Virtual interactive e-learning application: an evaluation of a student satisfaction

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ABSTRACT

In a web-based learning environment, interactivity has been referred to as the most important element for successful e-learning. This article presents the production cycle of an interactive medical device, namely a virtual 3D Electroencephalogram, and the study conducted to measure the students' satisfaction of the learning application based on Kano's quality model. The web-based interactive learning application introduces unique elements of interactivity with the learning content, specifically designed to train students at the use of the medical device. The results of a student survey conducted post-deployment suggest that the visual and interactive features embedded in the application have the potential to induce positive satisfaction of users. The proposed approach may serve as reference for the correct design of similar learning applications not only in the health context but also outside the realms of medical sciences.

KEYWORDS
E-learning, Web-based interactive application, Learner satisfaction, Electroencephalogram, Kano's model

1. INTRODUCTION

The explosive growth of the Internet has been accompanied by rapid growth in e-services. E-learning, one type of e-services, has been one of the most significant recent developments in both schools and corporations. It provides convenience and flexibility with anytime and anywhere accessibility, enables users to access up-to-date knowledge, find solutions for their studies/work-related problems, contribute their experience and knowledge.

Nichols (2003) defines e-Learning as strictly being accessible using technological tools that are either web-based, web-distributed, or web-capable. Over the past decade, science educators have been engaged in experimental projects that focus on the integration of the Internet and the World Wide Web as an additional medium for teaching and learning (Barak & Dori 2004). According to Barak & Dori (2004) the Internet is used as a source of scientific data and theoretical information and among its many applications, the Web serves as a tool for integrating virtual models, creating learning communities and designing new learning environments. Horton (2000) states that rapidly increasing world population needs and gets education by using web based education on Internet. Key to the success of the Web based education lies in the presentation of information that integrates an appropriate media technique (imaging dataset, technical illustration, animation, interactivity) with best practices in learning. Web based education becomes more and more an important educational environment with the progress of Internet and computer technology and interactivity has been heralded by many as one of feature of this technology. Interactivity, as the tool of developing abilities and skills of the student, is certainly a suitable complement within an e−learning support of education and it is an important benefit of multimedia Web-based learning instruction. For web-based education, interactivity can be provided with animations, simulations, audios, videos and films. It can also be used to teach content in a way traditional teaching materials cannot—for example, animations of mechanisms and processes can help students visualize how systems work together. An interactive multimedia module can visually stimulate a student and transform learning into an active, engaging process.

It is important to note that interactivity enhances learning only when implemented correctly. In Learning and Training Innovations magazine, Will Thalheimer explains how interactivity enhances learning and how excessive use may hinder it (http://ltinewsline.com/). It should be noted that some scholars (Sun & Hsu 2012; Northrup 2002; Borsook &Higginbotham-Wheat 1991) have found that more interactivity may increase the complexity of the learning. When designed correctly, an interactive multimedia module allows students to (1) visualize difficult and naturally dynamic concepts, (2) promote active learning, problem-solving, and critical thinking with interactive simulations and virtual environments, (3) interact with the content with self-quizzes, and (4) access content anytime, anywhere, at any pace (Huang 2005).

This study is an effort to explore the effectiveness of a web-based interactive learning application developed by Politecnico di Torino. This educational tool, namely virtual 3D Electroencephalogram, has been developed to train students at the use of an Electroencephalogram. This learning application can bridge knowledge and expertise and become the interdisciplinary learning material for today's students. In fact today the students are more and more surrounded by technology (computers, chat, email, and the web) so, for them, it is natural to expect media techniques incorporated in the learning materials.

2. INTERACTIVITY IN THE CONTEXT

The impact of interactivity on the increase in the quality and didactic effectiveness, in learning outcomes within educational process has been proved by several empirical studies (Hannafin & Peck 1988; Mayer 2001; Mayer & Chandler 2001; Schwan & Riempp 2004; Tung & Deng 2006; Kay & Knaack (2009); Wang, Vaughn & Liu 2011). Moore (1989) believe that interactivity is one of the most important and fundamental factors that affects student learning and attitudes in multimedia Web-based learning environments. According to Kristof & Satran (1995), interactivity motivates users by providing clear guidance and options, giving users controls that allowed them to self-direct, and making the experience easy and intuitive. Interactive displays, for example, provide the opportunity to stop, rewind, and restart and this, from the memory demand viewpoint, produces less cognitive load in learners and should improve comprehension (Wang P-Y et al. 2011).

Salajan, Perschbacher, Cash, Talwar, El-Badrawy & Mount (2009), Barker (1994) and Sims (1997) state that interactivity in education is a necessary and fundamental mechanism for knowledge acquisition and the development of both cognitive and physical skills. Bransford & Brown (1999) discuss the importance of interactivity in the context of computer-based instruction, suggesting that ''Interactivity makes it easy for students to revisit specific parts of the environments to explore them more fully, to test ideas, and to receive feedback".

Tversky, Morrison & Betrancourt (2002) believe that interactivity can help overcome to overcome the difficulties of perception and comprehension during the learning process. Thurmond & Wambach (2004) state that interactivity as the result of information exchange with content, other learners, instructors, and media technology can enhance learner comprehension.

Interactivity is also defined as the degree to which participants in a communication process have control over, and can exchange roles in mutual discourses (Williams, Rice, & Rogers 1989).

Interactive pages in Web Based Educational models make easier to training course and by this way increase quality of education (Karahocaa, Duldaa, Karahocaa, Yücela, Gulluoglua & Arifoglua 2010). As result of greater flexibility provided by the internet, in many disciplines Web based educational models have been developed for distance learning by educational institutions and companies. In the medical or health sciences, fox example, several studies describe the development

and implementation of interactive 3D models and illustrates the potential advantages of using interactive technologies for instruction.
Nigel (2007) provides an useful survey of some of the three-dimensional web-based interactive applications for medical education developed between 1995 and 2005.
Gerdprasert, Pruksacheva, Panijpan & Ruenwongsa (2010) develop a web-based learning media on the process and mechanism of labour for the third-year university nursing and midwifery students. Supplementation with this learning unit made learning significantly more effective than the traditional lecture by itself.
Hall, Drab, Campbell, Meyer & Smith (2007) describe a web-based courseware on Diabetes Mellitus successfully used to teach pharmaceutical students.
Gallagher, Dobrosielski-Vergona, Wingard & Williams (2005) examine the effectiveness of web-based course for gerontology provided to the dental students and the results obtained in terms of greater motivation, learning success, and knowledge retention.
Suen (2005) shows how Web-based Teaching can be used to supplement classroom instruction in an epidemiology course and the results obtained in terms of more flexible, stimulating, convenient and creative atmosphere when compared to the traditional instruction.
Rouse (2000) compares the effectiveness of three instructional intervention strategies (computer-assisted instruction (CAI), traditional class room lecture (TCL) and the combination of CAI and TCL) for teaching nursing students about congenital heart disease (CHD). CAI and TCL, used together, show a significant improvement in student performance than when either strategy is used alone.
Jang, Hwang, Park, KimY.M. & Kim, M.J. (2005) examine the effects of a Web-based teaching method (versus a traditional lecture method) on undergraduate nursing students' learning of electrocardiography (ECG). The result are that Web-based ECG learning program appears to be effective in helping nursing students to interpret ECG recordings
Bata-Jone & Avery (2004) describe the evaluation of an online graduate pharmacology course and compare the student outcomes of this course with those in the face-to-face course taught simultaneously. The positive comments highlight the clarity of instructions and the amount of information provided on course Web sites.
In these and many similar examples, interactivity is presented as an attribute of learning environments that enhances the quality of educational materials and that can facilitate learning. However, at the same time Turčáni & Magdin (2012) cite Moreno & Mayer (2005) and Moreno & Valdez (2005) who point to the potential limitations. In fact, a high degree of interactivity of the system does not necessarily ensure a high degree of comprehension - cognitive load (Mareš, 2011).
Domagk, Schwartz & Plass (2010) state “that a closer review of the design of these studies shows that these results may simply reflect divergent approaches to what is meant by interactivity”.
Our definition focuses on the type of learner/system response according to the definition formulated by Domagk et al. (2010). They define interactivity in the context of computer-based multimedia learning as the reciprocal activity between a learner and a multimedia learning system, in which the [re]action of the learner is dependent upon the [re]- action of the system and vice versa. This definition emphasizes the dynamic relationship between the learner and the learning system.
The degree or pattern of interaction with which people interact with media is referred by the interactivity level. Levels of interactivity measure how users perceive or experience interactivity in context. Many researchers have highlighted that increased level of interaction result in increased motivation, positive attitudes towards learning, more learning performance (Teo, Oh, Liu & Wei 2003; Northrup 2001; Liaw 2008). So, interactivity is proved to be an essential factor for learning satisfaction and success (Sun & Hsu 2012; Ozkan & Koseler 2009; Hong, Lai, & Holton 2003; Arbaugh 2002; Berge 2000; Jiang & Ting 1998; Khan 2005; Levy 2007; Shee & Wang 2008). In addition satisfaction increases as well when learners consider the content and manipulation of the web based instruction system to be useful (Wang & Reeves 2006; Liaw 2008).

Several researchers considered learner’s perceived effectiveness as an important indicator of an effective learning system (Piccoli, Ahmad & Ives 2001; Webster & Hackley 1997; Dillon & Gunawardena 1995; Leidner & Jarvenpaa 1993; Islas, Pérez, Rodriguez, Paredes, Ávila, & Mendoza 2007; Kim & Lee 2007; Liaw, Huang, & Chen 2007; Volery & Lord 2000; Holsapple & Lee-Post 2006; Selim 2007; Sun, Tsai, Finger, Chen & Yeh 2008).
This article contributes to and expands the framework of research on and development of web-based interactive instruction and proposes an approach to evaluate the user satisfaction in this context basing on the learner’s perceived effectiveness.

3. METHODOLOGY

3.1. Description of the e-learning medical application

3.1.1. Learning/training objectives

In this paper the authors show the design and the implementation of an 3D interactive medical instrumentation. It was created to facilitate professional learning/ training of medical instrumentations for Biomedical Engineers (BME’s), Biomedical Equipment Technicians (BMET’s), and Medical Device Technology Teachers (MDTT’s). With the use of interactive technologies, this application was developed within the Leonardo da Vinci project WEBD (Web based training of biomedical specialists) whose partners are Gazi university, Aachen university and Politecnico di Torino (http://www.webd.gazi.edu.tr/about.html).
This web-based application incorporates dynamic animations, interactivity and visual design to stimulate the students, to promote learning by doing, to enhance learning by increasing the interest, attention, concentration and retention in the learning activity. It provides convenience and flexibility with anytime and anywhere accessibility: in this way students can train with the device, becoming familiar with the instrumentation even without having a real instrumentation to disposition.
This medical device mirrors the real life circumstances in which an electroencephalogram (EEG) procedure is rendered, imitating real patients, anatomic regions and sequence of tasks necessary to its functionality. The electroencephalogram is a test that measures and records the electrical activity of the brain. Special sensors (electrodes) are attached to the patient head and hooked by wires to a computer. The computer records the brain's electrical activity on the screen or on paper as wavy lines (http://www.nlm.nih.gov/medlineplus, http://www.webmd.com/default.htm). The EEG is a readily available test that provides evidence of how the brain functions over time. Certain conditions, such as seizures, can be seen by the changes in the normal pattern of the brain's electrical activity. It also is used to evaluate people who are having problems associated with brain function. These problems might include confusion, coma, tumors, long-term difficulties with thinking or memory, or weakening of specific parts of the body (such as weakness associated with a stroke).

3.1.2. Design and development of the application

The 3D interactive application was developed using Autodesk 3DS Max and Viewpoint Enliven (www.viewpoint.com). A 3D hospital-like room, the medical equipment and the Virtual Human were modeled in Autodesk 3DS Max and then, imported in Enliven to compile and create interactive 3D and streaming media for the Internet. Users can interact with the 3D device, can navigate around the virtual model, move it in the three dimensions, turn 3D object in many ways, creating or modifying point of views, zooming into or out of it as if they were in the physical world.
The virtual device is equipped with a sequence of task. It is as a guideline that gives to students the possibility to learn the functioning of the medical device (fig. 1). Following the guidelines of which is equipped with the device, the learners know the exact order in which press the buttons of the interactive device for its working.

Figure 1 – Virtual model with EEG device, VH and sequence of the tasks

The essential components of an EEG machine include electrodes, amplifiers, a computer control module and a display device (fig.2).

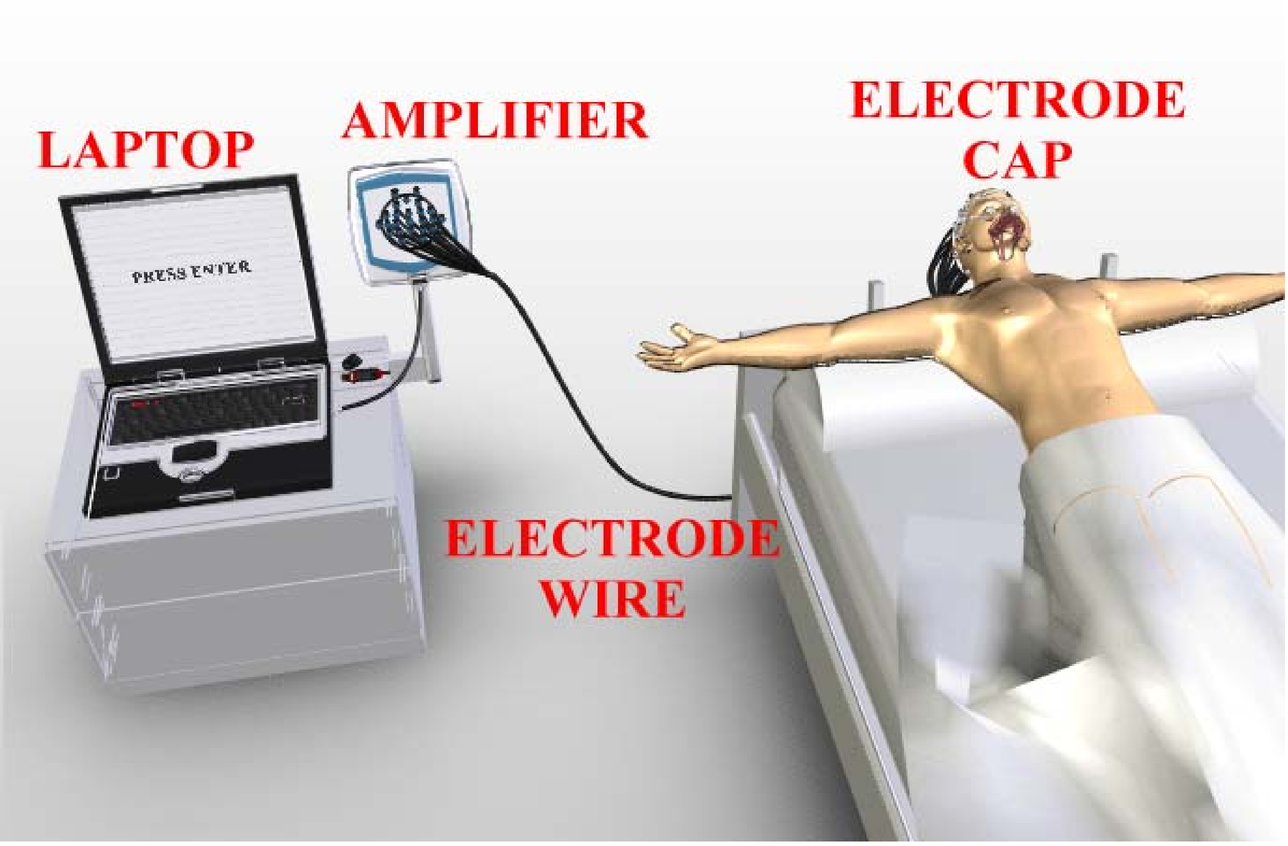

Figure 2. Essential components of an EEG machine and Virtual Human

An EEG measures brain waves through small button electrodes that are placed on the scalp. The patient lies down on the examining table or bed while eight to 20 electrodes are attached to his/her scalp or to an electrode cap in different places. In order to place the electrode, in our 3D model the user has to click the electrode wire (fig.3, fig.4, fig.5).

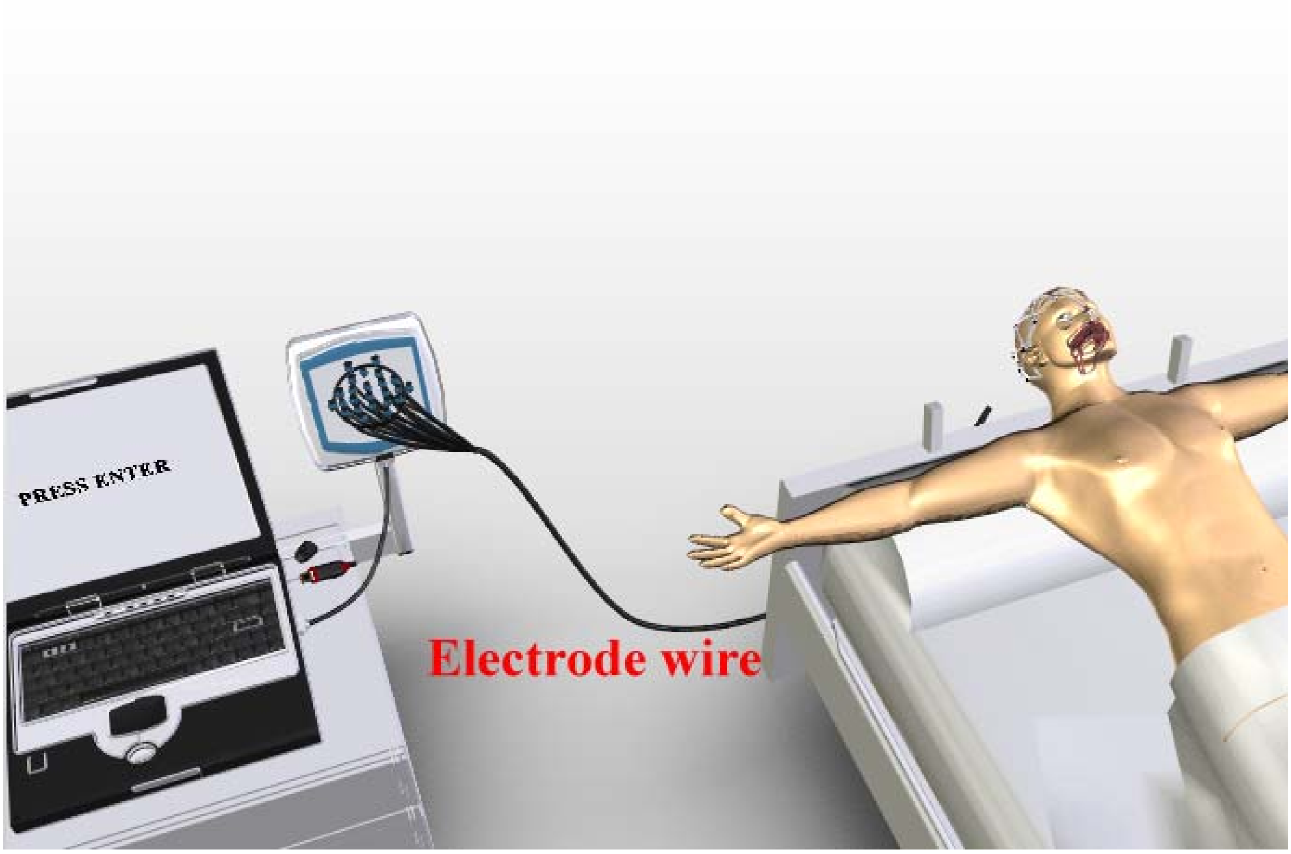

Figure 3. Electrode wire to click to place the electrodes on the scalp

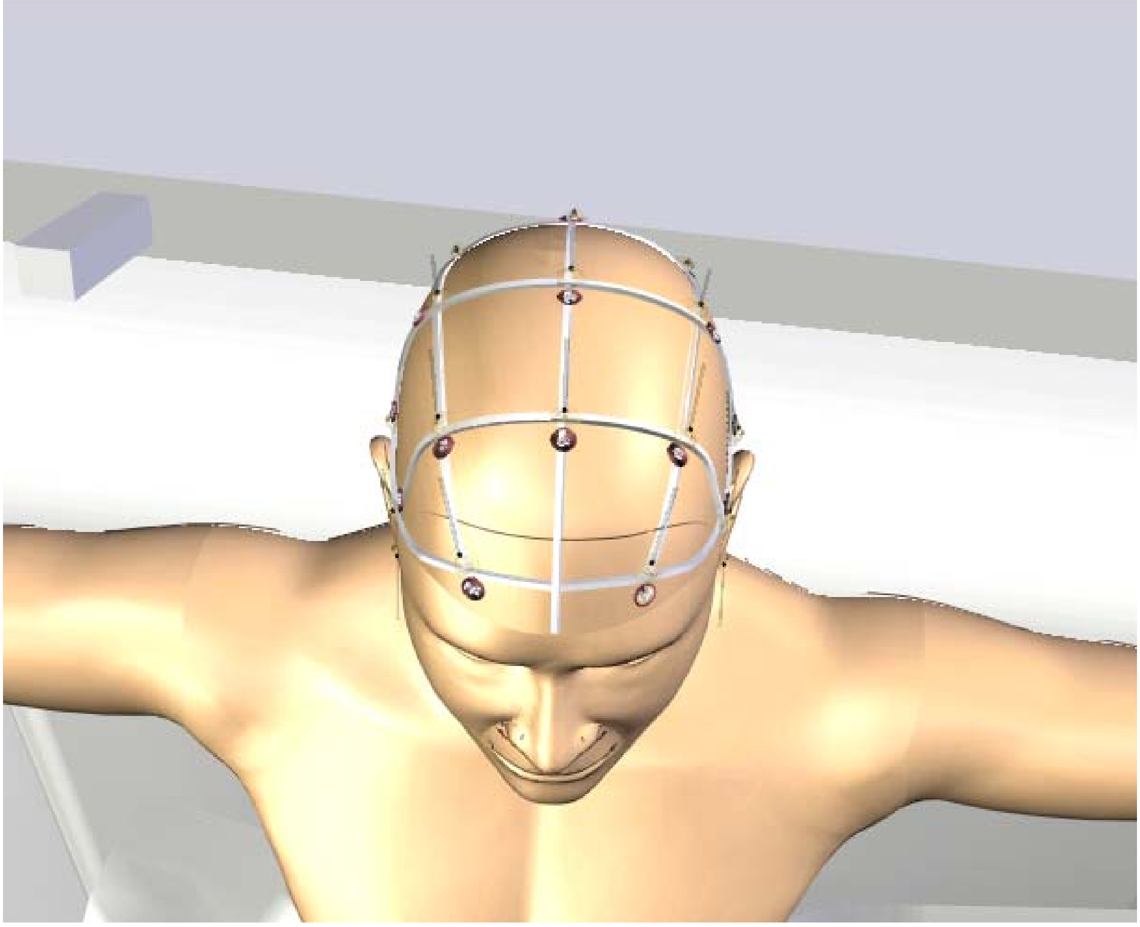

Figure 4. Patient scalp before the electrodes placement

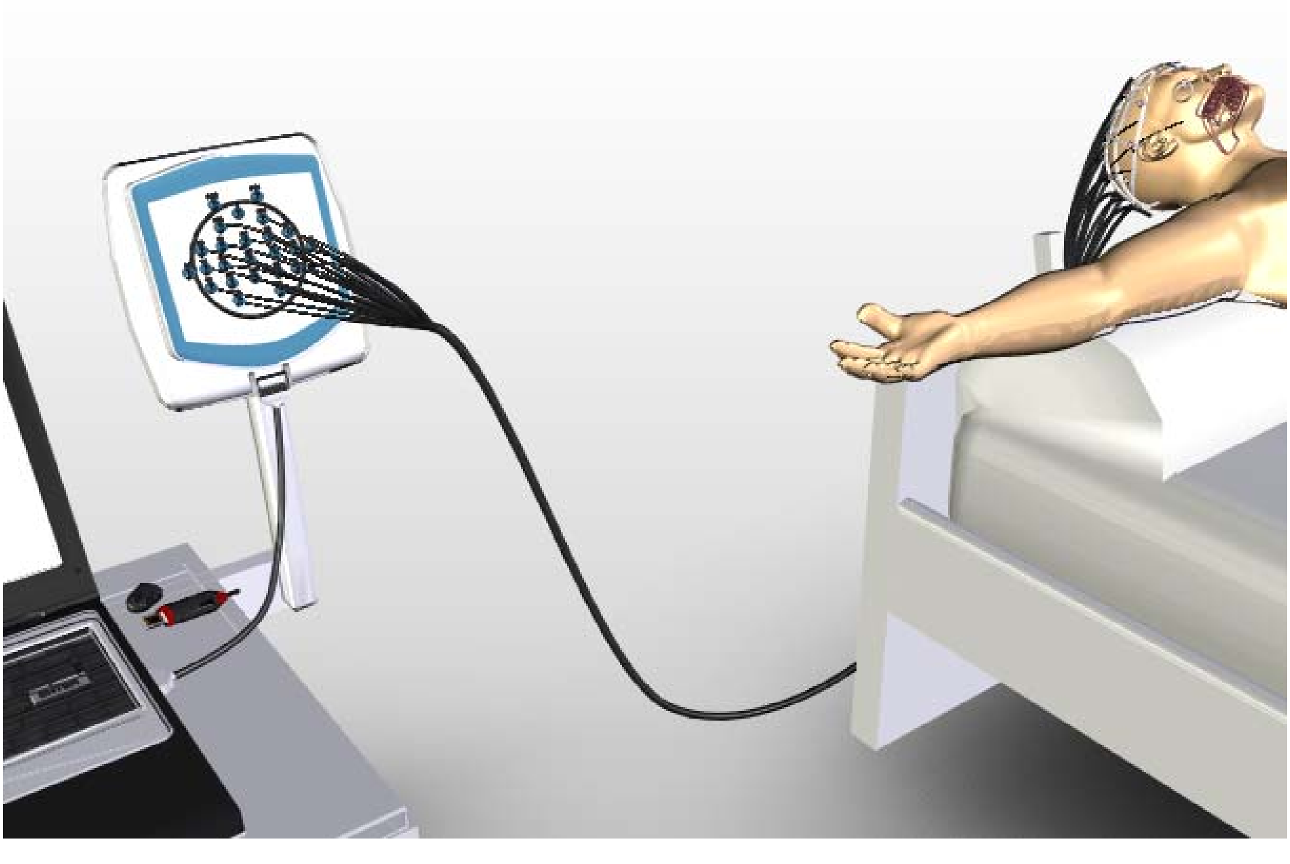

Figure 5. Patient scalp after the electrodes placement

The electrodes are connected by wires to an amplifier and a personal computer. In order to obtain this connection, in our 3D model it is necessary to click the amplifier (fig. 6). The EEG amplifiers convert the weak signals from the brain into a more discernable signal for the output device. They are differential amplifiers that are useful when measuring relatively low-level signals.

Figure 6. Electrodes connection to the amplifier

The output from the electrodes are recorded on a computer screen or drawn on a moving piece of graph paper. In either case, the electrical activity looks like a series of wavy lines.
Since the brain produces different signals at different points on the skull, multiple electrodes are used. The number of channels that an EEG machine has is related to the number of electrodes used. The more channels, the more detailed the brainwave picture. One pair of electrodes makes up a channel. EEG machines have anywhere from eight to 40 channels.
In our 3D virtual model, the selection of button “1” or the button “2” on the keyboard creates two different moving electrical activities that can be displayed on the monitor (fig.7, fig. 8, fig.9).

Figure 7. Channel selection by clicking “ENTER” on the keyboard

Figure 8. A 8 channel EEG recording

Figure 9. A 16 channel EEG recording

3.2 Introduction to Kano' s model

The evaluation of the effectiveness and success of e-learning systems are a critical issue in both practice and research. Several studies have shown that e-learning system usage and user satisfaction are considered the main determinants of information system (IS) success (Chen & Kuo 2011; DeLong & McLean 2003; Taylor & Todd 1995; Igbaria, Zinatelli, Cragg & Cvaye 1997; Seddon 1997; Gelderman 1998; Rai, Liang & Welker 2002; Chiu, Hsu, Sun, Lin & Sun 2005).
Increased satisfaction leads to increased usage, reduced user complaints, and thus improved individual performance (Chen & Kuo 2011; Patterson & Spreng 1997; Van Riel, Liljander & Jurriens 2001).
E-learning service quality provides a clear basis for e-learning service success. The authors propose an approach based on Kano' s model of customer satisfaction, used in the marketing context where customers compare their service expectation with what they perceived performance (Chen & Kuo 2011). In the e-learning context, students are compared to final customers since satisfaction with an educational product/service is one outcome of the exchanges between the e-learning systems and students (Chen & Kuo 2011; Wang 2003).
Matzler & Hinterhuber (1998) and Shen, Tan & Xie (2000) state that Kano's model has proved to be able to play an effective strategic role in determining the quality characteristic of a service. In the model, positive (functional) and negative (dysfunctional) questionnaires are conducted to collect the satisfaction difference per item from the interviewees, and to judge each item's quality

characteristic represented according to the “Kano’s evaluation form” (Table 1) proposed by Kano (1984).

Table 1. Kano’s evaluation form

Customer requirements → ↓		**Dysfunctional**				
Functional		*I like it*	*I expect it*	*I’m neutral*	*I can tolerate it*	*I dislike it*
	I like it	Questionable	Attractive	Attractive	Attractive	One-dimensional
	I expect it	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	I’m neutral	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	I can tolerate it	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	I dislike it	Reverse	Reverse	Reverse	Reverse	Questionable

The quality items (or attributes) are:

(1) Attractive quality: customer will be satisfied if this attribute present, but without dissatisfaction if absent. Attractive requirements are the product criteria which have the greatest influence on how satisfied a customer will be with a given product. Attractive requirements are neither explicitly expressed nor expected by the customer. Fulfilling these requirements leads to more than proportional satisfaction. If they are not met, however, there is no feeling of dissatisfaction.

(2) One-dimensional quality: customer satisfaction is proportional to the level of fulfilment: the higher the level of fulfilment, the higher the customer’s satisfaction, and vice versa. One-dimensional requirements are usually explicitly demanded by the customer.

(3) Must-be quality: this is the basic criteria of a product/service. If these requirements are not fulfilled, the customer will be extremely dissatisfied. On the other hand, as the customer takes these requirements for granted, their fulfilment will not increase his satisfaction. The customer regards the must-be requirements as prerequisites; he takes them for granted and therefore does not explicitly demand them. If they are not fulfilled, the customer will not be interested in the product, service or process at all

(4) Indifferent quality: an attribute whose presence or absence does not cause any customer satisfaction or dissatisfaction.

(5) Reverse quality: an attribute whose presence causes customer dissatisfaction, and whose absence results in customer satisfaction.

3.3 Customer satisfaction index

The procedure of Kano’s model classifies each quality items into one of the categories based on most the responses. However, many of the responses tended to be spread over several categories (A, O, M, and I). In this situation, a more differentiated interpretation is required. In order to find out which quality items can influence customer satisfaction, the customer satisfaction (CS) index is calculated (Berger et al., 1993). The CS index is indicative of how strongly a product feature may influence satisfaction or, in case of it “non-fulfilment” customer dissatisfaction.

The formulas to calculate the extents of satisfaction and of dissatisfaction are the following:

Extent of satisfaction: $$\frac{A+O}{A+O+M+I}$$

Extent of dissatisfaction: $$\frac{O+M}{(A+O+M+I)\cdot(-1)}$$

The extent of satisfaction (or positive CS index or Better value) ranges from 0 to 1; if the value is close to 1, it means that the feature has a positive effect on increasing user satisfaction while, when the extent of dissatisfaction (or negative CS index or Worse value) is close to - 1, it means that the feature can decrease user satisfaction.

4. RESULTS

As a first step towards the assessment of the interactive application developed at the Faculty of Engineering, the authors devised a study to gather information on the users satisfaction of the e-learning system. Users satisfaction of the E-learning system and the categorization of its quality features have been measured through Kano's questionnaire. The authors have developed this questionnaire taking their cue from the Wang's (2003) evaluation instrument on e-learning satisfaction (ELS) and the study of Chen and Kuo (2011) and Chen & Lin (2007). The questions were designed to investigate the perceived level of interactivity that the students experienced in using the application, the ease of use, the realism and enjoyment engendered by interacting with the application. In our analysis user satisfaction has been measured through three quality dimensions: learner interface, content, and personalization. The dimension of 'learner interface' considers the system interface quality: "ease of use", "user friendly", "realism", etc. The 'content' dimension is that e-learning application can provide well organised, well-structured, and understandable content. The dimension of 'personalisation' refers to users personal attention, understanding specific user needs.
The questionnaire was distributed to the students and staff (teachers and technician) of Faculty of Engineering who tested the application. The quality dimensions and the items of the examined e-learning application are shown in Table 2.

Table 2. Items of e-learning application satisfaction

Quality dimension	**Quality items**	
Learning interface (LI)	LI1	The application is easy to use
	LI2	The application has good flexibility (24h/24h, everywhere)
	LI3	The application is innovative
	LI4	The application doesn't require specific technical or medical ability in the use
	LI5	The application is only advisable for people with a lot of patience
	LI6	You must have a working internet connection to access the application
	LI7	In the application the navigation and exploration are facilitate (Click undo at any time to back-up a step; Left-click and drag to rotate the view; right-click and

		drag (or CTRL + left-click) to zoom; both-click and drag (or SHFT + left-click) to move the view within the window).
Content (CO)	CO1	The application provides content that exactly fitted your needs
	CO2	The application provides sufficient supporting materials (sequence of tasks) to help the users to understand the working of the medical instrumentation
	CO3	The application provides sufficient realism thanks to presence of virtual 3D objects
	CO4	The application's graphic depictions is accurate
	CO5	The application provides content with appropriate level of interactivity
Personalisation (PER)	PER1	The application enables you to acquire more easily the technical skills than in an equivalent training in the real environment
	PER2	The application is useful in helping you reinforce and/or expand your knowledge on the medical instrumentation
	PER3	The application enables you to become skilful at using of medical instrumentation
	PER4	The application stimulates the development of intellectual skills such as learning by doing
	PER5	The application enables you to familiarize with medical instrumentation in absence of real instrumentation
	PER6	The application increases the interest, attention and concentration in the learning activity and improves retention

In the questionnaire, each question has two parts: the functional form ("How do you feel if the item is present in the product?") and the Dysfunctional form ("How do you feel if that item is not present in the product?"). For each question, the student can answer in one of five different ways (1) I like it; (2) I expect it; (3) I am neutral; (4) I can tolerate it; (5) I dislike it.

By combining the two answers in the Kano evaluation table (Fig. 10), the e-learning application quality items can be classified into one of six categories: attractive quality (A), one-dimensional quality (O), must-be quality (M), indifferent quality (I), reverse quality (R), or questionable result (Q).

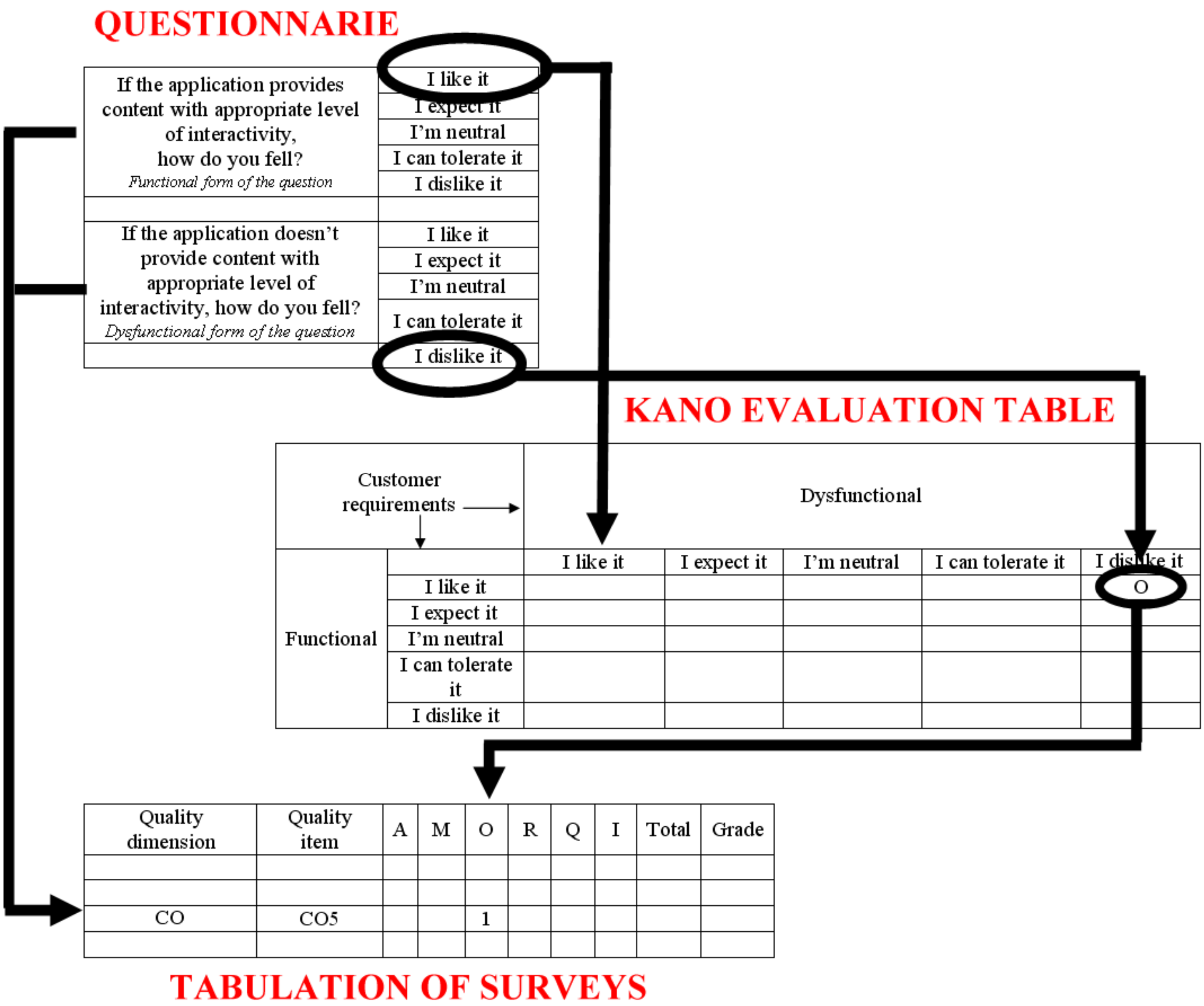

Figure 10. Looking up Questionnaire answers in evaluation table and tabulating the result

If the user answers, for example, "I like it" as regards "If the application provides content with an appropriate level of interactivity, how do you feel?" in the functional form of the question, and answers "I dislike it" as regards "If the application doesn't provide content with an appropriate level of interactivity, how do you feel?" in the dysfunctional form of the question, the combination of the questions in the Kano evaluation table finds an "O", indicating that level of interactivity in the e-learning's application is an One-dimensional quality item from the perspective of users.

If combining the answers yields category I, this means that the user is indifferent to this e-learning application quality item. The customer does not care whether it is present or not. The user is, moreover, not willing to spend more on this feature. Category Q stands for a questionable result. Normally, the answers do not fall into this category. Questionable scores signify that the question was phrased incorrectly, or that the person interviewed misunderstood the question or crossed out a wrong answer by mistake.

If looking up the answer in the evaluation table yields category R, this e-learning application quality item is not only not wanted by the customer but he/she even expects the reverse.

For each quality item, the classification is determined by the category having the highest response frequency. If two or more Kano Quality item frequency are the same for decision the quality category, we consider selecting the classification that would have the greatest impact on the product (use the following ordering: M>O>A>I). The results obtained by the analysis are shown in Table 3.

Table 3. Kano category for each quality item of the e-learning application

Quality dimension	**Quality items**		**Grade**
Learning interface (LI)	LI1	easy to use	O
	LI2	flexibility	O
	LI3	innovative	A
	LI4	not required technical or medical ability	A
	LI5	required patience	O
	LI6	working internet connection	I
	LI7	easy navigation and exploration	O
Content (CO)	CO1	the right content provided	O
	CO2	sufficient supporting materials provided	O
	CO3	realism	O
	CO4	graphic depiction	O
	CO5	interactivity	O
Personalisation (PER)	PER1	virtual training versus real training	A
	PER2	reinforce/expand knowledge	O
	PER3	skilful	M
	PER4	learning by doing	O
	PER5	familiarization	A
	PER6	interest, attention, concentration and retention	O

Note: A: Attractive; O: One-dimensional; M: Must be; I: Indifferent; R: Reverse; Q: Questionable

In our e-learning application, “easy navigation and exploration”, “interactivity”, “realism” are examples of One-dimensional qualities: the better they are, the more satisfied the student is, and vice versa. In the application the possibility to use the mouse to rotate, to zoom and to move the views and the presence of virtual interactive 3D objects are attributes that result in satisfaction when fulfilled and dissatisfaction when not fulfilled.

The “not required technical or medical ability” and “virtual training versus real training “ are examples of Attractive qualities: these features have unexpectedly delighted the users since they are attributes that were not normally expected by the users. This result shows that the application can be used also by people without specific medical knowledge. It enables to acquire more easily the technical skills necessary for the use of the device than in an real equivalent training with a significant time saving (because it is always accessible and available) and with costs saving (no real instrumentation is required).

Through the extents of satisfaction and dissatisfaction, this study also provides the best increase satisfaction items and the worse decrease satisfaction items to the e-learning application, as shown in Table 4.

Table 4. Results of Customer Satisfaction Index

Quality Items	**Extent of satisfaction**	**Extent of dissatisfaction**

LI1	easy to use	0,57	-0,90
LI2	flexibility	0,67	-0,90
LI3	innovative	0,97	-0,40
LI4	not required technical or medical ability	0,90	-0,50
LI5	required patience	0,43	-0,63
LI6	working internet connection	0,43	-0,47
LI7	easy navigation and exploration	0,80	-0,67
CO1	the right content provided	0,67	-0,63
CO2	sufficient supporting materials provided	0,50	-0,60
CO3	realism	0,77	-0,70
CO4	graphic depiction	0,60	-0,77
CO5	interactivity	0,73	-0,67
PER1	virtual training versus real training	0,90	-0,50
PER2	reinforce/expand knowledge	0,80	-0,63
PER3	skilful	0,53	-0,87
PER4	learning by doing	0,63	-0,47
PER5	familiarization	0,60	-0,47
PER6	interest, attention, concentration and retention	0,63	-0,53

In this table, it is possible to find how each feature can influence user satisfaction. If improvements in the e-learning application are achieved in terms of “innovative”, “not required technical or medical ability”, “the right content provided”, “virtual training versus real training”, and “reinforce/expand knowledge”, user satisfaction can be maximised. If improvements in the e-learning application are provided in terms of “easy to use”, “graphic depiction”, “skilful”, they can decrease user dissatisfaction markedly. While improvements in “easy navigation and exploration”, “realism”, “interactivity” not only can increase users’ satisfaction but also can decrease users’ dissatisfaction. This result can be used as a reference for a following development of the same application or for the design of the similar interactive learning applications.

5. CONCLUSIONS

In a typical learning environment, interactivity occurs when some aspect of the instruction prompts learners to respond with an answer or action. Interactivity has been referred to as the most important element for successful e-learning. Due to this reason, interactive instructional design is proved to be an essential factor for learning satisfaction and success. This study is an effort to explore the effectiveness of an interactive medical device, namely a virtual 3D Electroencephalogram. The features of the application allow the learners to manipulate content and interact more freely with the 3D device, to familiarize with medical instrumentation also in absence of real instrumentation and to acquire more easily the technical skills necessary to the use of the medical device than in an equivalent training in the real environment. The principles of interactivity built into the application may also be transferred to other subjects outside the realm of medical sciences or may serve as models for the design of similar applications. This study also measures the students' satisfaction of the learning application by means of Kano's model of customer satisfaction used in the marketing context. In this e-learning tool, students are compared to final customers since satisfaction with an educational product/service is one outcome of the exchanges between the e-learning systems and students. The results of the student survey conducted post-deployment suggest that the visual and interactive features embedded in the application have the potential to induce positive satisfaction of users. According to users, the application contains many elements of interactivity and virtual 3D objects that can be latently effective tools for the enhancement of learning of the specific tasks in the use of the medical device. So future process of design of similar applications or future re-design of this same tool will focus on improvements both in ease navigation and exploration of the applications as well as in the interactive and realistic features.

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