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Physical and psychosocial aspects of the learning environment in information technology rich classrooms

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Abstract

This paper reports on a study of environments in emerging Internet classrooms. At issue for this study is to what extent these 'technological classrooms' are providing a positive learning environment for students. To investigate this issue, this study involved an evaluation of the physical and psychosocial environments in computerised school settings through a combination of questionnaires and inventories which were later cross-referenced to case studies on a subset of these classrooms. Data were obtained from a series of physical evaluations of 43 settings in 24 school locations in British Columbia, Canada and Western Australia. Evaluations consisted of detailed inventories of the physical environment using the *Computerised Classroom Environment Inventory* (CCEI): an instrument developed specially for this study. Data on psychosocial aspects of the environment were obtained with the *What is Happening in this Classroom* (WIHIC) questionnaire administered to 1404 high school students making routine use of these computerised classrooms. Potential deficiencies in the physical environment of these locations included problems with individual workspaces, lighting and air quality. Whereas deficiencies in the psychosocial environment were confined to the dimension of *Autonomy*. Further analysis of these classroom environment data indicated that student *Autonomy* and *Task Orientation* were independently associated with students' *Satisfaction* with learning and that many physical (eg. lighting and workspace dimensions) and psychosocial factors (eg. students' perceptions of *Cooperation* and *Collaboration*) were also associated. The results provide a descriptive account of the learning environment in 'technology-rich' classrooms and further, indicate that ergonomic guidelines used in the implementation of IT in classrooms may have a positive influence on the learning environment.

Keywords
Computers, school, children, information technology, physical, psychosocial

1. Introduction

1.1 Background

Information technology (IT) use is increasing in nearly all facets of life in the developing world and it is now progressing rapidly in many schools. Summaries of research on adult users of IT, mainly in office environments (eg.Kroemer and Grandjean,1997), have shown that its implementation can have potentially negative and positive effects on user's health, satisfaction and productivity. Currently, very little research on the ergonomics of IT use by school children is available. While some reports have begun to investigate this issue in classrooms, few comprehensive ergonomics studies have been undertaken. Still, the implementation of IT in schools continues apace and this has changed many classrooms into 'technological learning environments' where students spend a large portion of their day learning (i.e. working) using computers.

1.2 Information technology in schools

Educational institutions are increasingly looking to IT as a technical aid in the development of new models of teaching and learning. This pressure to implement educational technologies is both societal and also related to new ideas about teaching and learning now developing within the educational research community. This includes trends towards greater individualisation in learning, the use of cooperative learning groups, integration of subject areas and an increasing focus on higher order thinking skills (OECD, 1987). Adams (1990) stated that the successful use of computers means involving students and educators in the learning process in new ways. As with any medium, the vitality of computer use in schools depends on good teaching. Professional knowledge about student learning, curricula, and classroom organization should complement other important information on effective, productive and safe computer use by school children. However, a search of the literature reveals few comprehensive reports on the safe and productive use of IT in schools.

The use of networked computers has developed into a popular and useful instructional medium for a number of reasons, including its accessibility, flexible storage and display options, ability to support and display multimedia, and ease of use (Alexander,1995). In a study of school classrooms (Berge & Collins, 1995), many benefits of using Computer-Mediated Communication were reported including increased opportunities for cooperative learning, improved social interactions and increased cultural awareness on the part of students. Eklund (1995) states that the power of educational computing lies mainly in the types of learning that it can support. He argues that it promotes student-centred learning, motivation, and exploration - all factors linked to higher-order learning. Importantly, while many factors point to the increasing use of computers as a powerful educational tool, computers (as machines) are themselves limited by their own technological needs (e.g. internet connection wiring, location of power supply.) Care must be taken that these do not override the important sociocultural, psychological and physiological human factors related to teaching and learning.

Whilst there have been many claims that increased use of IT facilitates learning, only a few studies could be found which examined physical outcomes of computer use by school children. Harris and Straker (2000) surveyed 314 students (10-17 years old) attending 3 Australian schools with compulsory laptop programs. The study found moderate amounts of computer use by school children (Mean daily laptop use 3.2 hours ranging up to 15 hours and mean weekly laptop use 16.9 hours ranging up to 80 hours). Interestingly, 60% of students reported discomfort associated with laptop use and maximum time on task was positively related to the discomfort experienced. Oates, Evans and Hedge (1999) evaluated the posture of 95 children (8-12 years old) and related computer workstations in 3 schools in USA. None or the workstations were adjustable and all exceeded dimensions recommended. All of the student postures were in the unacceptable range, as assessed by RULA (McAtammney and Corlett 1993). In a similar study, Laeser, Maxwell and Hedge (1999) evaluated the posture of 58 children (11-15 years old) using a typical USA school computer workstation and one adjusted to each child. Their results demonstrated significant improvements in children's posture were achievable with appropriately adjusted equipment.

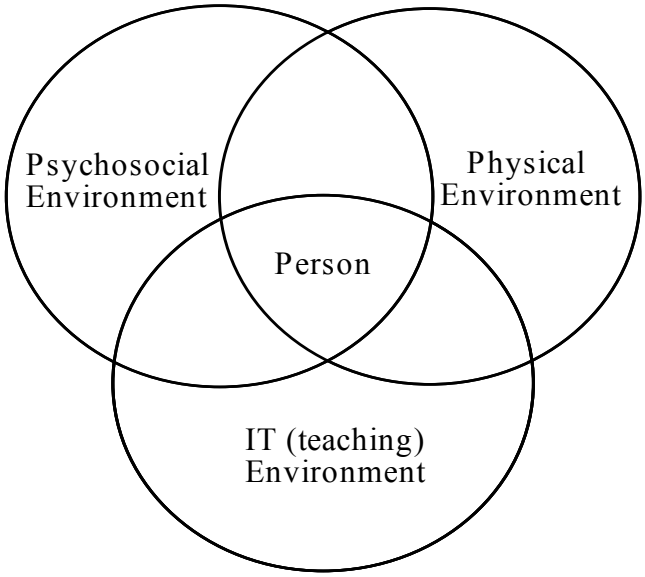
We therefore have some indications of potential productivity (learning) benefits of IT use by school children, some evidence on potential problems (and solutions) with school computer workstation designs and some evidence that increasing computer use is associated with increased discomfort. However, no broad description of IT use by school children has been reported. The purpose of this study was to first describe the current situation in IT rich classrooms and then to investigate relationships between physical (eg. aspects of the spatial, visual and workspace environments) and psychosocial factors such as degree of student cooperation, collaboration, task orientation and satisfaction.

1.3 Conceptual Framework

The apparent analogies between ergonomics in business and industry environments and investigations of the learning environment in schools has inspired the conceptual view used for this study of computer learning environments. Ultimately, the use of an educational productivity model such as the one espoused by Walberg (1991) was useful when considering a wide range of important factors operating within school classrooms. In this study, it was assumed that a variety of factors taken together influence student satisfaction. Ergonomists

have traditionally used research models that include a consideration of both physical and psychosocial factors. This approach also mirrors the true complexity of today's computerised classroom environments which have until now largely overlooked physical factors as they might influence students' satisfaction and productivity in their learning. Gardiner's (1989) model has been adapted as the conceptual framework for this study (see Figure 1). This model proposes the joint consideration of physical and psychosocial factors in the environment while considering information about the specific educational context.

Figure 1. A conceptual model for studying educational environments



Adapted from Gardiner (1989, p. 28)

2. Methodology

2.1 Design

The study was in two parts. The first part of the study was a broad investigation of the physical and psychosocial factors operating in 43 IT rich classrooms. Data on physical factors were obtained through observations and measurements using a specifically designed inventory (see Appendix) during on-site visits to these locations. Data on psychosocial factors were obtained using a questionnaire (see Appendix) which rated students' perceptions about the psychosocial learning environment as well as satisfaction with learning in these physical settings.

In the second part of the study, a small sub-sample of eight classrooms was selected from the original sample for more intense study. These case studies included detailed classroom observations of in-class behaviors followed by focused student and teacher interviews. The purpose of these was to investigate, qualitatively, questions that emerged in the first part of the study. More detailed physical environmental monitoring was also undertaken. These included measures of noise load as well as ambient air temperature and carbon dioxide levels. The inclusion of the qualitative and monitoring data with earlier inventory and questionnaire data completed a detailed profile for the physical and psychosocial environments in each of the selected classrooms. The results of this second part of the study are reported elsewhere (Zandvliet,1998;1999).

2.2 Sample

A sample of 1404 students in 81 randomly selected senior high school classes working in 43 different physical settings in Australia and Canada were selected for the first part of the study reported here. These classroom environments had a number of networked computers, with Internet resources, that were used substantially in delivering the curriculum. Individuals in these classes ranged between 15 to 17 years of age.

2.3 Measures

2.3.1 Computerised Classroom Environment Inventory

The *Computerised Classroom Environment Inventory* (CCEI) employed a hierarchical rating scale (scored out of five) which gave an estimate of a classroom's degree of 'fit' with currently published ergonomic guidelines (e.g. Kroemer & Grandjean, 1997). The inventory included a variety of general physical variables discretely

measured or noted by the researcher. The items were grouped into the domains of *Workspace*,*Computer*, *Visual* and *Spatial Environments*, and a rating of *Air Quality*. These considerations are those most usually noted by ergonomists (Grandjean, 1988; Kroemer & Grandjean, 1997). In order to attempt to ensure consistency, the inventory was completed by the same researcher in each setting and the unit of analysis was the individual classroom setting (sometimes shared by several class groupings). In addition, the number of computers in each setting and the type of room layout were also noted.

2.3.2 What is Happening in this Class Questionnaire

The psychosocial measures in the study were obtained by administering five scales selected and adapted from a learning environment instrument entitled the *What is Happening in this Class* (or WIHIC) questionnaire (Fraser, 1998; Fraser, Fisher & McRobbie, 1996). Specifically, the scales measuring *Student Cohesiveness*, *Involvement*, *Autonomy*, *Task Orientation* and *Cooperation* were selected for this study as they are consistent with the goals of reform efforts aimed at individualizing curriculum and instruction and increasing student interactions. These constructs are also consistent with variables considered important by ergonomists (eg. Grandjean, 1988; Kroemer & Grandjean, 1997). A further scale *Satisfaction* was added and included items selected and modified from the Test of Science Related Attitudes (Fraser, 1981). The questionnaire proved to be a valid and reliable measure for determining student perceptions of their learning environment (Zandvliet, 1999).

2.4 Procedure

A general description of 43 physical learning environments was completed by undertaking school visits to conduct evaluations of their computerised settings. On average, these evaluations took between 45-60 minutes to complete and were done outside of normal class time to facilitate the various physical measures needed for the environmental inventory. A worksheet entitled the *Computerised Classroom Environment Worksheet* was developed for this purpose (see Appendix).

Each of the participating schools was mailed class sets of WIHIC questionnaires to be completed by students at their school. Questionnaires were coded to indicate school, classroom and location. Detailed instructions were included to ensure consistency in administration of the questionnaire. For each of the classes, teachers were asked to administer the questionnaire to students as they worked in their usual computerised setting. Following this, teachers noted the physical location where the questionnaires had been completed on a cover page for each class set. This allowed questionnaire data to be linked to the other physical data collected during evaluations. Possible associations were explored using a computer statistical software package (SPSS Version 6.1).

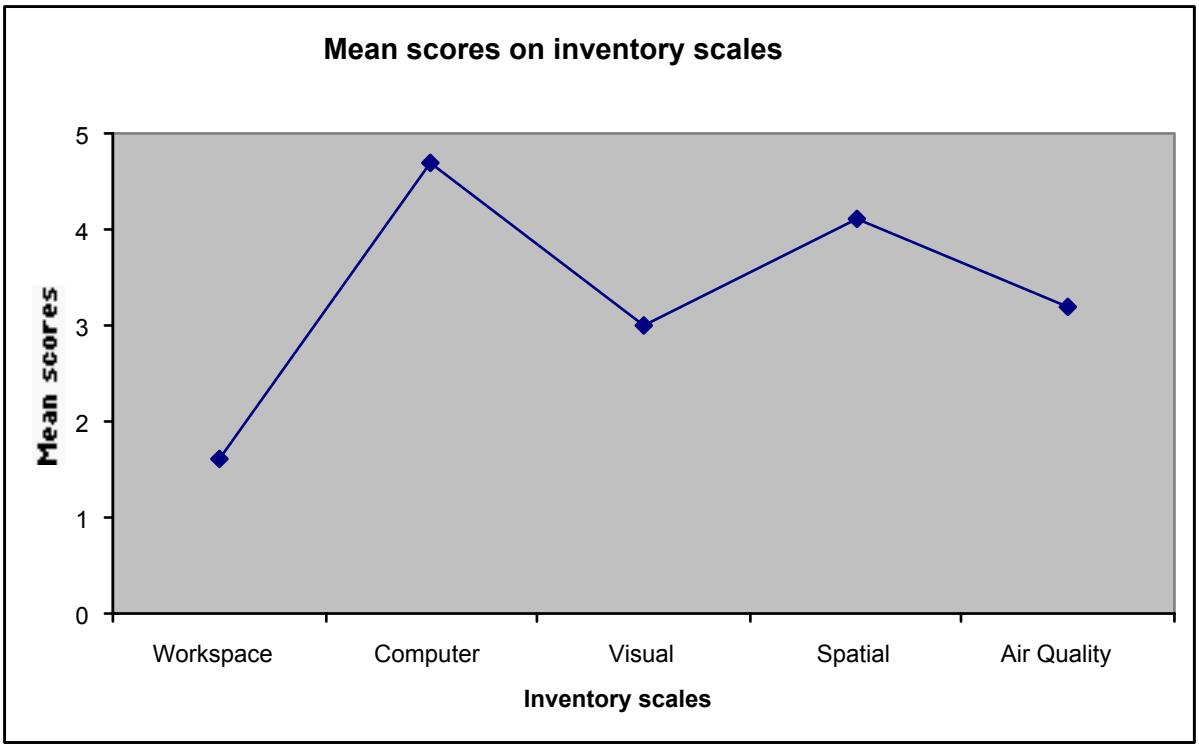
3. Results and Discussion

3.1 Physical environment

The ergonomics data collected in computerised classrooms indicates some important trends in the implementation of IT in schools. These data indicated that schools rated highest in their choice of computer equipment (*Computer Environment -- measuring the quality and suitability of the computers in use*) and the proper arrangement of this equipment throughout the room (*Spatial Environment -- measuring the suitability of the classroom floor plan*). On average, however, the studied schools were evaluated as deficient in the student work spaces where these computer were used (*Work Space Environment -- measuring the adjsutability of individual work stations*) and other measures (e.g.*Visual Environment -- measuring the suitability of lighting*) varied widely by location (see Figure 2).

These data are indicative of a problem in the sense that the implementation of IT in school classrooms may be inconsistent and further, may be creating negative impacts on the physical learning environment of schools. Whereas the ratings of such factors of *Air Quality*, lighting (*Visual Environment*) and spatial orientations (*Spatial Environment*) were less then ideal, these conditions may be seen as distracting the learner from their primary task of learning and in their extreme could create unsafe or dangerous working conditions for students.

Figure 2 Summary of physical environment data



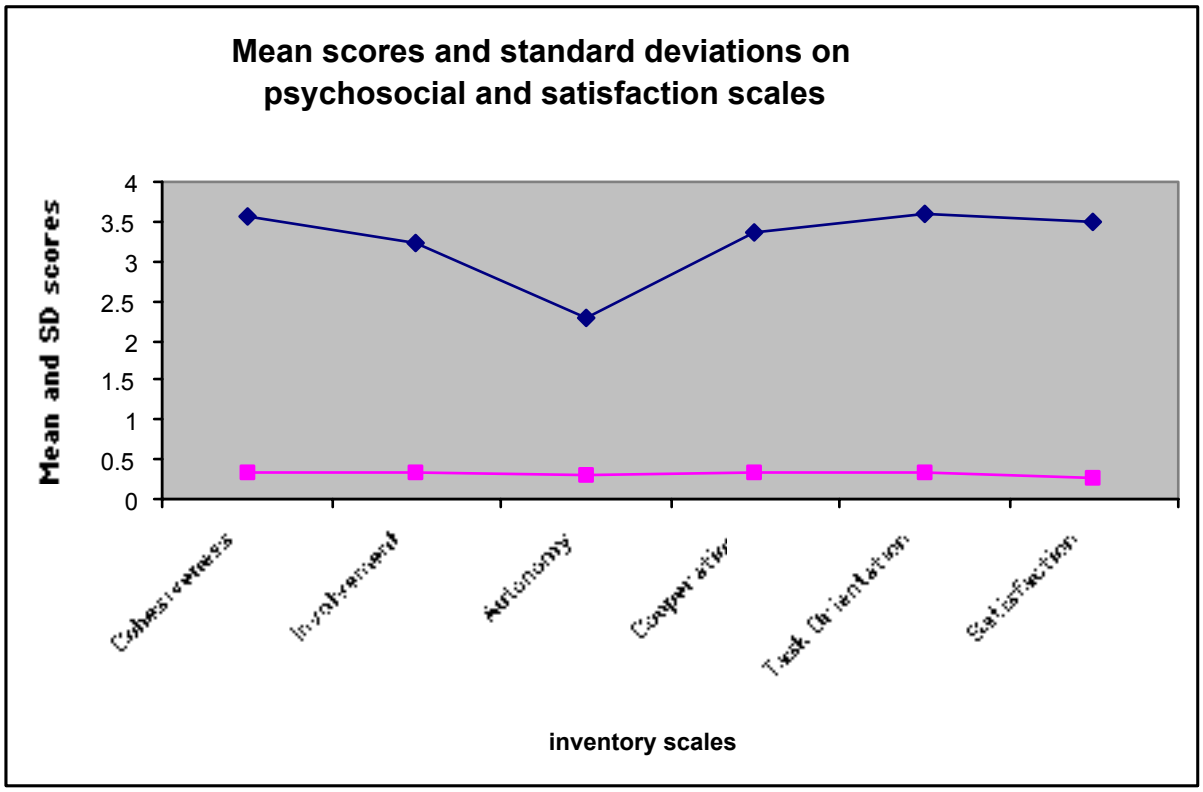
The evaluation of computer settings in schools also indicated that on average, these settings consisted of approximately 22 computer work stations. The most common room layout was arranged as a peripheral lab (27 out of a total 43 settings) defined as typically featuring computers located along the peripheral walls of a classroom with working students facing away from the centre of the room. Next in popularity was the linear layout (9 settings) which had students and machines in rows with students facing the front of the classroom. While the completion of these evaluations revealed much descriptive information about computerised settings in schools, teachers did indicate a preference for the peripheral set-up citing ease of movement around the classroom and ease of monitoring student screens as the most prevalent reasons. Overall, they also tended to rate high on the quality of the computer equipment selected and for the quality of the spatial environment.

Importantly, ratings of *Workspace Environment* in these settings were rated as fairly low. This would seem to indicate that this feature of computerised classrooms is in need of further attention by educators and ergonomists. The use of computers in the classroom needs to be balanced with the other needs of students which would include the provision of adequate space for place books and other non-computer related learning materials and to do other types of seated work. Most importantly, workstations should be more adjustable to the needs of various body sizes by including (at minimum) adjustable height seating and the provision of variable viewing heights for computer monitors (perhaps by varying workstation viewing height for different machines in a classroom). With these few measures many of the detrimental effects of IT implementation in classrooms could be minimized.

3.2 Psychosocial environment

The completion of questionnaires by students (and teachers) in a wide variety of computerised learning environments provided some good descriptive information about how these learning environments were perceived by the students. Overall, the study indicates that they viewed their learning environments positively and that these environments were characterised by relatively high levels of *Student Cohesiveness*, *Involvement*, *Task Orientation*, *Cooperation* and *Satisfaction* as shown in Figure 3. However, students rated the amount of *Autonomy* in these settings as low. This low rating may be in part due to any number of constraining factors, including, noted deficiencies in physical factors, curriculum constraints, or perhaps the inexperience of teachers in this relatively new teaching context.

Figure 3 Summary of psychosocial data



In the absence of empirical data to support reasons for the noted low ratings of *Autonomy* reported by students two speculative lines of explanation for this observation are offered. The first explanation might be related to a possible inherent quality of learning with computer technology in that many argue that IT uniquely supports individualized learning and once students have a taste of this, any interuption by the teacher could be seen as an intrusion into their autonomous and individual learning. A second explanation might be related to the teachers perceived competence with IT in these classroom settings (not investigated in this study). If teachers believe that they were less competent in the requisite IT skills involved in a learning activity, they might be tempted to reclaim their authority by increasing their reliance on more teacher focused classroom strategies thereby explaining negative or neutral student perceptions. Either of these lines of inquiry may be useful in directing future research on learning in IT settings.

3.3 Associations between physical and psychosocial factors

The evaluations of physical learning spaces indicated much about the learning environment. Relating this information with the psychosocial questionnaire data also revealed a number of interesting associations between these physical and psychosocial measures. Simple correlations and multiple linear regression analyses were computed to investigate possible associations between the measured physical and psychosocial factors. Each of the five psychosocial factors and the attitudinal scale of *Satisfaction'*in turn were used as dependent variables and then related to the set of five physical variables recorded during the evaluations. These data are presented as Table 1.

Table 1. Associations between Physical Classroom Variables (from the CCEI) and Psychosocial Variables (WIHIC) in terms of Simple Correlations (r) and Standardised Regression Coefficients (ß)

Physical variables	*Student Cohesiveness*		*Autonomy*		*Involvement*		*Task Orientation*		*Cooperation*		*Satisfaction*	
	r	*ß*	*r*	*ß*	*r*	*ß*	*r*	*ß*	*r*	*ß*	*r*	*ß*
Workspace	.08	.26	.28*	.30*	.17	.15	.22	.28*	.38**	.43**	.11	.12
Visual	.27*	.31*	.12	.36**	.22	.24	.31**	.38**	.05	-.10	.08	.06
Spatial	.03	-.03	.04	.13	.04	-.03	.07	.05	.17	.06	.10	.06
Computer	.00	-.14	.18	.10	.09	.01	-.08	-.29*	.06	-.18	-.04	-.12
Air Quality	.03	-.19	.22	.25	.05	-.13	.04	-.05	.18	.06	.06	-.02
Multiple correlation (R)	.37		.44*		.27		.45**		.42*		.16	

N=81 classes
p<.05, p < .01***

Results of the regression analysis between the physical factors and the psychosocial variables *Involvement* and *Student Cohesiveness* at the class level revealed no significant associations. However, a number of potentially important associations between the physical factors and all other psychosocial factors were found.

In the first instance, a number of significant independent associations between the *Workspace Environment* and student *Autonomy*, *Task Orientation* and *Cooperation* were noted. Further, significant independent associations between the *Visual Environment* and *Student Cohesiveness*, *Autonomy* and *Task Orientation* were also noted. These data support the premise that the physical attributes of learning spaces may influence the psychosocial environment within them and, further, may indirectly influence students' *Satisfaction* with learning. These findings were also corroborated by statements made by students and teachers during interviews in the case study locations. Independent statistical associations between students' satisfaction and physical factors were not evident in this analysis.

The noted links between the physical and psychosocial classroom environments are important in that the maintenance of a proper physical learning environment becomes an educational issue and that the failure to provide an optimum physical learning environment may detract students from their learning. It may be that deficiencies in the attributes of a learning space may also contribute to a collective unease which manifests itself at a psychosocial level. Therefore, deficiencies in such physical considerations such as the quality of the furnished environment and visual qualities such as the suitability of lighting may distract groups of students from their primary learning tasks and thereby diminish the quality of the learning environment.

3.4 Associations between number of workstations and physical factors
After considering the overall suitability of the computerised settings, an effort was then made to investigate associations with simply the number of computers in each setting and physical inventory data. Using multiple linear regression techniques the *Number of Work Stations* was identified as a dependent variable against the set of five physical variables obtained from the CCEI (*Workspace Environment, Computer Environment, Visual Environment, Spatial Environment* and *Air Quality*). These statistics are presented as Table 2.

Table 2. Associations between Physical Variables (from CCEI) and Number of Workstations in terms of Simple Correlations (r) and Standardised Regression Coefficients (ß)

Physical factor	*r*	*ß*
Workspace environment	-.26*	-.02
Computer environment	-.60**	-.65**
Visual Environment	-.02	.12
Spatial Environment	-.36**	-.13
Overall Air Quality	-.05	.19
Multiple correlation (R)	-.66**	

N= 43 locations
p<.05, p < .01***

Interpretation of the results presented in Table 2 demonstrates a fairly strong (though negative) association between the *Computer Environment* (suitability of computing equipment) and increasing numbers of computers work stations in the learning environment. Simple correlations between the number of workstations and the quality of the workspace and visual environments are also noted.

The strong negative association between the number of computers in a setting and the measure, *Computer Environment* (the quality of equipment) is an interesting one. This association probably reveals a common-sense economic relationship involving the purchase of computer equipment. For example, if a school has a fixed amount of funding for computers, it follows that if they buy more equipment, the quality of that equipment would be lower. This point is important one as this is a trade off that schools are often forced to make. In schools where funds are limited (most or all) this would seem to indicate that the best choice would be in purchasing better quality equipment even if this means purchasing less machines for the school. More evidence supporting this notion is also provided in the following section which considers psychosocial issues related to the number of computer workstations in a classroom setting.

3.5 Associations between number of work stations and psychosocial factors

To investigate this issue, a similar multiple linear regression analysis was repeated using *Number of Work Stations* as a dependent variable regressed against five psychosocial variables and *Satisfaction* scale derived from the questionnaire data. These results are presented as Table 3.

Table 3. Associations between Psychosocial Scales and Satisfaction with Number of Workstations in terms of Simple Correlations (r) and Standardised Regression Coefficients (ß)

WIHIC Scale	*r*	*ß*
Student Cohesiveness	.09	.15
Autonomy / Independence	-.27*	-.21
Involvement	-.15	-.38**
Task Orientation	.03	.22
Cooperation	.01	.16
Satisfaction	-.17	-.18
Multiple correlation (R)	.40*	

N=81 classes; *p<.05*, p < .01***

The data presented in Table 3 indicate that the psychosocial scale *Involvement* was negatively associated with increasing numbers of computer workstations in a setting. While other comparisons were made, no positive associations were demonstrated between increasing numbers of computers and the psychosocial scales**.** Also, an additional simple (though negative) correlation with *Autonomy* was noted. The negative associations noted between the number of computers and the psychosocial scale, *Involvement* is important. This relationship would seem to advise that increasing the number of computers in a setting (beyond some optimal number) is potentially counter-productive. This idea gains greater importance when it is considered that no positive associations with the number of computers were described in this research, or in the larger study. This point coupled with the adverse aspects noted in the previous section make a strong argument against the type of computer lab we often see which is crammed with the maximum number of (poorer quality) computers. These data suggest that this type of implementation has negative consequences for the learning environment in both the physical and psychosocial sense.

3.6 Other types of data

Importantly, the other parts of this study (Zandvliet, 1999) complemented the findings for the data emerging from the portion of the study reported in this paper. Interviews and classroom observations were used among a subset of eight schools from the total sample to further illustrate the relationships between physical and psychosocial measures and students' overall satisfaction with their learning. The relation of these data provided further descriptive and qualitative information about the overall learning environment in the classrooms where the surveys were conducted. Qualitative data (for example, teacher and student interview comments) confirmed the associations among physical and psychosocial factors which emerged from the quantitative analysis of data related to the questionnaire and computerised classroom evaluations. These data also informed the development of a new educational productivity model -- one which encompasses physical and psychosocial considerations regarding learning in these settings.

4. Conclusions

4.1 Significance of the Study

Importantly, the description of computerised classrooms presented in this study yielded the first cursory look at the learning and working environments that have been created by the implementation of IT in schools. The completion of ergonomic evaluations using the *Computerised Classroom Environment Inventory* (CCEI) revealed much information about the physical environment operant in these technological settings. Though these environments tended to be rated highly on the quality of the computer equipment selected and the quality of the spatial environment provided, ratings of the *Visual* and *Workspace Environments* in these

settings were rated consistently low. Further, correlational data showed that, while the factors measured in the environmental inventories were conceptually distinct, those environments rated highly for one physical variable also tended to be rated highly for other environment variables.

Finally, while there were only weak associations between *Satisfaction* and the physical variables considered in this study, many interesting associations between physical factors and the psychosocial learning environment scales were noted. These included associations between: *Autonomy* with the variables *Workspace Environment* and *Visual Environment*; *Cooperation* with *Workplace Environment*; *Student Cohesiveness* with *Visual Environment*; and *Task Orientation* with *Workspace Environment* and *Visual Environment*. These data suggest that the provision of adequate working environments for students is more than a comfort or safety issue but rather also a learning issue in that an inadequate physical learning environment might effect psychosocial disharmony perhaps disrupting or distracting the intended learning goals in these settings.

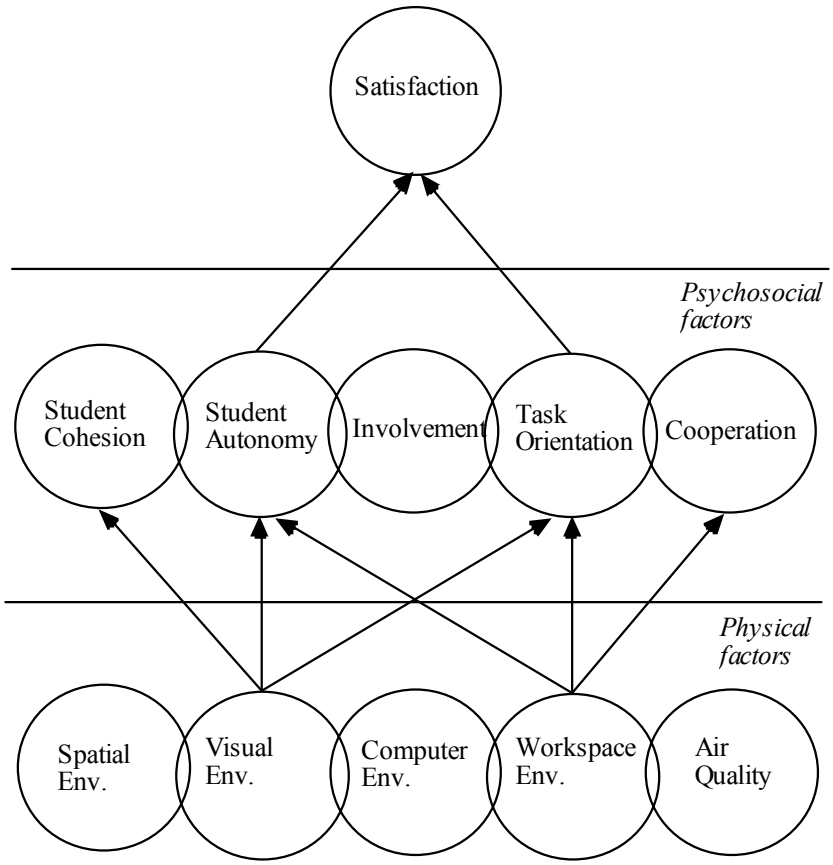
In summary, analysis of the quantitative physical data obtained with the environmental inventories of classrooms revealed some interesting relationships -- especially after they were linked to other data (such as the noted psychosocial factors). The results indicated that there are tentative and emerging links between the physical and psychosocial learning environments associated with the use of new information technologies and that, in particular, psychosocial factors may influence students' satisfaction with learning in these settings. As many associations between the physical and psychosocial environments have been noted, many ergonomic deficiencies may need more careful consideration by educators if the potential of information technology in improving classroom learning environments is to be fully realised.

4.2 An Emerging Productivity Model

This study is also significant because it jointly considered the physical and psychosocial learning environments in a single study while combining both qualitative and quantitative methods. The research is distinctive because of its holistic and ecological approach to the study of an important new learning environment: the technological classroom. By including questionnaire data with case studies and evaluations of physical classroom factors, its approach mirrors common ergonomic methods which have been effective in a wide variety of research in other settings, including technological settings within business and industry. Finally, this study identifies some important physical and psychosocial factors for inclusion in a new and developing model of educational productivity. The study may also stimulate further studies by collaborations of both ergonomists and educational researchers in the rapidly changing environment of technological classrooms.

The variety of data involved in various parts of this research have contributed to an emerging productivity model presented as Figure 4. This model includes the observed associations between psychosocial factors in computerised settings and students' satisfaction in these settings. Further, it also proposes that physical factors in classroom environments may also contribute to satisfaction (through their links to psychosocial variables) by subtly influencing these important aspects of the learning environment. Finally, the manipulation of physical factors (such as lighting and workspace) can also be considered as a positive and practical method of influencing the overall learning environment of a class and for increasing the general educational productivity of a classroom setting. In future studies we intend to develop other models and test them to see if they make effective predictors of educational productivity in computerised classroom settings.

Figure 4. Schematic Representation of a Emerging Model for Educational Productivity



(arrows and lines show significant relationships identified in this study)

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