

# Usability test of an interface for human comfort learning tool

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**Abstract** - *A thermal human comfort model, for the estimation of the full time dependent temperature distribution in all human body parts, has been integrated into a computer interface in order to facilitate its current use. During the development stage, the interface has been tested using questionnaires, in order to optimize its usability as a learning tool for post-graduate studies. The questionnaires have been distributed to four different groups defined based on the academic level and thermal comfort knowledge of the individuals. Through a statistical analysis to the obtained data was possible to measure the user satisfaction as also to identify its more and less positive characteristics. Some of the results are presented in this paper.*

**Keywords:** Thermal Comfort; Usability Testing; Statistical Analysis, Learning Tools.

## 1 Introduction

In a computational way, the development of a graphical interface it is not a straightforward task. It must follow the ergonomics requests defined by the user. The usability in user-interface design is a quality intrinsic to the software. The user can 'surf' through the system with satisfaction and efficiency [1]. An interface can be functional and well conceded, however the evaluation of its usability can effect the acceptance of the software.

Human comfort has becoming a major challenge in developing new technologies, since human performance is strongly influenced by thermal comfort. In this category, one should include the comfort in working places, automotive and transportation technologies, active wear and protective clothing.

The thermal human comfort perception is mainly affected by heat and mass transfer processes between human body and his environment work place. In order to teach and to facilitate to follows this subject, in an undergraduate level, a thermal human comfort model has been incorporated in a computer interface. The model calculates the full time dependent temperature distribution in all human body parts [2].

## 2 Application

The model of thermo regulation of the body-clothing-environment system used in this work was an adaptation of an existed model [3]. The thermo model is defined by a set of ordinary differential equations includes the heat transfer phenomena. The human body is divided into 16 different parts. Each divided into three layers: core, shell and skin. The heart and lungs constitute a single system. For the clothing, several layers can be considered. For the simplest model, two clothing layers and uncovered hands and head, a set of 70 ordinary differential equations over time are defined. The numerical solutions were obtained using the Runge-Kutta-Merson method due to its simplicity and robustness [4]. The final solutions are the skin temperature in time and in the several parts of the body, for different type of clothes and environmental. Due to the great number of parameters, physics and numerical, a database was developed in order to store all this information and also to store all the final results.

The graphical interface ConfThermal, integrate the numerical program and databases, was developed in Pascal (Delphi 6) for Windows environment. The user, after activate ConfThermal application, Figure 1, must use successively several menus: introduction of the initial parameters (1), call the numerical simulation program and visualize the final results (2), see the data base (3), call the help menu for any doubts in the interface use (4), and exit button to quit the application (5).

## 3 Usability Evaluation

The questionnaires are the most common methods to evaluate the interface usability not only due to its lower costs and final results in a short period of time but also since it uses the target users. In order to test the usability of the ConfThermal interface, as a first approach, two of the most common tests to measure the user satisfaction were used: SUMI (Software Usability Measurement Inventory) [5] and QUIS (Questionnaire for User Interface Satisfaction) [6-7]. The SUMI questionnaire measures the usability of the product in the user point a view: efficiency, empathy, control, help and learning. It is a questionnaire

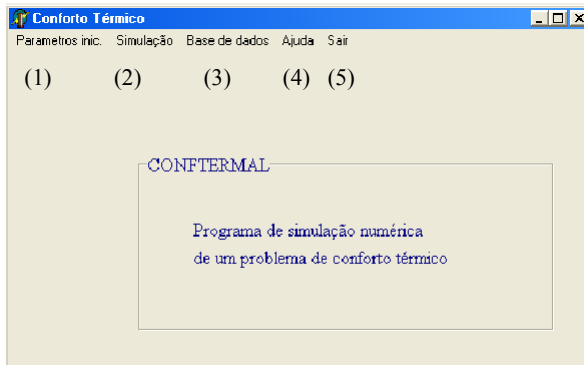


Figure 1. ConfTermal application main menu: introduction of the initial parameters (1), call the numerical simulation program and visualize the final results (2), see the data base (3), call the help menu for any doubts in the interface use (4), and exit button to quit the application (5).

with 50 questions with three levels of answers: Agree, Undecided, Disagree. The QUIS questionnaire has 27 questions divided into the five topics: Overall reactions to the software, Screen, Terminology and System information, Learning, and System capabilities. Each question has a specific satisfaction level, ascending from 0 on the left (inconsistent) to 9 on the right (consistent). These adjectives were positioned so that the scale went from unconstructive on the left to constructive on the right. The two questionnaires were translated and adapted to Portuguese language, before presented, since the English knowledge of the users could be a difficulty. The questionnaires were distributed to four user groups with a total number of 61 individuals, Figure 2. SUMI and QUIS questionnaires were conducted in a traditional laboratory environment where each user wrote their answer directly in the questionnaire paper sheet. All the questionnaires were anonymous.

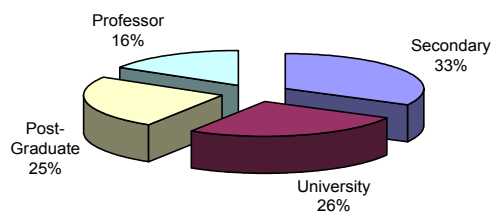


Figure 2. Users groups' percentage involved in the usability test of the graphical interface.

The first group, Secondary, includes students of the 12<sup>th</sup> year of the secondary level with some knowledge in computers and information technologies. They can evaluate the interface as a common user without any information of thermal comfort. The second group, University, includes undergraduate student of the 3<sup>rd</sup> and 4<sup>th</sup> year of Industrial Engineering course of the University of Minho. The users

of this group have some knowledge on ergonomics and thermal comfort subjects. The third group, Post-Graduate, includes the student of postgraduate level namely MSc on Human Engineering students of the same University. The users of this group have the higher knowledge on thermal comfort subject, however from different qualification background: doctors, attorneys, engineering, among others. The last group, Professor, includes university professors with higher knowledge in informatics. The choice of these four groups took into account the future target user groups that would make use of the ConfTermal interface developed.

## 4 Questionnaires Results

This section presents a summary of the questionnaires results from the 61 users.

### 4.1 SUMI

Due to high number and variety of questions, they were divided into two groups of questions: a first group with the questions where Agree as an answer is positive called favorable questions (19 questions), and where Disagree as an answer is a constructive opinion in the second group called no favorable questions (31 questions). Table 1 and Table 2 show some of the questions in the first and second group, respectively.

Table 1. Examples of Favorable Questions.

Nº	Question
2	I would recommend this software to my colleagues
7	I enjoy my sessions with this software
17	Working with this software is mentally stimulating
29	The speed of this software is fare enough
42	The software has a very attractive presentation
48	It is easy to see at a glance what the options are at each stage

Table 2. Examples of No Favorable Questions.

Nº	Question
1	This software responds too slowly to inputs
6	I sometimes don't know what to do next with this software
38	Error prevention messages are not adequate
41	The software hasn't always done what I was expecting
43	Either the amount or quality of the help information varies across the system
50	I have to look for assistance most times when I use this software

For each of the four users groups and for the favorable and no favorable groups' questions, the observed obtained results are illustrated in Figure 3 and Figure 4, respectively.

The observed differences in the number of answers are statistically significant, for both groups of favorable and no favorable questions. That is, independently of the user group, the number of answers for each level tends to be similar. This conclusion was obtained by performing a chi-square test (interval of confidence of 95%). Similar test was performed for the no favorable questions with

analogous decision: the observed differences in the number of answers are statistically significant. As previously mentioned, Disagree as an answer for the no favorable questions, is considered as a constructive opinion. All the questions with Undecided and Disagree, for the favorable question group, were identified for reflection in order to improve the graphical interface: the question 42 (Table 1). For no favorable question group, the questions with Agree were identified: question 6 and 43 (Table 2).

It is possible to identify the group with higher satisfaction with the graphic interface: users from the

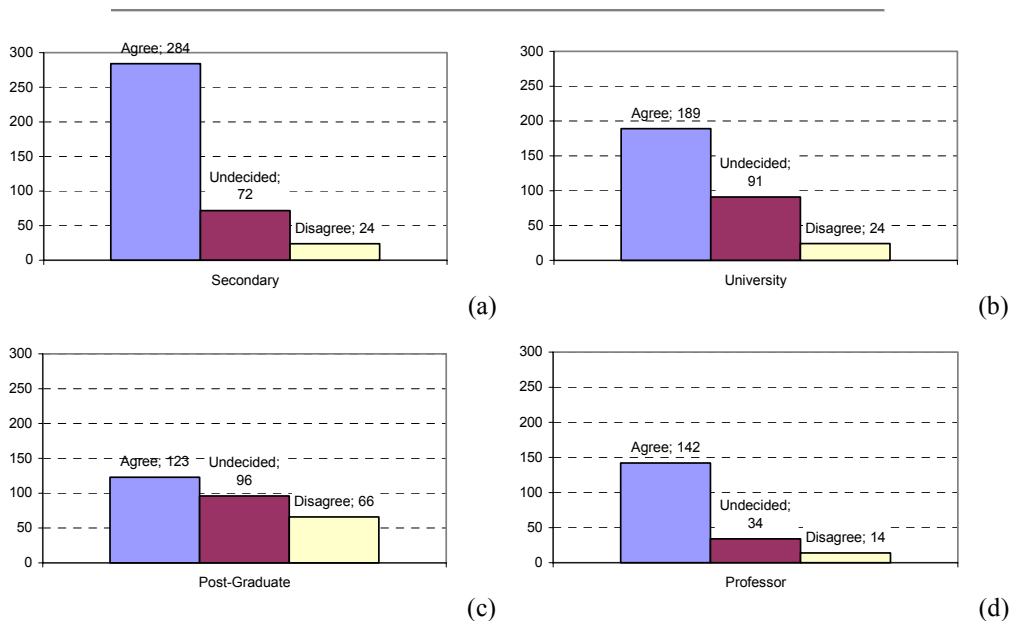


Figure 3. Obtained results for the SUMI favorable questions for the (a) Secondary, (b) University, (c) Post graduate and (d) Professor groups.

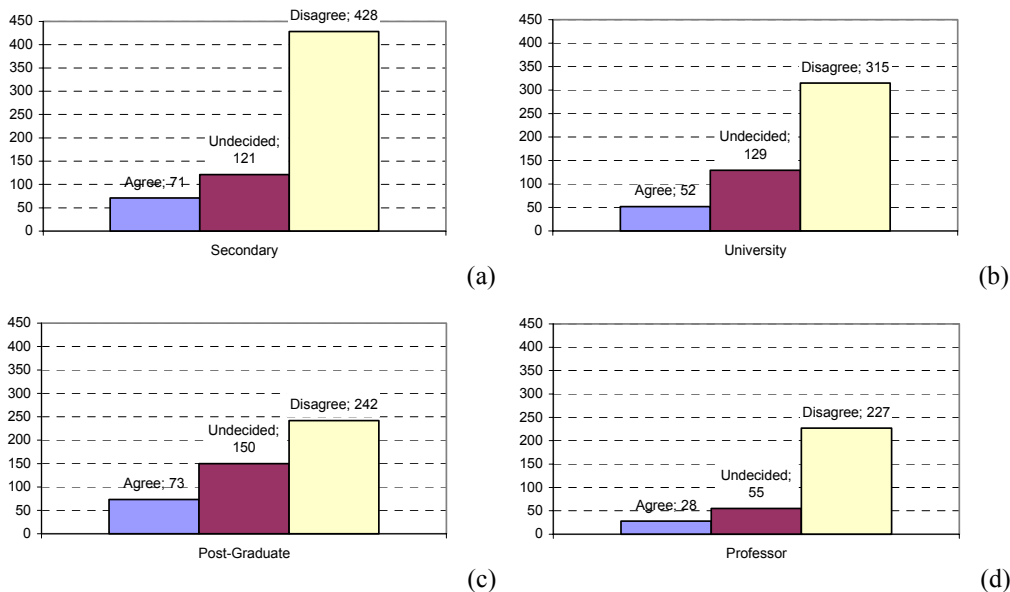


Figure 4. Obtained results for the SUMI no favorable questions for the (a) Secondary, (b) University, (c) Post graduate and (d) Professor groups.

Secondary group (Figure 3). This may be due to the insufficient knowledge of thermal comfort, only being evaluated as a simple informatics application. In opposition, the group of Post-Graduate, due to their knowledge in thermal comfort, was more critical. Similar conclusions can be observed for the no favorable questions (Figure 4), however looking to disagree answer as positives.

## 4.2 QUIZ

The QUIZ questionnaire is composed by a five sets of questions related to the user satisfaction of the human-computer interface: Q1, concerning to the overall reaction to the software (see Table 5); Q2, to the screen (see Table 6); Q3, to the terminology and system information (see Table 7); Q4 to the learning process, and Q5, to the system capabilities (see Table 8).

Table 5. Overall Reaction to the System questions.

N°	Question
Q1.1	Terrible / Wonderful
Q1.2	Difficult / Easy
Q1.3	Frustrating / Satisfying
Q1.4	Inadequate power / Adequate power
Q1.5	Dull / Stimulating
Q1.6	Rigid / Flexible

Table 6. Screen questions.

N°	Question
Q2.1	Characters on the computer screen, hard to read / easy to read
Q2.2	Highlighting on the screen simplifies, task not at all / very much
Q2.3	Organization of information on screen, confusing / very clear
Q2.4	Sequence of screens, confusing / very clear

Table 7. Terminology and System Information questions.

N°	Question
Q3.1	Use of terms throughout system, inconsistent / consistent
Q3.2	Computer terminology is related to the task, never / always
Q3.3	Position of messages on screen, inconsistent / consistent
Q3.4	Messages on screen which prompt user for input, confusing / clear
Q3.5	Computer keeps you informed about what it is doing, dull / stimulating
Q3.6	Error messages, unhelpful / helpful

Table 8. Learning questions.

N°	Question
Q4.1	Learning to operate the system, difficult / easy
Q4.2	Exploring new features by trial and error, difficult / easy
Q4.3	Remembering names and use of commands, difficult / easy
Q4.4	Tasks can be performed in a straightforward manner, never / always
Q4.5	Help messages on the screen, unhelpful / helpful
Q4.6	Supplemental reference materials, confusing / clear

Table 9. System capabilities questions.

N°	Question
Q5.1	System speed, too slow / fast enough
Q5.2	System reliability, unreliable / reliable
Q5.3	System tends to be, noisy / quiet
Q5.4	Correcting your mistakes, difficult / easy
Q5.5	Experienced and inexperienced users' needs are taken into consideration, never / always

For a detailed analysis, let's consider the obtained results in a graphical way, see Figures 5 to 9. It can be possible to identify the difference, or not, in the behavior of the four groups in the five sets of questions. Box plots are useful to comparing several sets of data. They provide an excellent visual summary of many important aspects of a distribution: measure of central location (the median), two measures of dispersion (the range and inter quartile range) and the skewness (from the orientation of the median relative to the quartiles).

All of the obtained means were higher than 5 (the mean value from 0 to 9) indicating a generalized positive evaluation in all the questions. However, for some questions, the s.d. can be considered large (> 2.0), namely on "Computer keeps you informed about what it is doing" and "Experienced and inexperienced users' needs are taken into consideration" corresponding to a lower mean values.

Analyzing Figure 5, the Postgraduate group has the lower attitude in opposition to the Secondary group with a higher attitude. The opinion concerning the screen, a more objective aspect, the Postgraduate group shows a similar behavior being the group with lower mean (Figure 6). The Secondary and Professor groups have similar positive behavior. These two groups were composed by elements that are more sensibility to the visual informatics aspects.

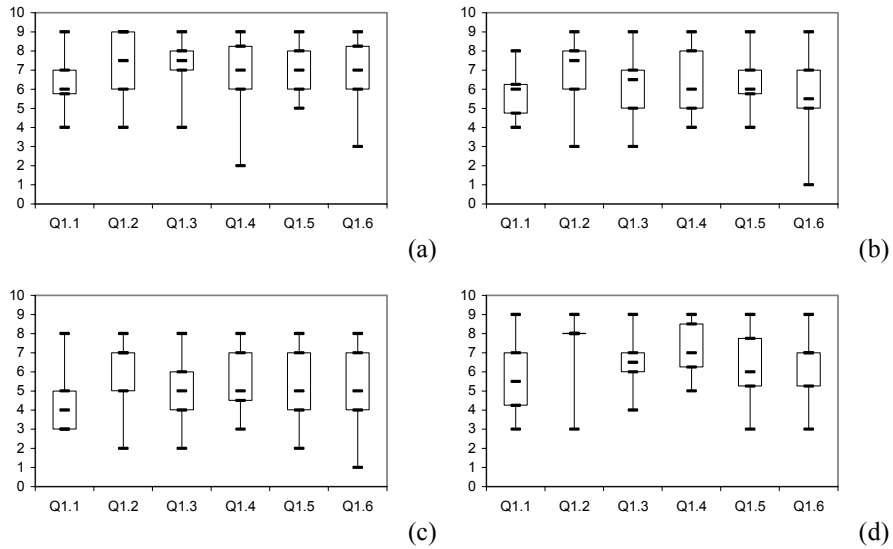


Figure 5. Box plots corresponding to the Overall Reactions to the System questions (Table 5) for the (a) Secondary, (b) University, (c) Post graduate and (d) Professor groups.

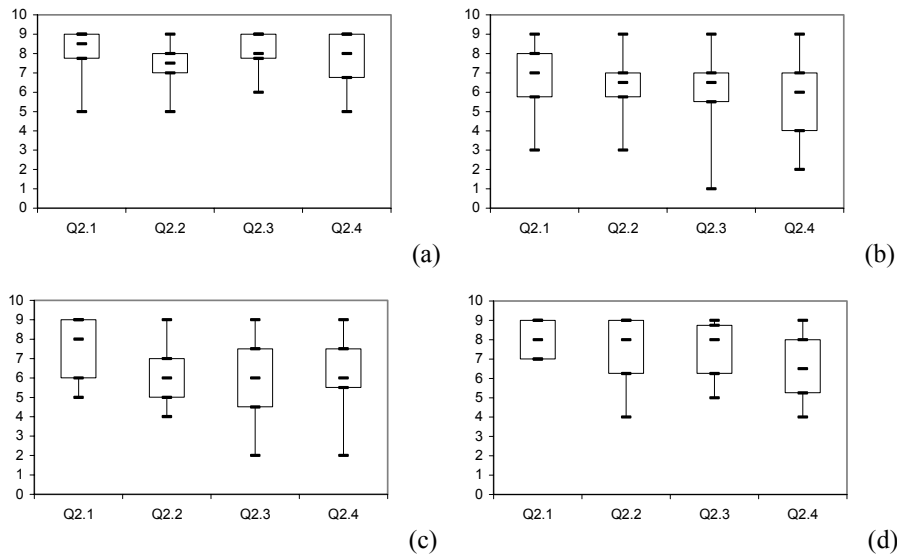


Figure 6. Box plots corresponding to the Screen questions (Table 6) for the (a) Secondary, (b) University, (c) Post graduate and (d) Professor groups.

For the Terminology and System Information questions, Figure 7, the first two questions, Q3.1 and Q3.2 (Table 7) are the ones more related to the topic in study (thermal comfort). As expected, the Postgraduate group has the lower opinions. The question Q3.5 “Computer keeps you informed about what it is doing”, reveals differences of opinion.

The questions concerning the Learning topic, has a special importance since can state if and how the graphical interface can be used as a learning tool. Figure 8 summarizes the obtained results. The results were very

encouraging: all groups pointed out positive opinion in all the learning questions.

For the last topic, System capabilities, also demonstrate a positive behavior (Figure 9). However, the last question, Q5.5 (Table 9 – “Experienced and inexperienced users’ needs are taken into consideration”) has a higher variety of answer. This can be explained by the fact that it was the first time that the users were confronted with this type of application, do not feeling yet, the need of this software.

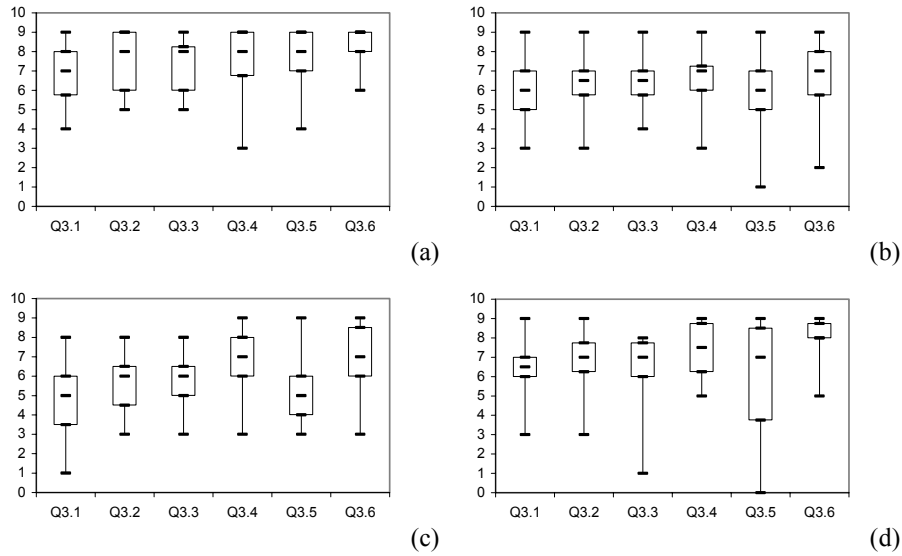


Figure 7. Box plots corresponding to the Terminology and System Information questions (Table 7) for the (a) Secondary, (b) University, (c) Post graduate and (d) Professor groups.

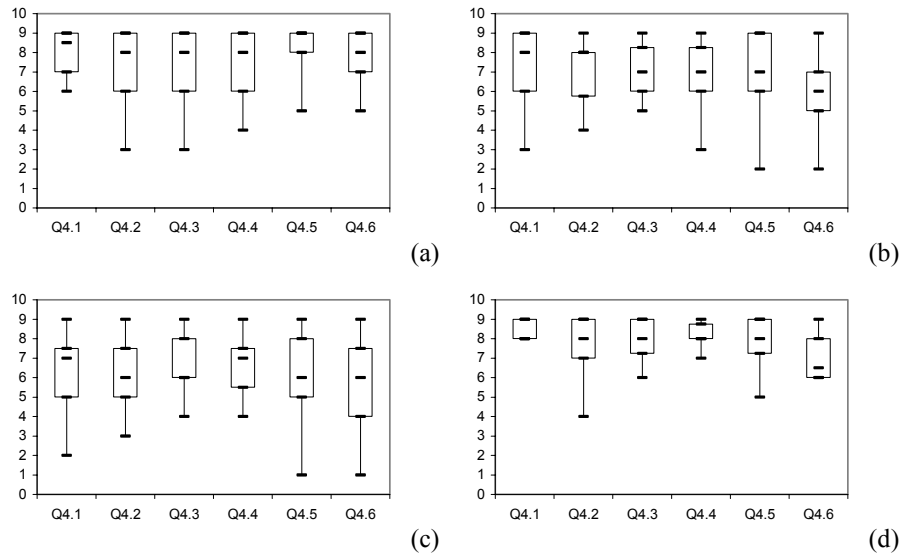


Figure 8. Box plots corresponding to the Learning questions (Table 8) for the (a) Secondary, (b) University, (c) Post graduate and (d) Professor groups.

## 5 Conclusions and Future Work

The ConfTernal interface developed main goal is to facilitate the use of the mathematical model that describes the thermal comfort. A usability evaluation was performed. Two questionnaires, SUMI and QUIS, were used and applied into four different groups of users, by the academic levels: Secondary (with students of 12<sup>th</sup> secondary level), University (university students of the 3<sup>rd</sup> and 4<sup>th</sup> year),

Post-Graduate (post graduate students of the MSc in Human Engineering), and Professor (group of several university professors, most of them holding a PhD).

At this preliminary stage in the study, the results suggest that the graphical interface was well accepted for all the four considered groups. It was possible to observe that users with higher thermal comfort knowledge tend to be more critical and demanding in the use of the interface.

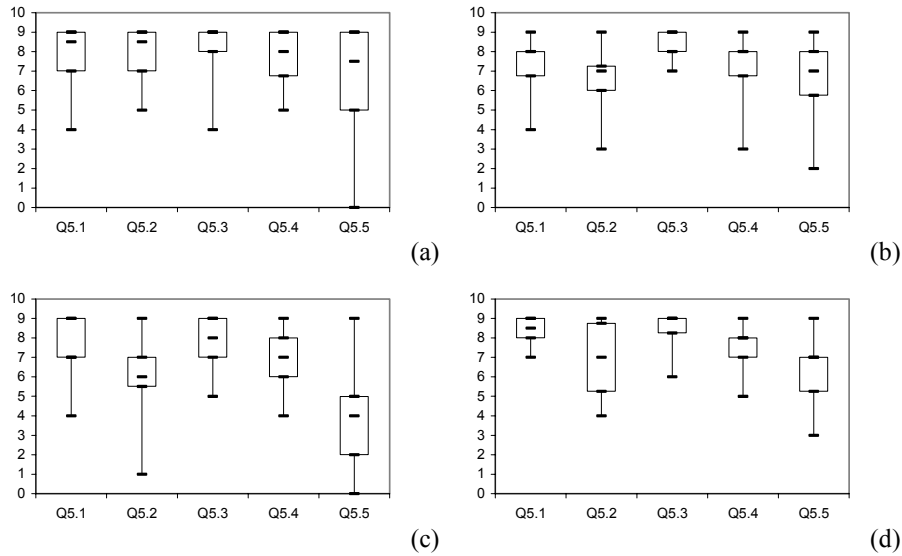


Figure 9. Box plots corresponding to the System capabilities questions (Table 9) for the (a) Secondary, (b) University, (c) Post graduate and (d) Professor groups.

Since the ConfTerral interface developed will be used as a learning tool for under and post graduate levels for the thermal comfort subject, the opinion concerning the learning topic was very important. The results were very encouraging: all groups pointed out positive opinion in all the learning questions.

Others problems were identified: smaller amount of documentation, namely when the user makes use of the Help menu, and the graphic representation of the human body with the final results of the temperature.

The two questionnaires results were used to improve and optimize the ConfTerral interface to an easy and joyful learning tool in the thermal comfort, and as a way to motivate the students to this subject.

## 6 Acknowledgments

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