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## Understanding the interaction of design students with portable computers in the classroom

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### Abstract

Laptop computers are an indispensable tool for the learning of Product Design. However the universities classrooms are not adapted to the new technological evolutions and working processes. The main objectives of this study were to analyze the human-computer interaction in Product Design classrooms, by observing the users, the work activity and the environment, to understand the current demands for the use of laptop computers, and to observe current patterns of student interaction, and their needs. Data were gathered and analyzed from a set of classrooms in a Portuguese university using the following methodologies: free observation; systematic indirect observation through video recording and analysis; and student survey. The results show that 56.5% of the study participants use information systems in the classroom, of these, 90% use laptop computers, and use this devices individually. In general, about 52% of the records indicate that in the classroom the information systems were used by less than 50% of the class students. This study results can promote: (a) the development of a set of data and information that can assist designers and other professionals in the product creation process; (b) the awareness of the universities to the need to modernize the spaces, furniture, and equipment, and to adapt them to the new processes of work and to the new student-computer interactional behaviors.

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## 1. Introduction

The teaching of product design at higher education institutions in Portugal has experienced several changes since the beginning of the 21st century. The new training processes based on student centered learning have made the information access more relevant [1]. These changes, along with others of technical, economical and social nature, resulted in a large increase in student use of laptop computers, a fundamental part in the education process [2, 3, 4].

In the end of the 20<sup>th</sup> century and in the beginning of the 21<sup>st</sup> century, personal computers and CAD software became an indispensable tool for the learning and practice of product design [5], compelling universities to equip themselves with desktop computers. Over the early twenty-first century the use of these desktop computers was progressively abandoned in favor of laptop computers used in almost all classes [6, 7]. Classrooms however were not adapted [8], and as a result the interaction between students and computers was negatively affected, since the work activity is conditioned by the existing conditions for the execution of a task [9]. However, only few research studies about classrooms' spaces are targeted towards higher education institutions [7, 10].

To be able to understand the necessary changes in the classroom, it is essential to analyze the type of information systems used during the classes of product design courses. The adoption of a systemic approach to an activity through the analysis of all possibilities of interactions in a real context is the main element for a good research [11]. Video analysis has been used in many areas, and this approach is also used in the environment analysis [12, 13]. The evaluation of behavioral habits in the classroom is needed. Thus, the observation methodology based on iSEE software [14] allows the classification and registration of interaction and postural behaviors for long periods of time and can be applied in this context (Fig. 1). The combination of some objective with subjective techniques, which generally are qualitative such as surveys, interviews and direct activity observation, make it possible to minimize the difficulties when applying these experimental methods in real context [14, 15, 16, 17].

The main objectives of this study were: (a) To conduct a human-computer interaction analysis in product design classrooms, observing the users, the work activity and the environment; (b) To understand the current demands in the use of laptop computers and other portable information systems; (c) To observe current standards of student interaction in the classroom, and their needs. This paper presents a part of a larger study which is being conducted in three Portuguese universities. It started in April 2013 and finished in February 2015, and reports the crossed results and analyses of a systematic indirect observation through video recording and analysis using the iSEE methodology, and a student online survey, both carried out at the University of Beira Interior in Portugal.

## 2. Methodology

In assessing patterns of interaction with equipment and environments, the observation and survey methods are the most used [18], being the observation methods referred to by some authors as preferable to the survey methods, for presenting more reliable results [19]. Indirect observation by means of video recordings offers several advantages when compared with direct observation. It allows the registration and a more accurate dynamic measurement of activities and interaction behaviors, a better contextualization of the observed behaviors by measuring its length and relating them with previous and next behaviors, the observation of video sequences in loop, separated by intervals, which reduces the effort required from the observer, and the use of multiple synchronized video cameras for multiple points of view [13]. Nevertheless surveys allow answering non-observable questions, assuming a similar function to the interview in the analysis of the work activity [20].

### 2.1. Participants

All students from the Industrial Design Course of the University of Beira Interior were selected. For video analysis all students attending the selected theoretical and theoretical/practical classes were filmed in the course of the classes. Classes were held in classrooms of three different types. To ensure proper sampling, representative disciplines were selected from the various possible combinations between type of class (theoretical and theoretical / practical) and type of classroom, of the two semesters of each of the three years of the course. In total 37 hours of footage were observed corresponding to 10 different disciplines. For the survey all the referred students were contacted online. Thus, the sample selection technique of the present study is non-probabilistic and by convenience.

## 2.2. Indirect observation

iSEE Software, developed by ErgoLab - University of Lisbon, was selected to register, measure and quantify the observation categories. The iSEE Software was chosen in preference to other traditional tools of observation and video analysis because it presents a more intuitive and easier use [13]. The iSEE software has a hierarchical structure of groups of pre classified observation categories. The observation of events is made by viewing video sequences. The duration of video sequences, and the interval between video sequences are defined by the observer. The recording of observation categories for each video sequence is done through an intuitive graphical interface (Fig. 1).

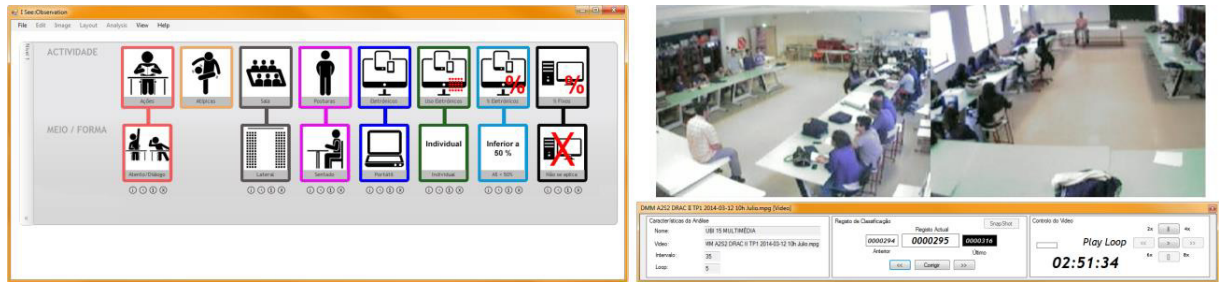


Fig. 1- Functional areas of the iSEE software interface

The observation categories were grouped into eight groups, each group containing up to 8 observation categories. Within each group one can only choose one category. Thus, for each video sequence, from 0 to 8 observation categories can be recorded. In the diagram shown in Fig. 2, the codes and description for the Interaction Categories (ICs) groups are presented. Since the students present in the classroom are observed in group rather than individually, the recorded observation categories reflect the predominant behaviors of the student group. The recordings were made by visualizing video sequences with 5 seconds long, with 30 second intervals, according to Fig. 3

The interactions between students and the classroom equipment were recorded in normal classes on the first and second semesters. The recording system consisted of two wireless video cameras (Wireless Chacon 34519 - 2,5 GHz – color), a receiver (Chacon 34514), an analogue video to digital converter (HD Video Capture M – H830M) and a laptop computer (Acer Aspire 5741G). The images of the two cameras were recorded simultaneously and synchronously in a digital format. The cameras were installed at diagonally opposite corners of classrooms, allowing to obtain two plans (front and back diagonal superior). This placement allowed to obtain images covering the whole area of the classrooms through proper orientation of each of the cameras. The cameras were placed at a height ranging from 2.5 meters to 3.5 meters, which made it possible to obtain images from a higher angle to minimize the creation of visual obstacles, considering that it provided the best visualization of the participants and activities (Fig. 4).

Participants were informed about study's goals through a group meeting and an individual approach on the day of the video recording. All video data collection was authorized by the professor and students through a consent form. Finally, participants were informed about the placement of all the cameras, and were instructed to perform their tasks as usual and not to change their habits due to the presence of cameras. The recording system was turned on 15 minutes before class started, and turned off 15 minutes after class ended, covering the periods in which the subjects activity were studied. After the filming period for each classroom, a quick analysis of the video was done in order to select the best videos, according to the following criteria: Longer stay of students in the classroom (preferred > 90% of video period); More than 60% of the video had a good visualization of the behaviors during class times.

The same equipment was used in three different types of classroom, according to the following description:

- Classrooms with individual desks (Fig 5a): Natural lighting; artificial lighting from fluorescent lamps; central heating system; natural ventilation; workstation of students consisting of individual desk and chair, grouped in rows arranged parallel to the wall of the blackboard; power plugs in the 4 corners, or on the left wall.
- Classrooms with drawing boards (Fig. 5b): Natural lighting; artificial lighting from fluorescent lamps; central heating system; natural ventilation; sink with running water; workstation of students consisting of adjustable drawing board and adjustable rotating chair; power plugs on the left wall.
- Classrooms with desktop computers (Fig. 5c): Natural lighting; artificial lighting from fluorescent lamps; central heating system; no natural ventilation; forced ventilation with cooling; students workstation consisting of individual desk and chair; desktop computers in the students desk connected to power and network through a device installation trucking; workstations without computers, with access to power and network; desks grouped in rows disposed perpendicularly to the wall of the frame; the desks cannot be moved.

Observation Categories								
Categories	A1 Students' Predominant Actions	A2 Students' Atypical Behaviors	A3 Occupation of the Classroom	A4 Students Postural Behaviors	A5 Electronic Equipment Used by Students	A6 Distribution of Users by Electronic Equipment	A7 Percentage of Electronic Equipment Utilization	A8 Percentage of Desktop Equipment Utilization
Ways	<ul style="list-style-type: none"> <li>-A1.1 Reading</li> <li>-A1.2 Writing</li> <li>-A1.3 Reading/ Writing</li> <li>-A1.4 Drawing</li> <li>-A1.5 Handle/Build objects</li> <li>-A1.6 Aware of lecture/dialog</li> <li>-A1.7 Arranging the workstation</li> <li>-A1.8 Other</li> </ul>	<ul style="list-style-type: none"> <li>-A2.1 Meal</li> <li>-A2.2 Improper use of equipment</li> <li>-A2.3 Mobile phone use (Voice)</li> <li>-A2.4 Mobile phone use (Text)</li> <li>-A2.5 Vandalism</li> <li>-A2.6 Sleeping</li> <li>-A2.7 Other</li> </ul>	<ul style="list-style-type: none"> <li>-A3.1 Front</li> <li>-A3.2 Front groups</li> <li>-A3.3 Behind</li> <li>-A3.4 Groups behind</li> <li>-A3.5 Side</li> <li>-A3.6 Side groups</li> <li>-A3.7 Random</li> <li>-A3.8 Other</li> </ul>	<ul style="list-style-type: none"> <li>-A4.1 Sitting</li> <li>-A4.2 Standing</li> <li>-A4.3 Walking</li> <li>-A4.4 Carrying volumes</li> <li>-A4.5 Missing from the picture</li> <li>-A4.6 Other</li> </ul>	<ul style="list-style-type: none"> <li>-A5.1 Laptop</li> <li>-A5.2 Desktop</li> <li>-A5.3 2 in 1 laptop</li> <li>-A5.4 Tablet</li> <li>-A5.5 Smartphone</li> <li>-A5.6 Digitizer table</li> <li>-A5.7 Other</li> </ul>	<ul style="list-style-type: none"> <li>-A6.1 Individual</li> <li>-A6.2 Groups of 2-5 students</li> <li>-A6.3 Groups of 6-10 students</li> <li>-A6.4 Groups of &gt;10 students</li> <li>-A6.5 Other</li> </ul>	<ul style="list-style-type: none"> <li>-A7.1 A5 = 0%</li> <li>-A7.2 A5 &lt; 50%</li> <li>-A7.3 A5 = 50%</li> <li>-A7.4 A5 &gt; 50%</li> <li>-A7.5 A5 = 100%</li> </ul>	<ul style="list-style-type: none"> <li>-A8.1 A5.2 = 0%</li> <li>-A8.2 A5.2 &lt; 50%</li> <li>-A8.3 A5.2 = 50%</li> <li>-A8.4 A5.2 &gt; 50%</li> <li>-A8.5 A5.2 = 100%</li> <li>-A8.6 Does not apply</li> </ul>

Fig. 2 - Categories and ways for Students Predominant Actions

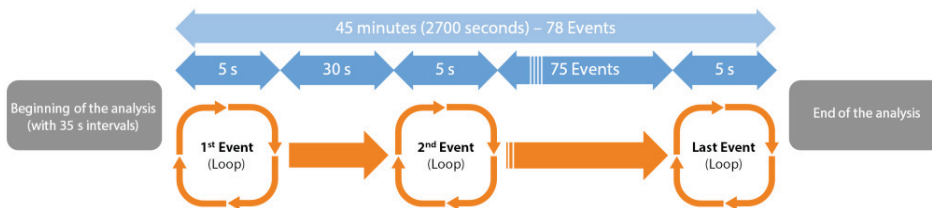


Fig. 3 - Flowchart with the systematic observation stages used by the software

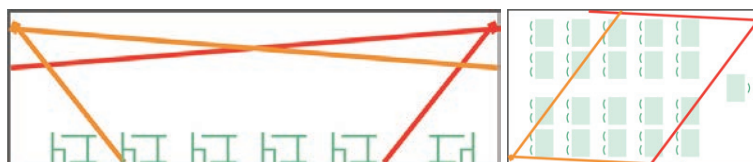


Fig. 4 - Location of video cameras



Fig. 5 - Classrooms with: a) individual desks; b) drawing boards; c) desktop computers.

### 2.3. Survey

In this study the survey was designed and implemented based on the methodology proposed by Gray [21], adapted from Czaja & Blair [22]. The study research questions were analyzed, and from these it was decided what information would be required to get through the survey in a coordinated way with other research methodologies. After the wording of the preliminary questionnaire, a pilot survey was conducted to a group of experts and students, based on which the questionnaire has been corrected in accordance with the following five groups: (1) Characterization of Sample, consisting of six questions; (2) Social Issues, consisting of seven questions about the interaction between classmates and between students and teachers; (3) Environmental Issues, consisting of five questions about lighting, noise, temperature, air, humidity, and odors; (4) Actional Issues, consisting of twenty-one questions about the material taken to the classroom by the students, the interaction with the equipment, and the interaction with the students computer equipment; (5) Spatial Issues, consisting of four questions about the interaction with the physical space, the furniture, and the infrastructures. The questionnaire was conducted using the Forms tool from Google Drive [23] and self-administrated online [24]. The survey link was released through personal and institutional student's emails, on the websites of the educational institutions, and in online social networks.

### 3. Results

A sample of 5148 observations, which corresponds to 36 hours and 45 minutes of 49 Designs classes of Portuguese University of Beira Interior, was classified into eight ICs. The results are presented in Fig. 6.

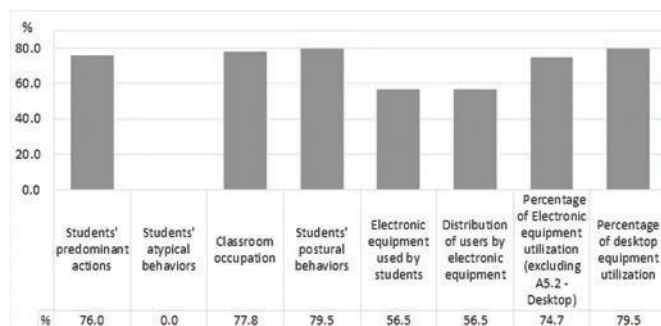


Fig. 6 - Results for Interactions Categories groups

The results of the first category (i.e. Students' predominant actions) show that 53.7% of the participants presented the "Aware of lecture/dialog with teacher or peers" as the most common students' action during classes (Fig. 7a). The category "Students' atypical behaviors" had no record. The category "Classroom occupation" presented the Side position as the most common classroom occupation, with 42.2% of postural behavior (Fig. 7b).

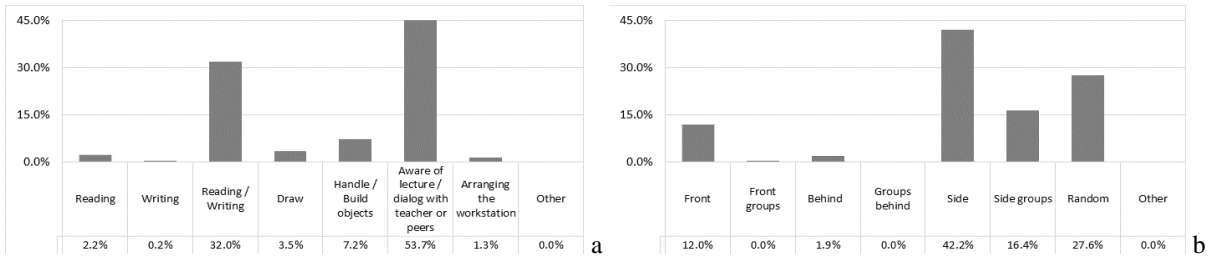


Fig. 7 – (a) Students` predominant actions; (b) Classroom occupation

In the "Students' postural behaviors" category, Sitting is the most common postural behavior during classes, with 88.4% of observations (Fig. 8a). In the "Electronic equipment used by students" category during the video capture, the most common activity was Using a Laptops, with 89.4% of observations (Fig. 8b).

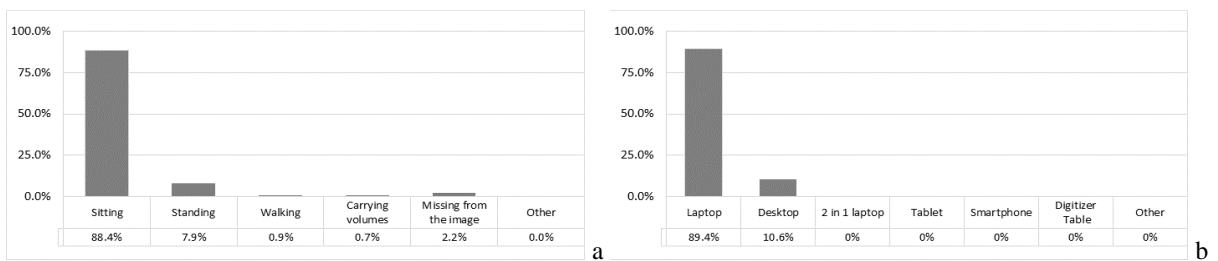


Fig. 8 – (a)Students `postural behaviours; (b) Electronic equipment used by students

The category “Distribution of users by electronic equipment” presented the individual use of equipment as the most common distribution electronic using, with 93.8% (Fig. 9a). Concerning the "Percentage of electronic equipment utilization" category, 52.9% of observations presented < 50% of participants using electronic equipment (Fig. 9b).

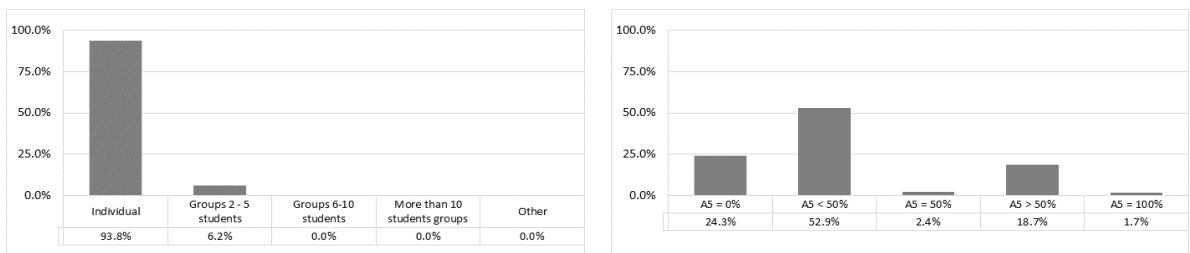


Fig. 9 – (a) Distribution of users by electronic equipment; (b) Percentage of elec. equip. utilization (excluding A5.2 - Desktop)

Concerning the "Percentage of desktop equipment utilization" category, 7.1% of observations presented > 50% of participants using desktop (Fig. 10).

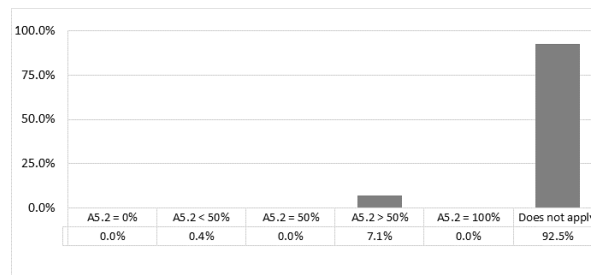


Fig. 10 - Percentage of desktop equipment utilization

#### 4. Conclusion

The results obtained with the present study had shown the importance of combine methodologies of indirect observation trough a customized methodology and surveys to assess and help researchers to understand the needs of product design students. The survey allows evaluating the opinions of the students and the non-observable problems they feel, while the indirect observation using the iSEE methodology enables the correlation of this information with the work activity, and also allows evaluating the interaction patterns of students in product design classes. It was confirmed that the two methods are complementary, allowing a better interpretation of results.

This study also generated a set of data and information that contribute to help educators, designers, architects, engineers, and other professionals to create new and more adequate solutions to the students' needs.

The results from the indirect observation methodology show that only during 56.5% of the observation period there were participants who used information systems in the classroom, and for approximately half of that time (52.9%), less than 50% of participants were using information systems. These results do not confirm, as expected, a high utilization of information systems by students. Thus, these results do not corroborate the assumption that the product design classrooms are not adapted to new technological developments and new work processes used by students, since these issues are related to the increasing use of information system during class.

However, there are two hypotheses that could explain these data. The first hypothesis is related to the characteristics of the classes and the activities that take place on them. During the lectures, students may be attentive to teacher most of the time. Thus, even if the computers were connected, they may be used for less than half of the class period, existing even periods when no students are using computers. In theoretical practical classes the execution of a task involves performing several activities, such as the use of a computer, drawing, the construction of objects, and the discussion of projects with colleagues and teachers, among others, as can be seen through the analysis of data obtained through indirect observation. As in the case of theoretical classes, these facts may justify that even if for most students using the computer is essential for achieving the tasks, its use occurs in less than half the duration of the class period.

The second hypothesis points to the fact that the lack of conditions in classrooms, which are not adapted to new technological developments and new work processes used by product design students, limit the use of computers.

A preliminary analysis of the survey results seems to support both hypotheses. In fact, 32.3% of the students take very often laptops to class, and 45.7% answered that they always take laptops to the class, which corresponds to a frequent or constant use of laptop computers by 78% of the respondents. These values are related to the number of classes in which computers are used, but not to the time during which they are effectively used in each class.

Regarding the lack of conditions in classrooms, it was found that in practical classes 36.2% of the students use as criteria for choosing their place the proximity to an electrical outlet. Also, in relation to the number of available electrical outlets, 33.2% of students agree, and 49.1% strongly agree, that these are insufficient. As to its location, 46.1% agree, and 34.1% strongly agree that their location is too far from the desk. These surveys' data are consistent with data obtained with indirect observations that indicate that 58.6% of students sit next to the side walls of the classrooms. By the description of the classrooms equipped with drawing boards, where most of the practical classes take place, it can be seen that most of the electrical outlets are placed in the left side wall.

The iSEE methodology was considered efficient for the proposed objectives, and findings and offers new challenges for future research. This paper presents a part of a larger study, which aims to evaluate and technologically adapt the product design classrooms for the 21st century through the observation of current student interaction patterns in the classroom during educational period in the University of Beira Interior. More data are being gathered from two other Portuguese universities, and the results will be compared with the conclusions of this study.

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