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The Effects of Physical Environmental Factors on Students' Perceptions in Computer Classrooms

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Key Words

Computer classroom design · Perception · Educational environment · Design preferences · Environmental settings

Abstract

The environmental setting has a direct impact on perception, comfort, motivation, and concentration in learning environments. Accordingly, in computer classrooms, technological equipment and classroom settings can enhance psychological comfort and the learning environment. With this in mind, seemingly subtle differences in interior design/layout, as opposed to the larger matters of architectural design and floorplan, were assumed to influence the perceptual performance of design students. To verify this hypothesis, the atmospheric attributes of two computer classrooms used to teach 3Dmax and AutoCAD drawing programs at the Department of Furniture and Decoration of Technical Education Faculty at Gazi University, Ankara, Turkey, were tested by eliciting responses to ten bipolar semantic differential items on a Likert-style scale. Results showed that differences in the environmental settings of each classroom had an important influence on the perceptual evaluations of students. Factors such as proximity/distance of pieces of equipment to one another, roominess/crowdedness in terms of the placement of the PC boxes, the presence of paintings and plants, and attention to circulation and sightlines, were observed to have an effect on whether student participants perceived a space positively or negatively. These results imply that preparing an optimal environment would encourage a good relationship between the student and his or her environment, thereby encouraging more productive learning and better motivation and concentration.

Introduction

The setting of a computer classroom is as important as that of a traditional classroom environment. In recent years, there has been an increased emphasis on the design of university computer classrooms in order that technological equipment and classroom settings can work to enhance the learning environment. Most recently, Walden [1] has emphasised that in relation to human well-being, designers should consider spatial conditions including colour scheme, lighting, heating, cooling and ventilation,

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acoustics, smells and furnishings. All of these aspects can significantly influence the student's sense of well-being and readiness to learn, and therefore also enhance learning performance [2]. Gifford [3] has indicated that students would learn better in a well-designed classroom and could be distracted by a poorly designed space. Also, along with students, teachers could also be affected by classroom settings, and may teach better in pleasurable classrooms where they feel their performance is enhanced. Luppicini [4] related a user response that exemplifies the importance of a personal interest in design decision-making:

> I am a teacher. There is a need to change the classroom design to meet educational reforms... There are desk centred classrooms with computers in front... The classroom could be less structured with more space...

Luppicini's study focused exclusively on the effects of physical environmental factors such as furnishings with regard to the effect of spatial and aesthetic quality on the perceptual performance of students in a computer classroom, leaving aside such variables as climate control, lighting, acoustics and olfactory perception.

It is clear that psychological comfort is as important as physical comfort in learning environments. Students' feelings, thoughts and behaviours are intrinsic to psychological comfort, which affects how students interact with and interpret their environments. Previous studies in the literature have focused on the design of computer classroom settings primarily with regard to three physical characteristics: seating arrangements, ergonomics and environmental factors. However, few studies have studied or comparatively examined the user perceptions of the environment apart from the physical settings. Such studies are briefly mentioned below for reference and to provide a background for this study.

Seating Arrangement

Seating arrangement is the most important issue with regard to collaborative learning and performance in computer classrooms. Many studies have examined the strengths and weaknesses of various seating arrangements in computer classrooms [5–11]. On the other hand, Emmons and Wilkinson [12] have explained that each seating arrangement has its own strengths and weaknesses. In addition to applying learning theory to the classroom arrangement, the interior designer should take into consideration local needs and constraints. The designer must also adhere to generally agreed upon ergonomic design principles. Furthermore, the instructor's workstation must provide complete control over the classroom environment, making it simple to switch between learning activities. Ideally, students should be able to see the instructor, as well as the screen and whiteboard, at the same time. If possible, no students should have their backs to the screen. A review of the literature suggests that the best seating arrangement in computer classrooms is a large seminar table, with students facing each other from end-to-end, thereby meeting the following considerations:

- Discussion and collaborative learning are encouraged
- More space is provided for improved circulation

Ergonomics

Additionally, the ergonomic design of computer classrooms must safely blend the design of the facility and the layout of the technology with human learning and performance factors [7,9,13–16]. According to Laeser et al. [7], teachers, learners and educational materials are considered to be the basic ingredients of the teaching and learning process, but the physical environment in which learning occurs is often neglected. The growth of classroom computer use necessitates consideration of ergonomic design issues that can support new modes of learning while minimising the negative health effects associated with the use of computers. In accordance with the literature, for an optimal ergonomic environment, the following issues related to users should be considered:

- Potential health impacts of equipment
- Screen height
- Viewing angles
- Workstation height and chair styles

Environmental Factors

Environmental factors, including acoustics, climate control, colour and lighting should provide for comfortable function in a computer classroom. Many researchers have examined the physical space of a classroom to determine its effectiveness in allowing students and teachers to function comfortably in the environment [15,17–21]. According to Owu [21], the layout of a classroom should direct the attention of students towards the instructor and the presentation area. Attention should also be given to aesthetics, including form, line, colour, texture and visual variety. Stuebing et al. [19] has found that a change in the physical environment would foster changes in teaching and learning. The design and arrangement of classroom furniture must adopt and support interactive technology. Furthermore, storage needs are greatly increased in the technology-rich

Table 1. The characteristics of the two computer classrooms used in the research

Interior design characteristics	Experiment 1 (Classroom 1)			Experiment 2 (Classroom 2)		
	Dimensions	Colours	Materials	Dimensions	Colours	Materials
Fine Structure						
Wall covering	–	Ivory	Plastic-oil paint	–	Ivory	Plastic paint
Floor covering	–	Oak	PVC (with tie figure)	–	Oak	PVC (with tie figure)
Ceiling covering	–	White	Plastic ceiling	–	White	Plastic ceiling
Entrance door	100 × 215	Oak	Covering	100 × 215	Oak	Covering
Window	200 × 200	Brown	Wooden	200 × 200	Brown	Wooden
Furniture						
Coat hanger	20 × 300	Beech	Melamine covered chipboard	85 × 120	Beech	Melamine covered chipboard
Material cabinet	90 × 50 × 208	Beech	Melamine covered chipboard	70 × 33 × 200	Beech	Melamine covered chipboard
Teacher table	150 × 60 × 76	Beech	Melamine covered chipboard	190 × 60 × 76	Beech	Melamine covered chipboard
Student table	70 × 50 × 76	Beech	Melamine covered chipboard	71 × 57 × 76	Beech	Melamine covered chipboard
Projection board	254 × 7 × 203	White	Laminated chipboard	246 × 7 × 203	White	Laminated chipboard
Projector	30 × 30 × 10	Metallic	Plastic covering	30 × 30 × 10	Metallic	Plastic covering
Board	216 × 2 × 116	White	Laminated chipboard	216 × 2 × 116	White	Laminated chipboard
Teacher chair	45 × 60 × 45/90	Mustard	Fabric	60 × 60 × 45/90	Claret	Fabric
Student chair	40 × 45 × 45/80	Blue	Fabric	40 × 45 × 45/80	Blue	Fabric
Radiator enclosure	259 × 34 × 70	Beech	Melamine covered chipboard	242 × 32 × 72	Beech	Melamine covered chipboard
Trash can	30 × 30 × 40	Grey	Plastic	30 × 30 × 40	Grey	Plastic
Painting frames	–	–	–	70 × 4 × 50	Brown	Wooden

classroom, including the need for accessible space for temporary storage. Stuebing concluded that a collaborative learning and teaching classroom needs to be arranged to support a collaborative working area. Allen [6] indicated that the furniture requirements of a computer classroom should include appropriately-sized tables, usable rolling chairs, whiteboards, bulletin boards and various decorative items. According to Coppola and Thomas [22], critical input issues should revolve around layout design, furniture style, number of chairs and printing requirements in a physical layout. Factors such as desktop space and student–teacher eye contact are held to be important issues in terms of student comfort and satisfaction when choosing furniture.

As is clear from this literature review, available studies generally address how computer classrooms are related to different sorts of physical comfort related to such computer or electronic classroom design factors as territorial needs and user preferences in terms of perceptions and social interactions, and how these affect psychological comfort. These findings should be taken into consideration in developing a pleasant and effective computer classroom space. However, this study has focused on determining the effects on student users' perceptual evaluations of computer classrooms designed with identical plans, layouts and dimensions, but differing as to the placement of PC boxes, the presence or absence of paintings and plants, and the tighter or looser seating arrangement allowing for greater or lesser circulation areas. Given the assumptions articulated above, the following hypothesis concerning the positive/negative effect of these physical environmental factors on the perceptual evaluations of students emerges.

In two computer rooms (1 and 2), having identical plans, layout and dimensions, the placement of PC boxes, whether on the table (1) or under the table (2); the presence of paintings and plants (1) or an absence of them (2); and a looser seating arrangement with a smaller circulation area (1) and a tighter seating arrangement with a larger circulation area (2) will have a significant impact on the perceptual evaluations of student users.

Methods

The following methods were employed to test the hypothesis.

Respondents

The research was carried out in the Department of Furniture and Decoration of the Technical Education Faculty at Gazi University, Ankara, Turkey. About 60 respondents, who had previous experience with the computer classrooms in the faculty, were chosen from among a total of approximately 70 senior class design students to complete a ''questionnaire on perceptual performance''.

Table 2. Means, SD and *t*-values of the dependent variables regarding the perceptual performances of students

Dependent variables	Computer classrooms				
	Experiment 1 (Classroom 1)		Experiment 2 (Classroom 2)		*t*-Values[b]
	$\overline{X}$[a]	SD	$\overline{X}$	SD	
Beautiful/ugly	2.66	1.07	1.76	0.72	−5.933*
Pleasant/unpleasant	2.86	1.29	1.93	0.73	−6.902*
Calming/agitating	3.03	1.20	2.06	0.93	−7.878*
Warm/cold	2.60	1.06	2.10	1.05	−7.195*
Bright/dark	2.01	0.92	1.66	0.93	−3.259*
Attractive/unattractive	3.08	1.16	2.21	1.02	−8.739*
Interesting/boring	3.06	0.97	3.00	1.17	−14.663*
Active/stationary	3.21	1.18	2.76	1.15	−11.910*
Large/small	2.83	1.10	2.28	1.10	−8.593*
High/low	2.20	1.02	1.96	1.00	−5.391*

$\overline{X}$, mean value; SD, standard deviation.
[a]Variable means ranged from 1 to 5, with higher numbers representing more negative responses.
[b]*t*-Values: the results of comparing variables of interior design characteristics.
*$p < 0.001$.

All the respondents were male, and between the ages of 18 and 23. The data for this study were obtained during the weekdays at various times of the day through face-to-face meetings in the computer classrooms during a 2-week period in 2008. At the outset, the students were briefly informed about the survey and were then asked to complete the questionnaire after visiting and viewing each computer classroom. It took the students approximately 15 min to complete each questionnaire.

Questionnaire Design

The questionnaire consisted of two sections:

- General information about the respondent (age, classroom, department).
- A five-point Likert-style semantic differential scale eliciting responses concerning the participant's perception of the two computer classrooms.

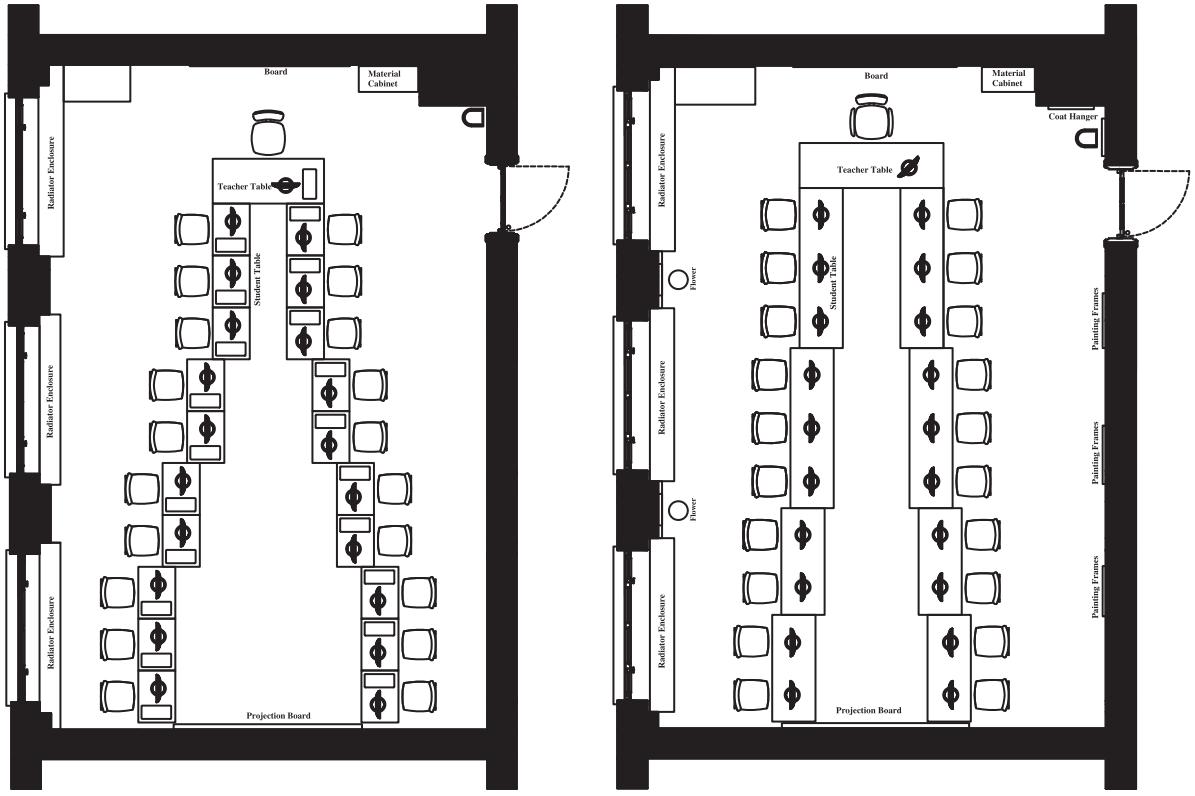
The participants were asked to evaluate each of ten bipolar adjective pairs on a five-point semantic differential scale. A total of ten such pairs – *beautiful/ugly*, *pleasant/unpleasant*, *calming/agitating*, *warm/cold*, *bright/dark*, *attractive/unattractive*, *interesting/boring*, *active/static*, *large/small*, *high/low* – were evaluated by the students after they were familiarised with the items. The technique of altering the sets of items from positive to negative, as done in various previous studies [23–32] was adopted to reduce the probability of respondents simply marking the scale randomly or on either of the extremes. In compiling the initial list of items, the intention was not to be overly specific, but rather to develop a list of general attributes that would suit the research topic – the design environment.

Environmental Setting

Two computer classrooms used for teaching 3Dmax and AutoCAD drawing programs in design education at the Department of Furniture and Decoration of the Technical Education Faculty at Gazi University, capable of accommodating about 20 students each, were used as the research setting in this study. The second-floor (European) computer classrooms were adjacent to one another in the same building, and both faced southeast. Details such as lighting, colour, materials and accessories have a significant effect on the perception and evaluation of an interior space [30,33–35]. Consequently, it was decided that the computer classrooms used as research environments must have the same plan type and physical settings (i.e. daylight, artificial light and air temperature) to accurately measure the differential effect of interior design elements (i.e. layout, interior elements, materials, accessories).

The environmental settings of these two computer classrooms were as follows:

- The rooms were the same size (53.4 m^2 each).
- Along the southeast wall were four square windows (one for each bay), measuring 200×200 cm^2. The windows were all operable and the prevention of daylight glare could be controlled with curtains when required.
- Daylight on the southeast facade on a clear day would register approximately 550 lm power on a light meter



Experiment 1 (Classroom 1) *Experiment 2 (Classroom 2)*

Fig. 1. Layouts of the two computer classrooms.

during 80% of the workday, which provided sufficient illumination levels without glare for working.

- The use of artificial light inside the classrooms was inevitable. Mounted in the 2.60 m-high suspended ceiling were fluorescent light fittings, each with 160 lx (4×40 lx), providing sufficient general illumination at the floor and table level.
- The internal air temperature – with the help of air conditioning in summer – was maintained between 22°C and 24°C in both computer classrooms.
- The rooms differed only with regard to the placement of PC boxes – on the table or under the table – and the presence or absence of paintings and plants.

Architectural floor plans and photographs of the two computer classrooms used in the study are given in Figures 1 and 2, respectively.

The interior design characteristics of the two computer classrooms (*classroom 1 and classroom 2*) are given in Table 1.

Statistical Analysis

Various factors are known to affect students' environmental perceptions. The differences in the interior design characteristics of the computer classrooms were considered among these factors and were accepted as independent variables. The data of the research were analysed in order to test the hypothesis of the study. The Cronbach's alpha coefficients of the dependent variables were calculated and a correlation test applied to determine whether there were relationships between the dependent variables. Afterwards, categorical means of the data were defined together with their standard deviations and *t*-values. Subsequently, a one-way analysis of variance (ANOVA) was applied in order to examine the effects of the differences in interior design characteristics on the perceptual evaluations of students in the context of computer classrooms. The data are given in graph form, showing comparisons of the significant means of the variances as revealed by the ANOVA.

Results

The reliability of the semantic differential items, including the design students' perceptual evaluations of the two computer classrooms, was tested via the Cronbach's alpha. The resulting coefficient estimate of

Experiment 1 (Classroom 1) *Experiment 2 (Classroom 2)*

Fig. 2. The two computer classrooms.

the internal consistency of the scale, encompassing the average scores for the ten bipolar semantic differential items, was 0.88. The coefficient of each item was above 0.70, representing good reliability according to some researchers [36–41]. Therefore, the scale may be considered reliable.

In the next phase of the analysis, the statistical relationships between the design students' perceptual evaluations of the differences in the interior design characteristics of the computer classrooms were analysed. The results of the research questionnaire are given in Table 2, including the mean, standard deviation (SD) and *t*-value for each of the items under the dependent variables. The differences in the interior design characteristics of the computer classrooms seem to have had positive/negative effects on the perceptual performances of students when the means and *t*-values in Table 2 are considered.

The differences between the design students' perceptions of the different interior design characteristics in the two computer classrooms were tested using the ANOVA. As shown in Table 3, the differences for the dependent variables *beautiful*/*ugly*, *pleasant*/*unpleasant*, *calming*/*agitating*, *warm*/*cold*, *bright*/*dark*, *attractive*/*unattractive*, *interesting*/*boring*, *active*/*stationary* and *large*/*small* were found to be statistically significant (at the level of $p<0.05$) across all the semantic differential items. It appears that each of the computer classrooms had an important effect on the perceptual evaluations of the design students, a result which supported the hypothesis. Therefore, it may be concluded that the differences between the interior design characteristics of these two computer classrooms with identical plans, layout and dimensions had a considerable effect on the students' perceptions. More specifically, it can be said that the differences between the placement of PC boxes (i.e. on the table, under the table), the presence or absence of paintings and plants, and the tighter or looser seating arrangement allowing for greater or lesser circulation areas in the computer classrooms would strongly affect students' perceptions of the spaces.

The graphs showing the differences between the students' evaluations of the physical environmental factors of the two computer classrooms depending on their perceptual performances are given in Figure 3.

As shown in Figure 3, it was found that student perceptions of each of the two different interior design characteristics of the computer classrooms were statistically different for all of the items included in the semantic

Table 3. ANOVA results of the dependent variables regarding the perceptual performances of students

Dependent variables		Sum of squares	*df*	Mean squares	*F*	Results
Beautiful/ugly	Between groups	200	1	24.300	28.655*	0.000
	Within groups	100.067	118	0.848		
	Total	124.367	119			
Pleasant/unpleasant	Between groups	26.133	1	26.133	23.600*	0.000
	Within groups	130.667	118	1.107		
	Total	156.800	119			
Calming/agitating	Between groups	28.033	1	28.033	24.029*	0.000
	Within groups	137.667	118	1.167		
	Total	165.700	119			
Warm/cold	Between groups	7.500	1	7.500	6.715*	0.011
	Within groups	131.800	118	1.117		
	Total	139.300	119			
Bright/dark	Between groups	3.675	1	3.675	4.238**	0.042
	Within groups	102.317	118	0.867		
	Total	105.992	119			
Attractive/unattractive	Between groups	22.533	1	22.533	18.624*	0.000
	Within groups	142.767	118	1.210		
	Total	165.300	119			
Interesting/boring	Between groups	10.800	1	10.800	9.208*	0.003
	Within groups	138.400	118	1.173		
	Total	149.200	119			
Active/stationary	Between groups	6.075	1	6.075	4.455**	0.037
	Within groups	160.917	118	1.364		
	Total	166.992	119			
Large/small	Between groups	9.075	1	9.075	7.410*	0.007
	Within groups	144.517	118	1.225		
	Total	153.592	119			
High/low	Between groups	1.633	1	1.633	1.586 ns	0.210
	Within groups	121.533	118	1.030		
	Total	123.167	119			

df, degree of freedom; ns, not significant.
*, **α: 0.01 and 0.05 are the levels of significance.

differential scale (*beautiful/ugly*, *pleasant/unpleasant*, *calming/agitating*, *warm/cold*, *bright/dark*, *attractive/unattractive*, *interesting/boring*, *active/stationary*, *large/small*, *high/low*). For all variables, the range of the computer classrooms from the most positive value to the most negative value can be arranged as: *experiment 2* (classroom 2) > *experiment 1* (classroom 1).

To summarise, it was clearly shown that there was a statistically significant difference ($p < 0.05$ level) between student perceptions of the interior design characteristics of *experiment 1* (classroom 1) and *experiment 2* (classroom 2) for these variables.

Experiment 2 (classroom 2) was evaluated as more beautiful, pleasant, calming, warm, bright, attractive, interesting, active, large and high than *classroom 1*. These results demonstrate the effect due to the differences in interior design characteristics of the computer classrooms having identical plans, layout and dimensions. In *classroom 2*, only the computer screens were on the desktops, with the computer tower stowed underneath the tables, whereas in *classroom 1* everything was placed on top of the tables. The perceived difference in the brightness of the two computer classrooms may have been a result of the efficient reflection of the southeast daylight from the windows off the light-coloured materials and colours of the walls and tables. That difference could also stem from the interior design decision to use stationary/classical type (four fixed legs) seating rather than active (rolling) chairs. It may be said that *classroom 2*, which contained plants, was perceived as more calming, warm, pleasant and attractive. In addition, perhaps because of the visual elements on the wall surfaces of *classroom 2* (framed pictures); it was also perceived as warm, interesting and active. As mentioned above, it has been seen that *classroom 2*'s closer table arrangement and the stowing of PC boxes and cables beneath the tables resulted in an

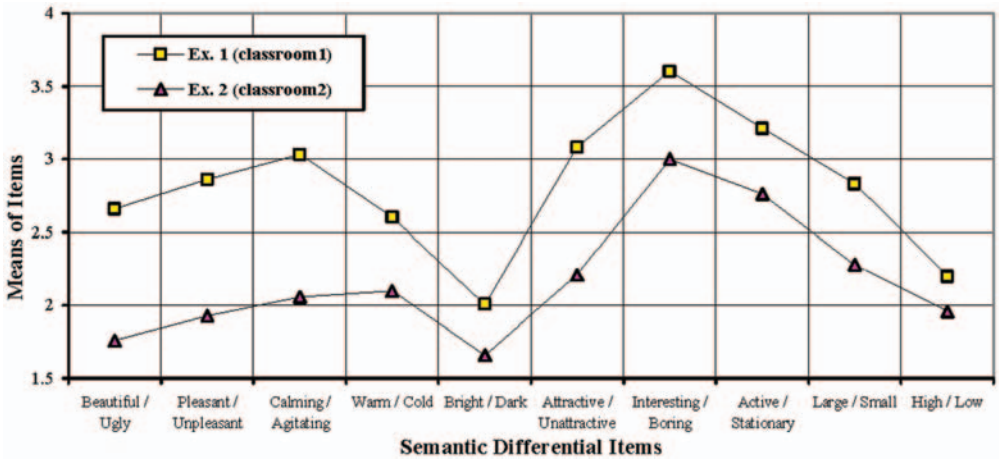


Fig. 3. The effect of physical environmental factors on perceptions of the computer classrooms.

environment that was perceived to be more pleasant, calming and large.

Discussion

The results of this study expressly demonstrate that the perceptual responses to computer classrooms designed with identical plans, layout and dimensions, but with varying interior design characteristics were found to be statistically significant (at the level of $p < 0.05$). *Experiment 2* (Classroom 2) was perceived more positively due to its different interior design characteristics (its closer table arrangement, which provided a greater circulation area with lower density, and the presence of paintings and plants), despite having architectural attributes (physical settings including acoustics, climate, colour, lighting, window dimensions and space) identical to those in *Experiment 1* (Classroom 1).

According to these results, factors such as the *proximity*/*distance* of pieces of equipment to one another; the *roominess*/*crowdedness* with respect to the PC boxes (i.e. on the table, under the table); the presence of paintings and plants; the increased size of circulation areas; and clearer sightlines are design criteria that carry substantial weight and merit attention with regard to occupant-interior communication. In examining computer classrooms at different scales and under e-designs at different times, Arlitsch [8] has shown the effect on the perceptual responses of students of the layout and arrangement of furniture and equipment, a result in line with the current research. In addition, the current results demonstrate that covering a table surface with computer equipment both makes it difficult for students and teachers to see one another and the screen and also hampers communication and discussion in the classroom.

In this study, *classroom 2* received a more favourable result than *classroom 1*. Its environmental conditions were perceived more positively, and the perceived spatial comfort in *classroom 2* was greater because of placing monitors only on the tabletops (stowing PC boxes, keyboards and cables under the table), not to mention the *roominess*/*crowdedness* balance based on a tighter table arrangement. McCreary et al. [42] pointed out that mounting tower-style computer cases in a tray under the desk and providing retractable trays under the table for keyboards maximises desk surface area. Also, it may be said that the ease of social interaction between students and instructor was enhanced by the tighter arrangement of the tables. In addition, the plants and framed pictures in *classroom 2* appeared to have had a positive effect on the perceptual evaluations of the students. Allen [6] has indicated that a computer classroom needs to include large green plants, colourful posters and a large bulletin board used by both teachers and students, all of which could contribute to a friendly atmosphere, as they would in any room. Also, Walden [1] has pointed out that environmental settings give students the opportunity to interact more directly with their learning environment and to identify with it, enhancing not only the student's general well-being but also his/her motivation to learn and perform.

Conclusion

Based on these results, differences in interior design characteristics in two classrooms having the same

architectural plan had a substantial influence on the perceptual evaluations of design students. Further, these results demonstrate that a preference for an environment is related to the perception of comfort. It seems clear that design factors can stimulate learning, and satisfy not only the student's physical needs but also his or her psychological needs in terms of motivation, concentration and comfort. The findings of this study suggest that the perceptual evaluations of students, especially in the design of computer classrooms in educational institutions should be given precedence.

Based on these findings, four guidelines are offered here along which physical environmental factors may reasonably be developed or modified:

- Environmental factors have a direct impact on psychological needs in terms of concentration and motivation. With this in mind, planners, architects and interior designers should pay heed to what types of environmental settings are most salutary and how best to make computer classrooms suitable for students.
- Elements of interior design and decoration should be arranged so as to encourage discussion and collaborative learning, and to make computer classrooms more flexible places.
- Plants may be important decoration elements, supplying a warmer atmosphere within the technological infrastructure of a computer classroom. In this direction, the authors suggest the use of plants in interiors to dilute the predominance of electronic equipment and improve the quality of technology–people relationships in computer classrooms.
- Similarly, it may be advisable in classroom design to employ textiles and woven fabrics, rather than plastic materials, to enhance environmental quality and user perception of computer classrooms.

Educational institutions and their planners, architects and interior designers can use these results and suggestions to enhance and user experiences with classrooms and make them more pleasurable, and thereby improve the success of students through improving their motivation and concentration.

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