoked by different types of multimedia and multi-representational learning materials [1].

In the international bibliography one can find a thorough research on the factors that involve in the students satisfaction [1]. Aldridge and Rowley articulate that according to students’ point, good quality education provides better learning opportunities and suggest that the
levels of satisfaction strongly affect the students’ success or failure of learning [6]. Numerous studies have been conducted to measure the student satisfaction at university level in developed part of the world. Various factors have been identified that can potentially affect the student satisfaction to different education services provided by the universities. Others researchers examined that both positive and negative emotions and cognitive component satisfaction correlate with student loyalty and that affective component of satisfaction serves as a better predictor than cognitive factor. Additionally, others studied the student overall impression of the quality of the education, teachers expertise and their interest in their subject, the quality and accessibility of IT facilities and the prospects of the degree furthering students careers were the most influential predictors of the students satisfaction [1]. Lin found after one-year exploratory study that hybrid course has the potential of bringing the best ends of two worlds together (online education, traditional education-face to face) through its possibility of meeting diverse learning needs with its multiple modes of delivery. Student learning could increase when the instructor provided learning environments not only in a traditional classroom, but in the web (interaction student with other students, student – instructor). The results suggested high level of satisfaction but also revealed several important issues and complexities involving hybrid course implementation [7]. Finally, most researchers failed to find statistically significant differences between online and traditional course performance [1].

III. BACKGROUND

In the investigative field of psychology, the use of the English word 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 [8].

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 (Fig. 2).

The simplest and more widely spread form of emotional states’ representation is that of categorization. There are various categorization sets such as: (a) Basic emotion categories, (b) daily emotions – labels characterizing and grouping emotions, (c) categories related to a particular application or those that have a particular concept context, and (d) categories describing wide emotional experiences, such as moods and preferences [8].

Many psychologists have claimed that the only way to interpret the totality of emotions is to suggest that there is a common evolotional base in the development of facial emotional expressions. But the biological approach cannot explain all the facets of a human’s emotional behavior [9]. While certain facial expressions are innate, some others are not innate nor are they global. This approach also cannot explain the mental processes that might represent states in the natural and social environment. There is a theoretical approach that seem to describe more realistically the human emotion creation. This was derived by the experiment of Schachter & Singer, and is the theory of two factors (Fig. 3).

According to this, environmental facts activate at the same time body stimulation and cognitive assessment of these events’ framework ([10],[11]).

During the last 25 years, psychology focuses again in the sequence of events involved in the creation” of an emotion. Zajonic considers that experiencing an emotion happens often before we have the time to assess it, while contrarily, Lazarous considers that the thought precedes the emotional experience, assessing that instantaneous cognitive assessments of situations can happen at the same time alongside the emotional experience ([12],[13]).

The speed with which we assess a situation is influenced by our previous experiences. The age scale also seems to influence the creation of emotions. It must be noted that there are also emotions that do not require cognitive processes (thought). For example, loud noises or seeing a snake. Such emotional reactions can be important for the
survival of the species and are related to certain stereotypical facial expressions which have global meaning [9].

Also, another 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 [14]. 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 [9].

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 expressions, (d) action tendencies, (e) subjective feelings, and (f) emotion regulation [15].

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 ([16],[17],[18]). 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 [19].

The optical perception includes the stimulant’s natural reception from the external world and the process/explanation of that stimulant. The observation of eye movement, as well as the pupil movement, is an established method in many years now and the technological developments in both material equipment and software, made it more viable as a practicality measurement approach [20]. The eyes’ movements are supposed to depict the level of the cognitive process a screen demands and consequently the level of facility or difficulty of its process. Usually, the optical measurement concentrates on the following: the eyes’ focus points, the eyes’ movement patterns and the pupil’s alterations. The measurement targets are the computer screen areas definition, easy or difficult to understand. In particular the eyes movement measurements focus on attention spots, where the eyes remain steady for a while, and on quick movement areas, where the eye moves quickly from one point of interest to another. The measurement methodology must fulfill all three requirements of the cognitive neuroscience (experiential verification, operational definition, repetition) and include data-tools: (a) Recording device: might include special glasses with the recording camera or a web camera, (b) Registration data process – analysis software and (c) data process software [20]. Moreover the research interest is focused in the interaction of gaze tracking during the presentation of information and content (internet) in a natural environment [21].

IV. PROPOSED RESEARCH PROTOCOL

The research purpose is defined in detecting, recognizing and interpreting the emotional information in conjunction with other information created during the execution of a scenario in an electronic learning marine system (simulators or training software). The emotional information comes from the user's emotional state before, during, and after the scenario/exercise. Its structure concerns the following sections:

(a) the mood/emotion before the scenario/exercise (oral text)
(b) Behavioral action (head movement, gaze) during the scenario and
(c) the emotional post-experience – satisfaction (oral text).

Measuring the emotional information will be realized using the following processes:

(a) Natural parameters' measurement: Movement parameters (head movement, gaze movement) and oral text as text and
(b) Registering user opinion/viewpoint/view.

The suggested protocol (Protocol Research of Affect Situation, PR-AS) is comprised by the following sections (Fig. 4): Influence Sector-IS: We suppose based on Action Tendency Theory (concern view) and on Practical Reasoning Theory by M. Bratman that there are possible
interactions (influences) in the user’s emotional state / satisfaction through intentions-desires-predisposition. This theoretical processing is characterized as a Framework for User’s Innate Stimuli. The influence’s department consists of the following measurements that take place before the scenario execution by way of questionnaires: (a) profile (learning-medical), (b) personality, (c) expectations-interesting and (d) personal background (education, professional experience, computer using) ([22],[23]).

**Emotion Measurement Sector – EMS**: The emotional analysis theories based on measurement process concern the meta-experience of the emotional state, either during measurement before the experiment (mood before the educational act) or after the experiment (sensation/view/opinion/stance). Measurements concerns the happiness-sad (emotion-mood) in combination with the degree of activation-assessment by the user within the framework of this dipole, i.e. the measurement of dynamics in relation to the stimuli (sound, animation, schemas, etc) received in total by the software-scenario (virtual relationship) considering that the user is always on a core emotional state (core affect) and the specific satisfaction for the scenario and software (evaluation process of the educational use for the software and scenario/exercise to the degree of satisfaction of the trainee-user) adopted by the Oatley approach that the (personal) goals have been achieved there is a sense of joy, while failures if followed by sadness and despair and is connected with the emotion of satisfaction ([24],[25]). At the same time the natural parameters comprising the protocol’s core are registered. These are the visual (head movement, gaze tracking) and voice recording (emotional reasoning). This is based on the use of tools for recording head movement (distance from the monitor, left-right head movement, left-right head rolling), gaze tracking (x,y coordinates) and voice recording (as reasoning of meta-emotional experience – lexicalization of emotional gravity). Additionally, the researcher records observations related to the physiological and non-physiological attitude of the user (mistakes, time of execution, execution success, the user’s psychological state).

**Appraisal sector – AS**: In this section, the Satisfaction recording takes place but also commenting related to the day when measurement is taking place & in total up to that moment, as far as the software tool is concerned, after the experimental conduct of the scenario/exercise (usability), personal self-evaluation, scenario evaluation (benefits) in combination with the weighed usability measurement tool (DEC SUS Tool) ([26],[27]).

Modeling every single emotional information through opinion/viewpoint/stance recording can be represented by the m-dimension vector where m represents the intensity (user responses), which are depicted with a value in the field of values (VF-Value Field). VF differs based on the collection tools’ structure [8]:

(a) **Binary range** [0,1], where 0 corresponds to lack of a particular emotion, while 1 represents the maximum emotional intensity.

(b) **Multitude range** [-2, 1, 0, 1, 2] where there is scaling according to the intensity of each emotion.

(c) **Hybrid model** (combination of the prior two choices).

\[
\text{AFS} = \text{em}(h, s) + \text{mf}(h, s) \cdot \text{VF}
\]

for

\[
\text{mf}(h, s) = \text{VF}
\]

\[
\text{em}(h, s) = \text{VF}
\]

\[
\text{VF} : \text{active} \rightarrow h : [2,1], s : [-1,-2].
\]

\[
\text{VF} : \text{no active} \rightarrow h : [0], s : [0].
\]

and

\[
\text{Ifl} = \{ \text{pr} (\text{inf}), \text{p} (\text{v}), \text{pb} (\text{inf}), \text{ex} (\text{inf}), \text{ev} (\text{g}) \}.
\]

The aforementioned modeling concerns recorded information/opinions/viewpoints/stances and not the natural parameters. Natural parameters (along with the researcher’s remarks) can be modeled as follows (VA-Visual attention, p;optical parameters, Why_lec;
photonically recording, \( fW\text{-word} \): weight factor per word, \( el\$: data of observer):

\[
VA = \{pi\}
\]

(7)

\[
Whylex = \sum_n fW - \text{word}
\]

(8)

\[
Obs$ = [el\$]
\]

(9)

Data processing concerns the composition of all the above mentioned relationships so that patterns of the natural parameters in relation to emotional states (happiness) and Satisfaction Scale can be found (Fig. 5).

\[
\text{Hypo}_1: \text{Detecting emotional information (Happiness/Satisfaction) by use of non conventional means (combination of language/oral word through head movement/gaze tracking): } \text{There is an assigned relationship between the emotional state to the eye \& head movement or meta-emotional experience via spoken words?}
\]

\[
\text{Hypo}_2: \text{Recognizing an emotional state – user satisfaction by relating natural parameters \& recordings by the users of information/opinions/viewpoints (Affects, Evaluation): } \text{There is a relation between the user influence and the user satisfaction by the software \& the scenario as well as the emotional exercise experience?}
\]

\[
\text{Hypo}_3: \text{Interconnection of all of the above in relation to Marine Education and Training (regulations, standards etc): The use of new technologies in marine education \& training, according to the user, is beneficial?}
\]

\[
\text{HypoPR} - \text{AS} = \sum_3 \text{Hypo}
\]

(10)

The interpretation of the PR-AS research results will be realized using the framework of the research hypotheses (Hypo PR-AS).

V. TOOLS

The detection of emotional information will be realized using the Technical \& Theoretical Tools (Fig.6):

\textit{Tool-1 (T1)}: In the protocol the optical data registration will be conducted by the “Face Analysis” software that was developed by the IVML Lab of the National Technical University of Athens, in connection with a Web camera set on the computer in which there is the subject of the research (educational software \& MATLAB). That particular software records a large number of variables but we focus on the following parameters that refer to the user’s eyes and head movement: (a) eyes movement: vertical \& horizontal eye movements (Eye gaze vector), (b) user’s head position in regard to the eyes up/down – right/left movement (Head Pose Vector: pitch, yaw), (c) eye distance from the computer screen (Dist_monitor) and (d) rolling of the head (eye angle from a horizontal level) [28].

\textit{Tool-2 (T2)}: Use of a microphone for voice recording of spoken words (speech-text). This will be used for the registration of 3 temporal marks: (a) First Point (T_a) - the temporal mark before recording for measuring mood. This executes the voice recording (1 file) of the user where the user explains how he/she feels and why, (b) Second Point (T_b) - a temporal mark after the recording for the measurement of mood-emotion after the recording. This executes the voice recording (1 file) of the user where the user explains how he/she feels and why and (c) Third Point (T_c) - a temporal mark after the recording where the satisfaction choices are justified (software, scenario). This executes the voice recording (1 file) of the user where the user explains how he/she feels and why. The voice recordings consisting of 3 .WAV type files will be analyzed further during the processing section in three dimensions: Lexicological (emotional analysis), Style analysis of linguistic characteristics, and Qualitative analysis of the spoken word so that the user emotional state/satisfaction can be justified [29].

\textit{Tool-3(T3)}: Questionnaires using for opinion/attitudes/expectation/self-evaluation. It concerns 3 questionnaires: (a) T3-A, influence data, (b) T3-B, mood, scenario label, recording data and (c) T3-C, User appraisal concerning software, scenario, educational environment, positive/negative points (string array), error administration, total assessment and suggestions (String array) in combination with the usability tool SUS ([26],[30]).
VI. DISCUSSION-CONCLUSIONS

The main purpose of the research via PR-AS is the investigation of satisfaction-happiness of a user of marine education equipment (engine-navigation simulators, ECDIS, MATLAB) via the assistance of biometric tools, language tools but also other traditional methods (questionnaires-interviews).

More specifically in Marine Education (ME), the use of neuroscientific methods & tools (biometric tools) is a useful contribution in its amelioration. ME follows 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, dexterity 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 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 ([31],[32]). 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.

Modern developments in educational technology come to influence the educational process through the introduction of modern educational software either by using it during teaching basic scientific knowledge or by using it in the simulation of basic functions on the ship & on safety problem management as well as on the environment safety. The introduction of simulators and other modern training tools constitutes an important research question on what degree it can fulfill all the expectations set forth by the STCW‘95. The user’s higher demands, the need for better education, the need to lessen human errors (restricting accidents) cause complexity in the modern educational tools, higher cost as well as greater time for their development [33]. But the question remains: Can modern tools be effective in learning and offer user satisfaction? The traditional assessment methods don’t offer “objective” assessments because they are based on “subjective” user and specialist answers. On the contrary, using the tools offered by neuroscience in the observance of physiological reactions offers more “objective” information with regards the reactions of the trainees during the use of educational software of any type (tutorial, simulator etc.) ([34],[35],[36]). Also the use of the language parameter in the investigation of satisfaction and more specifically the Greek language (focused in the Greek marine education and more widely for Greek marine force which is one of the 3 largest globally) offers one more important research factor that has wide consequences as far as the linguistic characteristic assessment is concerned for the detection of emotional information [34].

The suggested protocol focuses in the following dimensions of research work; (a) investigation of basic emotional state (happiness-sad) of a user of a marine system of electronic learning as far as the dipole happiness-sad through interaction, (b) investigation of the emotional state connection to satisfaction as far as the educational use of such systems is concerned, of training programs of scenario-exercises, (c) investigation of possible detection means for emotional states – physiological parameters in electronic learning environments (visual & language recording), and (d) interactions of all of the above with relation to Marine education and training (standards, etc.) [31].

A research providing an objective data registration on the user’s emotional state which affects any ability in problem solving and project execution procedures, poses an important challenge. In particular, by the use of biometric tools and neuroscience methods, the adult education level and more importantly the marine education is expanded, opening new horizons in the educational research within the new educational frame set up by the use of new technologies.

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**AUTHORS**

**D. Papachristos**, is a Technical and Laboratory assistant at the Technological Educational Institute of Piraeus (School of Engineering, Dept. of Automation Engineering) in Aigaleo, PO 12244, Greece (email: dmpapachristos@yahoo.gr).

**K. Alafodimos**, is a Professor at the Technological Educational Institute of Piraeus (School of Engineering, Department of Automation Engineering) in Aigaleo, Athens PO 12244, Greece (email: calafod@teipir.gr).

**N. Nikitakos**, is a Professor at the Department of Shipping, Trade and Transport in the University of Aegean, PO 82100, Chios, Greece (email: nnik@aegean.gr).

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