Visual discomfort among university students who use CAD workstations

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Abstract.

BACKGROUND: Extensive literature in ergonomics and optometry has indicated that computer use is closely associated with visual problems. Computer-Aided Design (CAD) requires a substantial effort on behalf of the visual system. The manifestations of visual fatigue phenomena may affect the working behavior and the human-system interaction.

OBJECTIVE: The aim of this survey is to identify the normal working conditions and how the eventual visual fatigue phenomena are able to influence the working behavior of CAD users.

METHODS: A questionnaire was created and submitted to a sample of 150 university students, who attend the Faculty of Engineering of the University of Pisa (Italy).

RESULTS: The questionnaire results show that university students spend on average 7 hours per day at the computer for CAD drafting. Most of the participants work in strongly lit environments, with high brightness screens and negative polarity. Such conditions cause high contrasts in luminance, especially between screen and surfaces that fall within the field of vision. The results show that 135 out of 150 students report visual fatigue during long CAD sessions, which in most cases leads to difficulty in continuing the activity and changing usual working behavior.

CONCLUSIONS*:* The results of the questionnaire show that the university students work in highly variable lighting conditions and with little attention on the luminance distribution on the field of view. This has highlighted the importance, for VDT workstations, of not limiting the risk analysis to the postural ergonomics (how usually occurs) but extend it to the workplace as a whole, analyzing also the ergonomics of vision, which involves different consideration on the natural and artificial lighting of the workplace and on the characteristics of the display.

Keywords: Human-system interaction, CAD workstation, visual fatigue, working behavior, lighting of workplaces.

1. Introduction

The workplace with video display terminal (VDT) is currently used in a wide variety of activities and there are numerous workers who spend significant portions of the workday using VDTs. For this reason, in recent years there has developed the need to carry out a detailed analysis of the risks associated with the use of VDTs, in order to safeguard the safety and health of the workers [1-3].

The use of VDT involves a variety of risks most often underestimated by the community, which is typically more sensitive to those work activities which may cause very high damage to health but which have a very low probability of occurrence. On the contrary, by using a workstation with VDT, operations carried out, may cause minor damage which occur many times during the working day. It has been proven that the improvement of ergonomics of the workplace (and of the equipment) and the achievement of high levels of environmental comfort (as a thermal, acoustic and visual comfort) may help to reduce errors and fatigue and, more generally, improve the performance of the worker and their feeling of well-being [1].

Bergqvist [4] through a study carried out at the end of the 1980s, showed that eye discomfort and probably also hand/wrist problems were associated with VDT work. Subsequently, numerous studies have further investigated the consequences of incorrect postures during VDT use [5-7] and the psychological effects of computer use [8]. It should be noted, however, that it is necessary not to limit the risk assessment only to the postural ergonomics, but extend it to the workplace as a whole, by analysing also the ergonomics of vision, which involves considerations on the natural and artificial lighting of the workplace and on the characteristics of the display.

During work with VDT, the display and the surfaces that fall in the field of view may have very different values of luminance. In all these cases, the intensive adjustment of the human eye to the different levels of luminance can lead to visual fatigue [2,9,10]. From the observation of images with unnatural spatial structure and an excess of contrast energy at spatial frequencies to which the visual system is generally most sensitive visual stress can occur [11]. Extensive literature in ergonomics and optometry has indicated that computer use is closely associated with various visual problems, which are referred to as Computer Vision Syndrome (CVS) in medical science [12].

The first studies on the ergonomics of the VDT workstation refer to workstations typical of office jobs, which involves tasks of reading and writing of text documents. However it is necessary to analyze working conditions that also include different using modes. For example, a research on operators of call centers demonstrated the importance of studying the CVS and the association between the symptoms and working conditions [13]. A significant example is the increasingly Computer-aided Design (CAD) workstations, for which the features of displaying information on the screen are generally different from those of reading and writing. In carrying out this special activity, computer use duration alone cannot accurately represent the workloads of various computer tasks [14], but it is necessary also consider the other aspects that characterize the visual task and the workplace.

In this paper the authors analyze the working behavior, with special reference to the attention paid to the lighting conditions, of a sample of CAD users. The aim of this analysis is the identification of the common working conditions and how the eventual visual fatigue phenomena are able to influence the working behavior of the CAD users, especially for university students.

2. The CAD workstation

The term Computer-Aided Design (CAD) refers to technical design or drafting achieved with a computer through the use of particular dedicated software. Drawing with a CAD has already completely replaced technical drafting produced on drawing boards as it brings numerous advantages: it implies shorter processing times (especially when editing existing drawings), it allows one to create two and three dimensional models, it permits fast display of perspectives, axonometric projections, exploded views, cutaway axonometric views, renderings and animations. Since the introduction of geometric modeling technology in CAD systems, engineering designers have been able to speed up the design process and improve the design quality as well as collaborate on a design project with co-designers seated in different parts of the world [15].

CAD workstations are computer workstations which are very widespread in a number of work environments (Fig. 1); for this reason there is no standard CAD workstation but rather it is necessary to evaluate the characteristics which may be considered common to all CAD workstations on a case-by-case basis. Although drawing is not the sole activity carried out at some workstations, drawing sessions are generally quite prolonged and operator attention is drawn almost exclusively toward the screen which constitutes the main element of vision. Another characteristic element is represented by screen polarity [16]; most CAD drawing software is set to negative polarity by default (a black or dark background color with white or light colored text); this setting can be modified by the user, but it is the most widespread configuration [1]. CAD requires a substantial effort on behalf of the visual system, so it would be appropriate that the workstation be adequately designed for attempting to guarantee satisfactory visual comfort in order to reduce visual fatigue to a minimum. Visual system disorders (visual fatigue) deriving from the use of VDTs, are referred to in specialized literature as asthenopia. Occupational asthenopia is defined as a syndrome caused by working factors and assignments which, together with the ophthalmic characteristics of the subject, facilitate the outbreak or reiteration of a set of ocular and/or visual symptoms which, in the most serious cases, may also be accompanied by general disorders [3,17]. In specialized technical literature [6,9,18] it is an accepted fact that the use of VDTs, especially if prolonged in time, can also cause musculo-skeletal disorders and worsen forms of stress and mental fatigue nowadays identified in the scope of work related stress.

Due to the large variety of both the work environments in which CAD workstations have been installed as well as the tasks carried out by workers, it is difficult to find a lighting solution which is repeatable for all possible CAD workstations. On the other hand it is simpler and more effective to establish principles of "visual ergonomics" which enable to reach adequate levels of comfort in any possible lighting situation [4,10,19,20,21].

Lighting requirements of VDT workstations (including CAD workstations) are introduced and described in two international technical standards [22,23]: ISO 9241-6 (1999) and EN 12464-1 (2011). ISO9241-6 describes the ergonomics requirements for office display terminals (VDTs); concerning lighting, the importance of controlling glare and of using an appropriate distribution of luminance are highlighted. EN 12464-1 specifies lighting requirements for indoor workplaces in order to comply with requirements for visual comfort and visual performance in persons having normal ophthalmic (visual) capacity.

CAD work is often carried out in strong ambient lighting conditions (high luminance of background elements entering the field of view). The high contrast in luminance between all the surfaces which enter in the field of view (i.e. display, work plane surface, background surfaces) can lead to visual fatigue. In order to ensure an adequate lighting comfort, when the user observes the display (static visual condition) ratios between the luminance of the display (object of the visual task, L_{VT}) and the luminance of the area surrounding the visual task (objects in the background, L_B) should be kept in the following range [21-25]: $1/3 \leq L_{VT}/L_B \leq 3$. Similarly the ratios between the luminance of the surfaces that are observed in sequence (dynamic visual condition), in other words the luminance of two consecutive objects of the visual task (e.g. the luminance of the display, L_{VT1}, and the luminance of a white paper on the desk, L_{VT2}), should be kept in the range [21-25]: $1/10 \leq L_{VT1}/L_{VT2} \leq 10$.

This problem could be worse in the presence of natural light, which if not correctly screened, can cause annoying reflections on the screen and, in the worst cases, glare and visual discomfort. It is thus possible to state that users are frequently exposed to environments in which it is not possible to control the distribution of luminance and that they may experience visual fatigue.

In order to assess the effective level of lighting comfort which is characteristic of a CAD workstation it is essential to analyze habitual working practices via in situ measurements or informational questionnaires handed out to operators or by using both such tools [21,24,25,26].

3. Methods

Questionnaire design is very important in that even slight differences in question structure may lead to differing results. It has been demonstrated [27] that different wordings of the same question rarely produce a consistent answer. It seems evident that a less than accurate design of the questionnaire would cause result processing and extrapolation of final considerations to be problematic.

The questionnaire presented in this study was developed between September 2012 and March 2014 (within the scope of the activities of the Lighting and Acoustics Laboratory of the University of Pisa) with the aim of conducting a statistical study for evaluating visual ergonomics and visual comfort of a CAD workstation.

In order to avoid acquiescence bias [28] simple questions were formulated based on objective parameters and avoiding subjective evaluations. The questionnaire was designed with a limited length and the questions were written in a clear and unambiguous way and a sample potentially interested on these issues was selected. Furthermore, to avoid social desirability bias [29], participants completed the questionnaire anonymously.

Before the submission of the questionnaire to the extended sample, a preliminary pilot study was conducted on a selected sample consisting of 10 university students (during the preparation of their master degree thesis in building engineering) and 10 members of the health and safety committee [1,21,24]. The composition of the sample of the pilot study was chosen so that 50% (college students) were competent in the use of CAD and the remaining 50% (member of health and safety committee) had expertise in the health and safety conditions at work. The suggestions obtained during the pilot study have been used to better formulate some questions, for the benefit of the clarity and to rule out any misinterpretation.

A final multiple choice questionnaire was submitted to a sample of 150 university students, who routinely use CAD drawing software. The aim was identify the normal working conditions (in particular the time spent at the VDT, the lighting conditions of the workplace, the settings of the display and the eventual manifestation of visual fatigue phenomena) and how the eventual visual fatigue phenomena are able to influence the working behavior. It is important to note that this type of analysis does not take into account the frequency and the intensity of symptoms as the clinical aspects of the phenomenon of visual fatigue are not objectives of the survey. However, it is important to observe the degree of awareness that the participants demonstrate with respect to the appearance of visual fatigue phenomena even in the absence of specific training on the health and safety to the workplace.

The questionnaire was written in Italian, that is the native speaking of the entire sample, and it was submitted to the sample on paper form. Every person in the sample received and filled out the questionnaire, during breaks in university lectures, in a room of the Lighting and Acoustic Laboratory. Given the size of the room, the people belonging to the sample did not fill out the questionnaire at the same time, but at different times, divided into groups.

Being the sample composed by university students, who routinely use CAD drawing software, during the submission of the questionnaire, it was specified that the object of the investigation was the visual comfort of CAD workstation and hence in order to fill the questionnaire is necessary to consider an usual CAD work day.

3.1 Development of the questionnaire

The assessment questionnaire (Fig. 2) is composed of: an initial informational section for describing characteristics of the sample (age, gender, university degree) and a second section regarding working practices (time spent in front of a computer, habitual working environment lighting conditions, screen settings, visual fatigue). Apart from the initial information, the questionnaire is composed of a total of 8 questions, and in particular by: one open-ended question (Question No.1), four multiple choice questions (Questions Nos. 2, 4, 6 and 8), and three dichotomous questions (Questions Nos. 3, 5 and 7). Question No. 5 asked whether students suffer visual fatigue during CAD design sessions. If the answer was negative the questionnaire is considered complete. If the answer is positive, the interviewee was asked to specify the symptoms with which fatigue arises (Question No. 6, Fig. 2) and whether, in the presence of fatigue, work activities are more difficult to carry out (Question No. 7, Fig. 2). In Question No. 6 the participants were able to choose more than one preference, if fatigue appears in different forms. The list of possible answers in the questionnaire originates from the complexity of symptoms with which occupational asthenopia and Computer Vision Syndrome (CVS) are diagnosed. In the case of a negative answer to Question No. 7 the questionnaire is completed. In the case of a positive answer the questionnaire continues with the last Question (Fig. 2). In Question No. 8 participants were asked to describe their behaviour when difficulties arise in order to highlight any compensatory action adopted.

3.2 Participants

For this survey it was necessary to identify a sample of individuals who habitually use a computer for CAD drawing, at least 5 hours per week. For this reason, as screening criteria, it was decided to include university students enrolled in the following courses: 'Master’s Degree in Building and Structural Engineering' and 'Master’s Degree (single cycle) Architectural and Building Engineering' at the University of Pisa. Students who took part voluntarily in the survey attended the Lighting and Applied Acoustics course in the periods October 2012-January 2013 and October 2013-January 2014 during the activities planned for the first period of the final year of the master's degrees.

4. Results

The sample who took part in the survey (150 individuals) was composed of 52% males (78 individuals) and 48% females (72 individuals), (see Table. 1). Just over half the participants (55%) were aged between 25 and 30, 42% were aged below 25 and only 3% were aged above 30, (see Table.1). Furthermore, 83% of the participants were students attending a Master's Degree in Building and Structural Engineering and 17% were students attending Master's Degree in Architectural and Building Engineering.

The daily time spent working on the computer by each individual (Question No. 1, Fig. 2) was assessed, referred to the time spent working on the computer for preparing design exams and in particular for CAD design. As shown in Tab. 1, 66% of the sample spends at least six hours a day in front of a screen and the remaining 34% less than five hours.

The type of polarity set by CAD users (Question No. 3, Fig. 2) represents an interesting piece of information, indeed characterizes (provides information about) the object of vision and, together with habitual ambient lighting conditions and screen brightness, defines the context of use. As shown in Tab. 1, 88% of the analyzed sample uses design software with a negative polarity and only 12% uses a positive polarity.

Screen brightness is defined as "an attribute of visual perception in which a source appears to be radiating or reflecting light" and is often inappropriately set by users; in fact, brightness should be adjusted according to ambient lighting conditions. From answers to Question No. 4 (Fig. 2) it is clear that 25% of the sample is not aware of the settings for the screen in use and that almost half (47%) the interviewees set screen brightness to 100% (Tab. 1).

Habitual lighting conditions were then assessed (Question No. 2, Fig. 2). The results are represented in Tab. 1 and reveal that 71% of the sample works in mixed lighting conditions (both natural and artificial), 7% use only natural light and only 3% of the interviewees works in the dark. It should be noted that CAD drafting on behalf of university students is mainly carried out on portable computers in unusual places (e.g. study classrooms and libraries) in which there is no control over ambient lighting and so habitual lighting conditions are "involuntary".

The answers to Questions Nos. 2, 3 and 4, confirm that almost all students work with a negative polarity screen setting (low screen luminance values), but uses the screen with high brightness and contrast settings (large differences between the luminance of a black background and white details on the screen).

Questions Nos. 5, 6, 7 are in-depth investigations into the appearance of visual fatigue phenomena in relation to the main symptoms felt during CAD design. As shown in Tab. 1, 90% of the interviewees (135 out of 150 students), declare they are subject to visual fatigue during their working day. The symptoms more declared by the students are (see Tab. 1): burning eyes, blurred vision, headaches, red eyes, and dry eyes. 87% of the individuals which experience visual fatigue (118 out of 135 students) report that it is more difficult to carry out their work at the computer, while the remaining 13% (17 out of 135 students) declares they manage to continue working with no problems (Tab. 1). Among the participants who having difficulty in continuing their activity at the computer, 50% (59 out of 118 students, Tab. 1) temporarily interrupt their work , thus correctly intervening (as stated by the Italian Legislative Decree 81/2008 [30], see Section 5), considering that the symptoms correlated with the use of VDTs are characterised by a quick reversibility so that visual capacity is readily recovered through an appropriate period of rest. Another 25% (29 out of 118 students, Tab. 1) reduce the observation distance and take on an incorrect posture which causes both visual system as well as musculoskeletal system fatigue. Finally, the remaining 25% (30 out of 118 students, Tab. 1) increases the lighting so increasing the contrast of luminance between the screen and surrounding surfaces and thus accentuating the conditions that caused the appearance of fatigue.

A more in-depth analysis were conducted in order to investigate possible different in the arise of visual fatigue in relation of age, gender, hours of use of the VDT, screen brightness and polarity used (see Tab. 2). The statistical analysis was carried out using crosstabs with Chi-square calculation. P-values less than 0.05 were considered statistical significant.

From the obtained results it is possible to point out the following considerations.

1) In the manifestation of visual fatigue, there was no significant difference between male and female (p=0.47), between different age (p=0.89), and between the positive and negative polarities (p=0.50).

2) The visual fatigue is felt by increasing percentages with the increase of the VDT's hours of use, however the differences are not statistically significant (p=0.58).

3) The manifestation of the visual fatigue is observed for very high percentages in the case of monitors set with high brightness values (75% or 100%) and in the case of people who do not know the setting level of the brightness of own monitor. The latter case can depend on the fact that the default brightness of the monitor is generally or very high (≥75%) or very low (<25%), both cases produce not comfortable visual conditions.

4) The manifestation of the visual fatigue is observed for high percentages of people, for both the polarities of the monitor (positive and negative).

5. Discussion

A survey of working practices at CAD workstations was carried out by submitting a questionnaire to a sample of 150 university students who attend the Faculty of Engineering of the University of Pisa. The questions are related to visual ergonomics and comfort of CAD workstations. In particular, the following areas were investigated: the duration of drafting sessions, screen settings, habitual study environment lighting conditions and any appearance of visual fatigue issues.

In Italy the Occupational Health and Safety act is governed by Legislative Decree 81/2008 [30]. In such Legislative Decree "VDT workers" are defined as "workers utilising equipment provided with video terminals, systematically or habitually for 20 hours per week excluding interruptions". This category of workers is subject to specific health surveillance; in particular, biennial health checks are prescribed for workers over the age of fifty and quinquennial health checks otherwise. Furthermore, it is also prescribed that, they must have a break of 15 minutes every 120 minutes of continuous activity [3,17,30].

Questionnaire results show that university students spend on average 7 hours per day at the computer for CAD drafting; thus, if a five day working week is considered, the weekly total is about 35 hours. It should be considered that, unlike workers, students do not work a predetermined number of days per week and could therefore work for even a greater number of hours.

When university students carry out design activities they are subjected to high workloads at the computer and their effort can certainly be compared with that of VDT workers. While VDT workers carry out their activities in office environments at workstations satisfying ergonomic requirements connected to human posture, university students often make use of laptop in unusual workplaces (e.g. study halls and libraries) in which there is no control over ambient lighting.

From results of question No. 2 it can be noted that many students work in very enlightened environments (lit rooms), i.e. mixed natural and artificial light. From results of question No. 3 it can be observed that negative polarity is much more used. Such conditions cause high contrasts in luminance both within the screen surface between the black background and all light-coloured elements (text, symbols and windows), as well as between screen and surfaces that fall within the field of vision (light-coloured desktops). From results of question No. 4 it can be observed that the students work with high level of brightness. Probably the student set high brightness to try to reduce the contrast of luminance between the display and the others surfaces that fall in the field of view. Furthermore, extensive use of natural lighting (a potentially critical element with regard to optimal display of information on the screen), can prove to be particularly harmful with a negative-polarity screen setting: a black screen (especially shiny screens) is much more reflective.

The questionnaire results show that 135 out of 150 students complain about visual fatigue during long CAD sessions and are able to choose their own symptoms within a list of symptoms correlated with occupational asthenopia [3]. The observed symptoms are those characterising work at the VDT and are descriptive of the main syndromes correlated to it (occupational asthenopia and CVS); in particular the most frequent symptoms are: burning eyes, blurred vision and headaches.

It is interesting to observe that the students of the faculty of engineering demonstrate a considerable interest in the issues related to ergonomics and visual ergonomics of VDT workstation. It is important to consider that the use of laptop for the CAD drawing, is a specific use that requires the use of the mouse and therefore a support surface (desk). In these conditions the angle of observation is different while the viewing distances are usually comparable with those of fixed workstations. Consequently in order to evaluate the manifestation of the visual fatigue, the difference between fixed and mobile (laptop) VDT workstations is not very significant. Very different are instead the repercussions on the postural ergonomics for the use of laptops in place of fixed VDT workstations, but this analysis is beyond the scope of the present study.

6. Conclusions

In this survey the common working conditions and the eventual visual fatigue phenomena were investigated for a sample of 150 university students which can be considered CAD users. The investigation was performed by submitting a questionnaire created by the Authors.

The most part of interviewed students are subjected to strenuous VDT work for CAD drawing. They spent more than six hours per day drawing and their effort can be compared with that of VDT workers.

The results of the questionnaire show that the university students work in highly variable lighting conditions and with lacking of knowledge about the implication of the display brightness settings on the visual comfort.

This has highlighted the importance, for VDT workstations, of not limiting the risk analysis to the postural ergonomics (how usually occurs) but extend it to the workplace as a whole, analyzing also the ergonomics of vision, which involves different consideration on the natural and artificial lighting of the workplace and on the characteristics of the display.

Moreover considering that the students spent a lot of time for CAD drawing in classrooms and study halls where the lighting systems were not specifically designed for VDT use and where they are not able to control ambient lighting, it is important to educate them how to correctly set the brightness values of the display, according to the polarity set and to the ambient lighting, in order to minimize the visual fatigue phenomena.

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Tables

Tab. 1: Results of the questionnaire.

***Questions*/Answers**	**No.**	**Percentage (%)**
Gender		
Male	78	52
Female	72	48
Age groups		
20-24 years old	63	42
25-30 years old	82	55
> 30 years old	5	3
1- How many hours do you observe the VDT in a day?		
Less than 2 hours	4	3
Between 3 and 5 hours	47	31
Between 6 and 8 hours	60	40
More than 8 hours	39	26
2. In which lighting conditions usually work?		
Natural lighting	11	7
Mixed natural and artificial lighting	106	71
Direct artificial lighting	12	8
Indirect artificial lighting (diffuse)	16	11
Darkroom	5	3
3. In which screen condition are you used to draw?		
Black background (Negative polarity)	132	88
White background (Positive polarity)	18	12
4. With which brightness setting of the screen are you used to work?		
Maximum (100%)	70	47
At 75%	24	16
At 50%	17	11
At 25%	2	1
Don't know	37	25
5. During a CAD work day, do you experience visual fatigue?		
Yes	135	90
No	15	10
6. If YES, in which form is revealed visual fatigue? (One or more answers can be selected)		
Burning eyes	79	53
Watering eyes	24	16
Itching eyes	7	5
Dry eyes	30	20
Red eyes	35	23
Blurred vision	57	38
Double vision	17	11
Headaches	46	31
Other	6	4
7. The visual fatigue makes more difficult the reading activities to the monitor?		
Yes	118	87
No	17	13
8. If YES, the visual difficulty is compensated by:		
Increase natural lighting	4	3
Increase artificial lighting	26	22
Reduction of viewing distance	29	25
Suspension of activities	59	50

Tab. 2: Correlation between visual fatigue and gender, age, daily hours of use of the VDT, brightness of the screen, and polarity used.

Gender	**Visual fatigue**	**No.**	**Percentage (%)**
Male	Yes	72	92
	No	6	8
Female	Yes	64	89
	No	8	11
Age			
< 24	Yes	57	90
	No	6	10
25 ÷ 30	Yes	74	90
	No	8	10
> 30	Yes	5	100
	No	0	0
Daily hours of use of the VDT			
> 8 h	Yes	36	92
	No	3	8
6-8 h	Yes	54	90
	No	6	10
3-5 h	Yes	40	85
	No	7	15
< 2 h	Yes	3	75
	No	1	25
Brightness of the screen			
Don't know	Yes	35	95
	No	2	5
100 %	Yes	63	91
	No	6	9
75 %	Yes	23	96
	No	1	4
50 %	Yes	14	78
	No	4	22
25 %	Yes	2	100
	No	0	0
Polarity			
Negative	Yes	119	89
	No	14	11
Positive	Yes	17	94
	No	1	6

Figure captions

Fig.1: Examples of CAD workstation.

Fig. 2: Assessment questionnaire of visual ergonomics and visual comfort of CAD workstation.

Figures

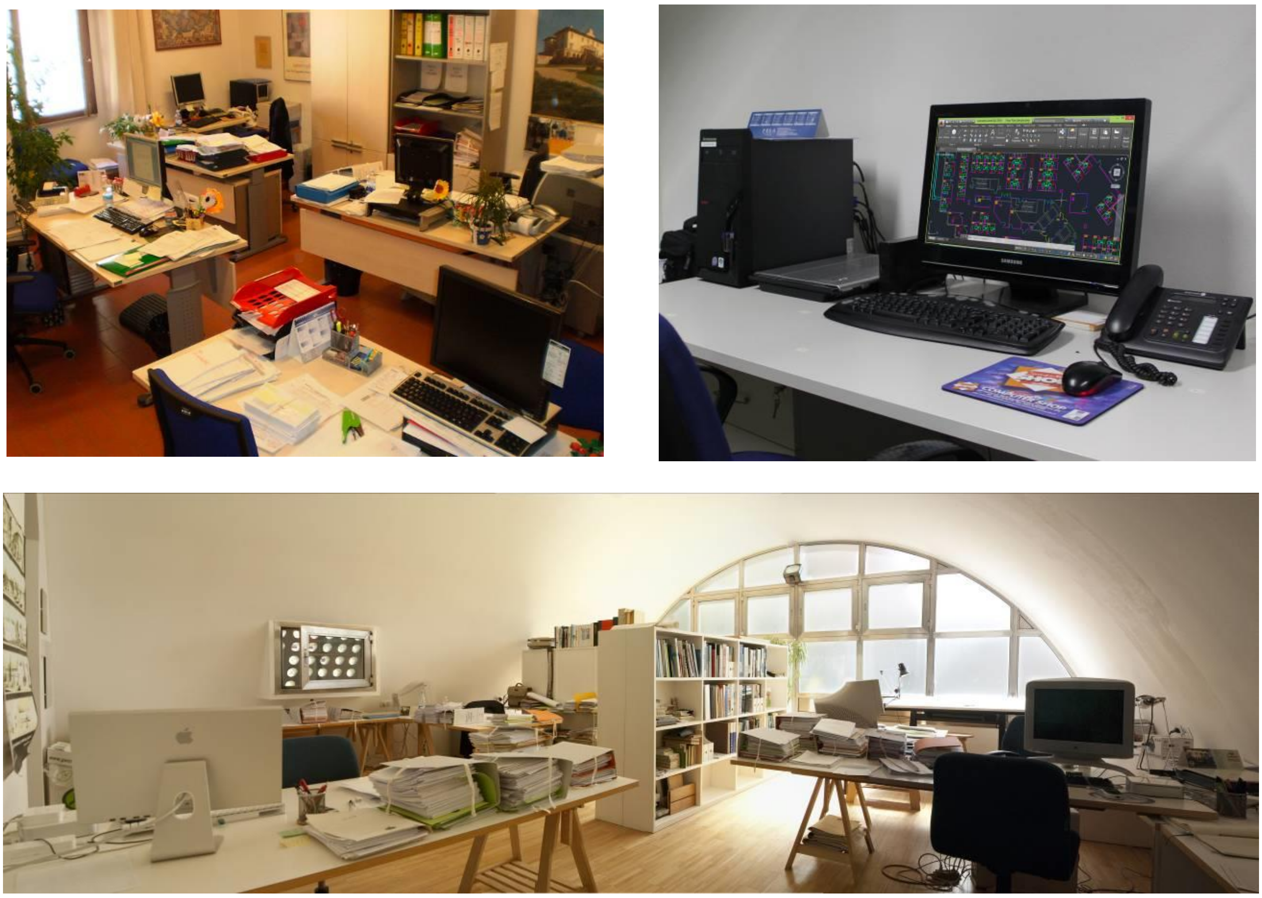

Fig.1: Examples of CAD workstation.

Date of birth __/__/____ Age: _______ Gender: M F
Degree Course:______________ Academic year: __________

1. How many hours do you observe the VDT in a day? _________

2. In which lighting conditions usually work?
a) Natural lighting b) Mixed natural and artificial lighting c) artificial direct light
d) artificial indirect light (diffuse) e) Darkroom

3. In which screen condition are you used to draw?
a) Black background (Negative polarity) b) White background (Positive polarity)

4. With which brightness setting of the screen are you used to work?
a) Maximum brightness (100%) b) Brightness at ___% c) Don't know

5. During a CAD work day, do you experience visual fatigue? Yes No

If No, the questionnaire is completed.

6. If YES, in which form is revealed visual fatigue? (one or more answers can be selected)
a) Burning eyes b) Watering eyes c) Itching eyes d) Dry eyes
e) Red eyes f) Blurred vision g) Double vision h) Headaches
i) Other:___________

7. The visual fatigue makes more difficult the reading activities to the monitor? Yes No

If No, the questionnaire is completed.

8. If YES, the visual difficulty is compensated by:
a) Increase natural lighting b) Increase artificial lighting c) Reduction of viewing distance
d) Suspension of activities e) Other:_______

Fig. 2: Assessment questionnaire of visual ergonomics and visual comfort of CAD workstation.