Cognitive and space ergonomics in the schools computer laboratories

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ABSTRACT
The present article describes the features of the schools computer laboratories of the Greek primary and secondary education and the conditions that are encountered in didactics because of the arrangement of their workstations. These conditions concern the ergonomics of space regarding the equipment along with the cognitive consequences on the learning process. For dealing with the presented situation, the various modes of arrangement are compared according to the guidelines of cognitive ergonomics, accompanied by relevant suggestions that were successfully applied in school practice and can be generally useful in similar occasions.

KEYWORDS
Cognitive ergonomics, space ergonomics, computer laboratory

RÉSUMÉ
Le présent article décrit les traits des laboratoires informatiques scolaires de l’éducation primaire et secondaire grecque et les conditions rencontrées lors l’enseignement résultant de l’aménagement des postes de travail. Ces conditions concernent l'ergonomie de l'espace par rapport à l’équipement ainsi que les conséquences cognitives du procès d'apprentissage. Pour affronter la situation présentée, les différents modes d’aménagement sont comparés selon les règles de l'ergonomie cognitive, accompagnés par des suggestions relatives qui ont été mises en œuvre avec succès dans la pratique scolaire et peuvent être généralement utiles dans des occasions similaires.

MOTS-CLÉS
Ergonomie cognitive, ergonomie de l'espace, laboratoire d'informatique

INTRODUCTION

The quality of the teaching/learning process that it is conducted in the **s**chools **co**mputer **lab**oratory (henceforth SCoLab) depends on various factors that include the suitability of hardware and software, the curriculum, the arrangement of equipment in the available space and the existence of other teaching devices. Especially in the teaching practice, the authors encountered difficulties that led to a relevant experimentation for the discovery of the most effective solution (Papakitsos & Chorozoglou, 1998). The difficulties in the teaching practice were caused by the arrangement of the devices of the SCoLab and the effect of these arrangements to the easiness of the learning activity, to interface navigation, to supervise/monitor and assist students and finally to the acoustics and visibility of the SCoLab.

In order to improve the teaching practice, the authors consulted firstly the relevant official regulations (HMERA, 1989). For the last 25 years, until the most recent official document about the SCoLab specifications (DIOFANTOS, 2015), these regulations refer only to the technical requirements of the hardware and software but not to the didactical ones. From previous experience, using the computer laboratories of post-secondary vocational and tertiary education, it was ascertained that the arrangement of workstations being proposed was not necessarily suitable for primary and secondary education students.

Another official document that contains guidelines for setting up a SCoLab, considering as well the ergonomics of the arrangement of the equipment and workstations, although since 1998, is quite classic (Pedagogical Institute, 1998). In this document, there are three different modes of arrangement proposed that they will be described in the next section.

ARRANGEMENT MODES

The arrangement modes of the SCoLab have been adopted from the equivalent ones of the tertiary education institutions (Garger, 2011) to cover different didactical requirements. Three of these popular modes will be conventionally called herein as:

- The *perimeter's* (or *Inverted U-shaped*), where the workstations are placed along the walls of the lab (Figure 1);
- The *parallel* (close to *U-shaped*), where the workstations are placed in parallel rows, leaving a corridor between them, while the middle rows are placed back-to-back (Figure 2);
- The *tandem* (or *classic*), where the workstations are placed in rows, facing the direction of the board (blackboard, interactive board or projection screen; see Figure 3).

All of the modes were tested for their didactic functionality in consecutive years, according to certain criteria, as it will be exemplified below.

DIDACTICS SPECIFICATIONS

In order to compare the different modes of arrangement for the SCoLab workstations, and consequently for the rest of the teaching equipment that has been also deemed diachronically necessary (GCS, 1997; CIE2015, 2015), the authors had to define the relevant didactics specifications. These specifications have to conform to the guidelines of cognitive and physical/space ergonomics (Helander, 1997; Wickens, Gordon & Liu, 1998; Hendrick, 1999). Poor performance in physical/space ergonomics may cause a physical fatigue that results in mental fatigue as well (Karwowski, 1991; Wickens, 1992; Smith, 1993).

Thus, especially for cognitive ergonomics (Hollnagel, 1997, 2001; Hoc, 2000, 2001), which are our goal for the optimum arrangement of the equipment, the generally accepted guidelines are the following (Papakitsos, 2015):

a) to enforce the safe execution of a task;
b) to reduce the percentage of errors;
c) to increase productivity and effectiveness;
d) to ensure comfortable conditions that satisfy the users of a system.

Adapting and determining these guidelines for the didactical activity, concerning the students, we look for:

- easiness of visibility towards both the computer screen and the board (b-d);
- safety of the students regarding the cable-lines and the radiation of the devices (a).

Concerning the teachers, we look for:

- easy access to the work-stations (b, d);
- good surveillance of the room for the prompt intervention at the emergence of any problem (a, b);
- facilitating the usage of didactical equipment (c, d).

Considering the above requirements, a comparison and evaluation of the arrangement modes had been conducted, as described in the next section.

MODE COMPARISON & EVALUATION

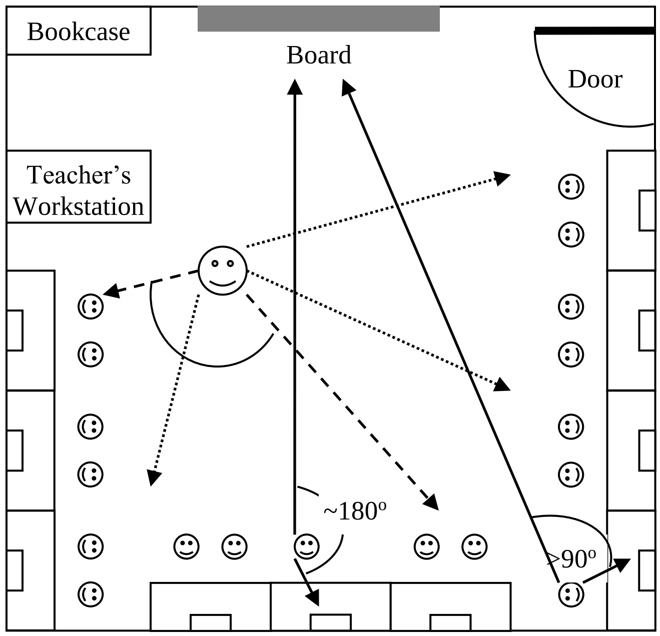
The learning environment of a SCoLab is very similar to a working environment using computers (Pedagogical Institute, 1998, p. 2), regarding though the physical ergonomics of a workstation. In addition, there are specific considerations, necessary for facilitating a learning process (Rook, Choi & McDonald, 2015). Thus, the ergonomic design of a learning environment is very important for achieving didactic goals. Accordingly, each arrangement mode offers a somewhat different learning environment.

The perimeter's mode (Figure 1) offers increased safety (ii) but poor easiness of visibility (i). Most students have to turn from 90^o to 180^o degrees in order to have visual contact with the board. In addition, the row of workstations opposite to the board may have a distance from it up to eight (8) meters, according to the size of the lab, which is rather far-away. The accessibility of the teacher is good (iii) but the surveillance is good merely for 1/2 to 2/3 of the lab at any given time (iv).

The parallel mode (Figure 2) offers safety (ii) for the side-ways rows of the workstations but it requires vertical cable-lines for the middle rows. Half of the students have to turn 120^o degrees for attending the board. The teacher has poor accessibility (iii) to half of the lab, depending on the corridor that he/she is situated, having to move in a circular path. The surveillance (iv) is also very poor for 1/3 of the lab at any given time.

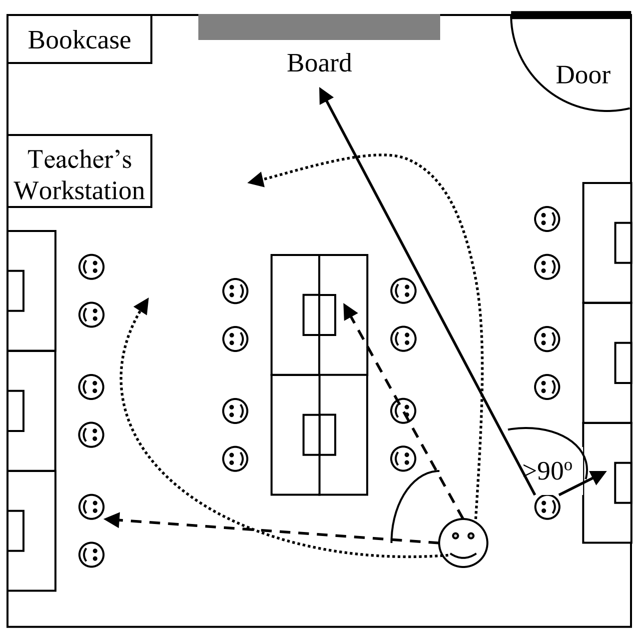
The tandem mode (Figure 3) offers adequate safety (ii) provided that the cable-lines will be carefully placed at the back of the workstations. The students have excellent visibility (i) to both the board and the computer screen, with limited effort. The teachers have good accessibility (iii) to the entire lab depending on the size of the corridors. The surveillance ability from the back of the lab, opposite to the board, covers all the workstations at any given time. The distance of the last rows of the workstations can be decreased to six (6) meters away from the board, depending on the size of the room. The overall required space can be also decreased occasionally to 30% compared to the other modes, for the same number of workstations (10).

FIGURE 1



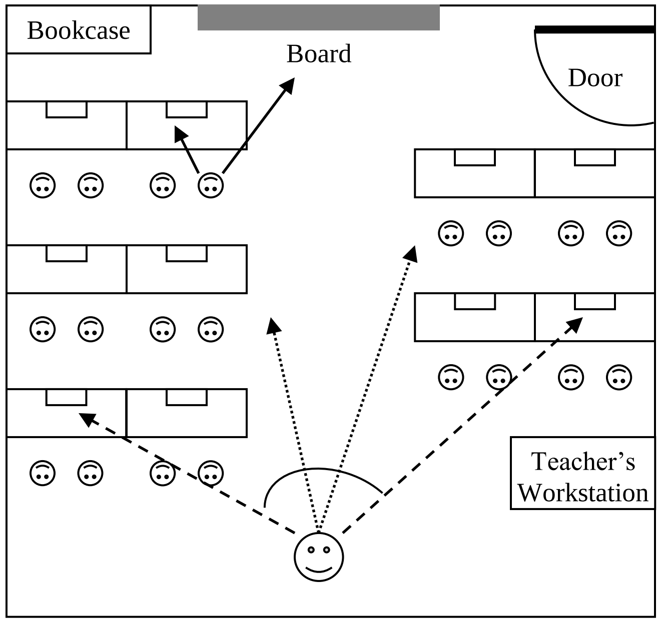
The perimeter's mode of workstations arrangement

FIGURE 2



The parallel mode of workstations arrangement

FIGURE 3



The tandem mode of workstations arrangement

Regarding the first requirement (i), it should be noted that the computing courses in primary and secondary education are both lecture-based and project-based, in a fifty-fifty allocation. Moreover this allocation is mostly per session, namely, half of the session's time is spent in using the workstation and half in attending teaching guidance. The students have frequently to turn from the computer screen to the board and vice-versa. Even in the tertiary education institutes (e.g., the National & Kapodistrian University of Athens and the National Technical University of Athens that are the largest and oldest tertiary institutes of Greece), the computer labs that are used for the beginners may have the tandem mode of arrangement.

We will consider now the previous descriptions of the arrangement modes in relation to the learning process. The various learning theories (Behaviorism, Cognitivism, Constructivism, etc.) are connected more to the development of educational software, by suggesting relevant guidelines (Kapravelou, 2011, p. 110-111), rather than to the environment ergonomics of the SCoLab. Respectively, various studies stress the importance of using educational technology in the learning process, for teaching both Computer Science courses (Tzelepi & Kotini, 2013) and in general (Vrasidas, Zebylas & Petrou, 2005). Yet, these studies relate the usage of computing technology mainly to the learning theory of Constructivism (Piaget, 1977). The teaching goal is to set student-centered environments (Pedersen & Liu, 2003; Jones, 2007), where the teacher acts as a facilitator (Rogers, 1983; Hannafin & Hannafin, 2010). Even so, a moderate number of instructions are necessary, either in introductory sessions or for beginners or for clarification purposes. Thus, the environment of the SCoLab should accommodate the students and the teacher too, the latter in order to fulfill adequately the facilitator's task. In this respect, and in overall as well, the preferable mode is the tandem one (Figure 3), as exemplified previously.

Thus, the authors suggest the tandem mode, although the vast majority of the SCoLabs in their educational regions are arranged according to the perimeter's mode.

CONCLUSIONS

In an attempt to suggest a didactically more functional SCoLab, the authors experimented and evaluated the three different officially proposed modes of workstations arrangement: The perimeter's, the parallel and the tandem. The criteria for this evaluation were determined by the adaptation of the guidelines of cognitive and space ergonomics to the didactic conditions and practice of the SCoLab. The comparative testing of the different modes in a period of three academic years resulted in regarding the tandem mode as more preferable to the rest, in every aspect.

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