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DE ENGENHARIA CIVIL

LEARNING ENVIRONMENTS: THE INFLUENCE OF PHYSICAL SETTINGS ON STUDENTS BEHAVIOUR AND SCHOOL PERFORMANCE

Lisboa • Janeiro de 2010

AMBIENTE DE ENSINO: A INFLUÊNCIA DAS CARACTERÍSTICAS FÍSICAS DA ESCOLA NO COMPORTAMENTO DOS ALUNOS E NO DESEMPENHO ESCOLAR

RESUMO

Este relatório apresenta um projecto de investigação sobre a influência das características físicas dos equipamentos escolares no comportamento dos alunos e no desempenho escolar. Este projecto foi submetido à Fundação para a Ciência e Tecnologia em 2008 no âmbito do concurso "Factores de sucesso escolar no ensino básico e secundário".

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SUMMARY

This report presents a research project about the influence of the physical characteristics of schools on students' behaviour and school achievement. This project was submitted for financing to Fundação para a Ciência e Tecnologia in 2008 within a specific call untitled "Factors of school success on basic and secondary grades".

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1. Enquadramento

O presente relatório apresenta a componente técnico-científica de um projecto de investigação submetido para apreciação à Fundação para a Ciência e Tecnologia em 2008, no âmbito de um concurso específico intitulado "Factores de sucesso escolar no ensino básico e secundário.

A abertura deste concurso para apresentação de projectos nesta área específica foi resultante da cooperação entre o Ministério da Ciência, Tecnologia e Ensino Superior e o Ministério da Educação e tinha como objectivo o financiamento de investigação sobre factores e condições que contribuem para promover o sucesso escolar e combater o abandono no ensino básico e secundário.

O presente projecto, não seleccionado para financiamento, foi submetido na área científica das Ciências da Educação e contou com a participação de vários investigadores do Departamento de Edifícios do LNEC[1] com diferentes formações académicas, de modo a consolidar-se uma equipa de investigação interdisciplinar face à natureza e aos objectivos gerais do projecto.

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[1] A responsabilidade científica do projecto ficou a cargo da Dr.ª Margarida Rebelo (DED/NESO) (Investigador Responsável), contando a equipa com a colaboração dos seguintes investigadores do DED: Dr.ª Marluci Menezes (NESO), Arq. Isabel Plácido (NAU), Eng.º Carlos Pina dos Santos e Dr. Luís Matias (NRI) e Dr. António Santos (NAICI).

2. Apresentação do projecto de investigação

2.1. Abstract/Resumo

2.1.1. Abstract

The research about the role of environmental context in human development and behaviour has received particular attention in the last three decades. However, much of this research has emphasized phenomenological conceptions about that context, in paying particular attention to psychological environments as experienced by individuals in order to produce explanations for their behaviours. Although Urie Bronfenbrenner's (1979) ecological systems perspective called, almost 30 years ago, our attention to the importance of studying the physical environment and materials used in these contexts to understand the behaviour of individuals, the fact is that this topic has been receiving less attention from the educative community, particularly in our country. Indeed, when the social and educational psychologists focused in school environment, they mainly studied the relation between students, families and teachers in understanding students' behaviour in school context, and specifically in the promotion of their success (Rebelo, Monteiro and Santos, 1998). Ecological systems perspective draws attention to the importance of contextual variables to understand the processes of development (microsystems), specifically referring to the importance of studying materials, spatial organization and how it is used and appropriated in explaining school behaviour, and more specifically school performance. So, the identification of environmental variables that may influence students' school response is particularly important in current controversy about factors that explain school success and failure.

Despite the lower production of research related with the influence of environmental factors, when compared to other factors such as cognitive, emotional, social and familiar, there is a considerable empirical evidence and knowledge that strengthen the relation between space physical characteristics and students' school performance.

Indeed, the knowledge produced around this issue has managed to show unequivocally that the buildings in which students spend much of their learning and educational process has influence in the way they learn, and several studies show that students who study in buildings with problems have a worse school performance than students who study in functional buildings with acceptable quality.

Generally, studies that have focused on this issue, point to the influence of environmental factors in four dimensions of scholar response, particularly in performance (curricular performance improvement), involvement (attention and behaviour improvement), affection (improving self-esteem and motivating the teachers' community as well as students) and, finally, in presence (increasing levels of presence, reducing late arrivals and non presences).

Having as general goal the study of environmental factors that influence the students' behaviour and school response, this proposal, strongly interdisciplinary by nature, has as specific objective the characterization of a representative school sample from the first three educational levels (mainland) in three main groups of environmental parameters: 1) space and constructive aspects of school buildings (constructive quality, size and age of the school, aesthetic quality of the building, space-functional organization), 2) use and appropriation of school interior and exterior space (characterization of behavioural sceneries and the use of school equipment), 3) school building characterisation in according to visual and thermal comfort (air quality, temperature / humidity, lighting and day lighting).

One of the ultimate objectives of this project is precisely the production of technical recommendations that may help in school building renovation process, already started for secondary schools in Portugal, through the promotion of a fertile interdisciplinary dialogue and a broad understanding of the variables accountable for improving students' academic response in the different levels of their formal education.

2.1.2. Resumo

A investigação sobre o papel do contexto ambiental no desenvolvimento e no comportamento dos indivíduos tem recebido particular atenção nas três últimas décadas. Muita desta investigação tem, no entanto, enfatizado concepções fenomenológicas desse contexto, ou seja, tem prestado atenção aos ambientes psicológicos tal como são vividos pelos indivíduos para tentar produzir explicações para os seus comportamentos. Apesar de a perspectiva dos sistemas ecológicos de Urie Bronfenbrenner (1979) ter chamado, há quase 30 anos, a atenção para a importância do estudo do ambiente físico e dos materiais utilizados nestes contextos para o entendimento do comportamento dos indivíduos, a verdade é que este tema tem recebido menos atenção da comunidade educativa, nomeadamente no nosso país. De facto, quando os psicólogos sociais e educacionais se debruçaram sobre o ambiente escolar trataram essencialmente de estudar a relação entre alunos, família e professores no entendimento do comportamento dos alunos em meio escolar e especificamente na promoção do sucesso (Brophy, 1986; Rebelo, Monteiro e Santos, 1998). A perspectiva dos sistemas ecológicos chama a atenção para a importância das variáveis contextuais no entendimento dos processos de desenvolvimento (microssistemas), referindo-se especificamente à importância do estudo dos materiais, da organização do espaço e da forma como este é usado e apropriado na explicação do comportamento escolar e especificamente do desempenho escolar. Assim, a identificação das variáveis ambientais passíveis de influenciarem a resposta escolar dos alunos assume

particular importância nas actuais controvérsias a propósito dos factores explicativos de (in)sucesso escolar.

Apesar da menor produção de investigação no domínio da influência dos factores ambientais comparativamente a outros factores, como por exemplo de natureza cognitiva, emocional, familiar e social, existe um acervo acumulado de conhecimento que fundamenta bem a relação entre as características físicas do espaço e a resposta escolar dos alunos. De facto, o conhecimento produzido em torno desta temática conseguiu demonstrar inequivocamente que os edifícios em que os alunos passam grande parte do seu processo de escolarização e de aprendizagem influenciam o modo como estes aprendem, onde vários estudos atestam que os alunos que estudam em edifícios com problemas obtêm um pior desempenho escolar do que os alunos que estudam em edifícios funcionais e de qualidade aceitável. De uma forma geral, os estudos que se debruçaram sobre esta questão apontam para a influência de parâmetros ambientais em quatro dimensões da resposta escolar, designadamente, no desempenho (melhoria no desempenho curricular), no envolvimento (melhoria da atenção e do comportamento), no afecto (melhoria da auto-estima e da motivação na comunidade docente e nos próprios alunos) e, finalmente, na assiduidade (aumento dos níveis de assiduidade, redução dos atrasos e das faltas).

Tomando como objectivo geral o estudo dos factores ambientais que influenciam o comportamento e a resposta escolar dos alunos, esta proposta, de natureza marcadamente interdisciplinar, tem como objectivos específicos a caracterização de uma amostra representativa da tipologias de escolas do 1.º, 2.º e 3.º ciclos de todo o país (Continente) em três grupos de parâmetros ambientais: 1) espaço e aspectos construtivos dos edifícios escolares (qualidade construtiva, dimensão da escola, idade da escola, qualidade estética do edificado, organização espaço-funcional); 2) uso e apropriação do espaço interior e exterior da escola (caracterização dos cenários comportamentais e do uso dos equipamentos escolares); 3) caracterização do

edificado escolar relativamente ao conforto visual e térmico (qualidade do ar, temperatura/humidade, iluminação e iluminação natural).

Um dos objectivos últimos deste projecto é precisamente a produção de recomendações técnicas que auxiliem o processo de renovação do parque escolar já iniciado relativamente às escolas secundárias do país, através da promoção de um diálogo interdisciplinar profícuo e um entendimento alargado das variáveis responsáveis pela melhoria da resposta escolar dos alunos nos vários ciclos da sua aprendizagem.

2.2. Objectives

2.2.1. Project Objectives

Despite considerable growth in knowledge about factors related to student achievement and the notable successes of numerous effective programs to reduce school failure it is not clear the association between physical environment and school performance. Using an interdisciplinary perspective, the main goal of this study is to identify the impact of environmental variables on learning outcomes. In this sense, the project main goals are:

1. To characterize school buildings regarding space and constructive conditions (quality of building condition, size of school building, aesthetics, age of building, space functional organization);

2. To characterize school indoor and outdoor spaces regarding the type of use and appropriation made by school community (teachers, students, administrators, other personnel);

3. To characterize school buildings regarding indoor thermal and visual conditions (indoor air quality, temperature/humidity, lighting, day lighting).

2.2.2. Principal Investigator Objectives

The principal investigator has experience on the evaluation of risk factors associated with school response and learning outcomes and with the design and implementation of intervention programs in the educational field. The team has experience in the evaluation of buildings quality, space use and appropriation and indoor thermal and visual comfort.

Besides involvement in the preparation of public buildings technical recommendations, the project members participated in several researches and applied studies in those areas.

The main objective of the principal investigator is to promote an interdisciplinary dialogue and a challenging understanding of school response by involving different but complementary perspectives. Also, this study will allow the promotion of public schools buildings in Portugal and specific technical recommendations to the amplification of National Program of Modernization of Secondary Schools (Resolução do Conselho de Ministros n.º 1/2007, de 3 de Janeiro), presently in development, to other school typologies.

2.3. State of the Art

When we refer to the concept of human development it is crucial to draw attention to the bidirectional aspect of the relationship between individuals and surrounding environments. In school contexts, both social and physical environments are supplied and organized by adults, accordingly to their personal goals and based on their social and cultural expectations about children's behaviour and development. It has been empirically observed by many researchers that surrounding environment has a deep influence on education and learning processes, school achievement and academic response.

In this regard, the following state of art presents a brief description of the most influent environmental variables affecting and/or related to school response and academic achievement.

Spaces and places can evoke emotional responses and elicit or inhibit behavioural responses. Regarding school size, studies indicated that poor school facilities were considered a major cause of behavioural disruptions in schools and that anxiety level of buildings occupants increase when buildings are operated at or approximately maximum capacity.

Other studies analysed the relation between school and classroom size and the student's performance. Here, they concluded that smaller equipments provide to the students a better performance with more positive attitudes, one deeper extracurricular involvement, stronger social bonds and more parental involvement.

The definition of the school's physical conditions should be a participative process and the team responsible for the planning and conception of these units, besides multidisciplinary, must pay attention to the users specifics necessities - children, relatives, teachers, professionals, administrators – and clearly define the conditions related to physical space, as well as the educational goals. It is important to remember that school is integrated in a wider context that includes not only the natural ecosystem, but also the society with its cultural, social and physical diversity - so, the building facilities must be conceived to bring the differences together in order to achieve educational and human enrichment, as well as the respect for the diversity.

Class size is an important factor in school design, school building's planning, design, construction, cost, maintenance, and operation. Despite the debate about this topic, research results showed that students in small classes did better in math and reading tests at the end of kindergarten, students from smaller classes behaved better than students from larger classes, and these differences persisted through at least fourth grades, the effects were stronger

for students of lower socio-economic status, and the effects were stronger for African-American students (Schneider, 2002).

The spatial arrangements fulfil an important role for education and children development, especially in collective environments, because they help to support certain forms of social organization of applied educational practices. In fact, the nature of spatial arrangements created for children in school contexts let us perceive the educational philosophy behind it. Different types of interactions can appear in result of different types of environments where teachers have an essential role in the organization of places where educational processes occur.

Authors like Legendre (1986) categorize several types of spatial existing arrangements according to their influence on children's behaviour, namely in the stimulation and development of children's autonomy in pre-school age. Legendre's main conclusion lead to consider that in circumscribed spaces, with the existence of barriers, children interact more with each other, while in open spaces they tend to remain near the adults. The spatial arrangement can then favour the creation of interaction opportunities between children and between them and educators.

Additional studies showed that circumscribed areas favour a bigger interaction between children, because it allows keeping a certain distance from the adult and there is less opportunity for other children or adult to interrupt - what usually happens in open spaces - offering so, a sensation of protection and privacy.

Besides, this kind of spaces helps children to keep attention in other's activities and behaviours, which appears as an essential condition to establish longer interactions.

Research conducted in US regarding the influence of physical environment on individuals behaviour showed a relationship between the type of facility attended and students' behaviour. A major design issue of the last few decades

has been that of open-plan schools. Results demonstrated that students in open space facilities demonstrated a tendency to exhibit less disruptive behaviour in schools and students in traditional schools (more closed and divided spaces) tended to be more disruptive in class. Also, results showed that students in buildings with a more attractive physical environment were more disciplined, absent, or experienced health problems less frequently than students in a building with a less desirable physical environment.

Building age, quality, and aesthetics are other environmental factors influencing learning outcomes. Literature reviews (Earthman & Lemasters, 1996, 1998; Schneider, 2002) report links between building quality and higher test scores, given the reliable correlations between students achievement and better building quality and newer school buildings.

Indoor environments in schools are of particular public concern because: i) Schools, comparing with other buildings, are seen as particularly likely to have environmental deficiencies that could lead to poor indoor environmental quality; ii) Children breathe higher volumes of air relative to their body weights and are actively growing.

The relationship between indoor environment and individuals' behaviour has been widely studied for the last several decades. This growing body of literature linked educational achievement and student performance to the quality of air in schools (IAQ), by showing that poor IAQ has been associated with increased student absenteeism. For example, Smedje and Norback (1999) found a positive relationship between airborne bacteria and asthma in children, which in turn increased absentee rates. Also, Rosen and Richardson (1999) found that improving air quality through electrostatic air cleaning technology reduces absenteeism. Temperature and humidity also affect IAQ.

Wyon, Andersen, and Lundqvist (1979) showed that student performance at mental tasks is affected by changes in temperature, supporting the hypothesis

that students will perform mental tasks best in rooms kept at moderate humidity levels and moderate temperatures.

Researchers have been studying the influence of temperature range on learning for several decades. Harner (1974, cited in Schneider, 2002) found that the best temperature range for learning is 68° to 74° Fahrenheit and that the ability to learn is negatively affected by temperatures above 74° Fahrenheit.

According with King and Marans (1979; cited in Schneider, 202), as temperature and humidity increase, students feel greater discomfort, and their achievement and task-performance decreases.

There is a considerable amount of literature relating to different kinds of lighting, from daylight to artificial, and there is a disagreement among researchers on which form of lighting is the most suitable for the classroom. Regarding student achievement it is argued that day lighting offers the most positive effect (Earthman, 2004). Knez & Kers (2000) found that lighting conditions that induced negative affect reduced performance, and therefore, lighting conditions that induced positive affect improved performance or enhanced cognitive performance in memory and problem solving tasks.

Finally, and considering the literature in this topic, it is possible to identify that the underlying issue is the question of how the environment is supposed to have effects on its users. As Higgins and colleagues stated "clearly this is not a simple matter of architectural determinism. So the relationship between people and their environment must be complex and therefore any outcomes from a change in setting are likely to be produced through an involved chain of events. It is the defining and understanding of these mediating chains that is key" (2005: 35).

2.4. Results, repercussions and regionalisation

2.4.1. Diffusion of Results

This project will be developed by a research team of LNEC's Building Department with the participation of a social psychologist, an anthropologist, an architect, a civil engineer and two building physicists.

The results of the project will be published in two scientific reports and in national and international major technical journals.

The results of the project will help designers, educators, regulators and policy makers to implement the construction of sustainable school buildings providing appropriate learning environments, i. e., adequate space organizational, adequate space use and appropriation, and indoor satisfactory thermal and visual conditions. At the end of the project a national workshop will also be organized in order to help the results dissemination and a wider discussion.

2.4.2. Repercussions

The need of identifying the causes of school failure and dropout is not a emergent issue in current societies. In fact, and mainly during the past two decades, research in several fields has demonstrated the different factors influencing school response. In order to understand the impact of environmental factors on improve school response, it is necessary to examine the circumstances of schooling and the meaning given to these by those in the school as well as those in the outside environment. By encouraging the development of those factors that facilitate change or nurturing hem if they already exist, technicians increase the opportunity for change to become a permanent part of the school environment. The development of a sustainable school network in all the dimensions involved in learning and education will help current and next generations to participate in a better educational system

and the opportunity to construct their educational formation in satisfactory conditions. In this regard, the present study proposes a more unusual analysis of schooling since it centres on environmental variables affecting school response. The identification of the physical parameters influencing school response will provide the technical knowledge to be applied by responsible designers, educators, regulators and policy makers involved in the promotion of healthier and sustainable educational formations. Also, the results deriving from this project can be applied in schools renovation program, currently in development in an initial sample of secondary degree schools, allowing a process of physical, environmental and functional efficacy. In sum, and by accomplish the above mentioned goals, the final purpose of this study is to assist educators, architects and other involved staff in planning and designing developmentally appropriate learning environments for public schools.

2.4.3. Regionalisation

The study of the impact of physical variables on students' performance and school response implies the development of models that should be representative of the general situation across all country. In this sense, this project will contribute to a positive improvement of space organization, use and appropriation, and visual and thermal comfort by studying elementary (1st to 4th grade) and middle schools (5th to 9th grades) across all country. Also this project will provide the necessary technical knowledge to be applied in the promotion of adequate schools spaces contributing to more sustainable schools.

LNEC will benefit from this project by continuing and innovating the development of important research areas (environmental psychology, space anthropology, sustainable design and planning, energy efficiency, thermal comfort and day lighting in buildings), which this institution introduced in Portugal several decades ago, acquiring national and international recognition. Also, this study will give continuity to a series of recent studies

developed by LNEC's Building Department regarding technical recommendations for Public Security Forces Facilities (for example, police stations) and Social Welfare Facilities (Rest homes, kindergartens). The present project will increase and improve the long-established link of this institution to civil society, by collaborating in the resolution of practical problems of school building designers, educators, policy makers and users.

2.5. Tasks

2.5.1. Task 1 – Literature: Review, state of the art and systematisation

Expected results: A literature review and systematization will be developed regarding the influence of environmental variables on school response and learning outcomes. This task will provide a structure for schools characterization in all evaluating parameters (building, space use and appropriation, visual and thermal comfort).

Task description: Bibliographical update and search, and a brief state of the art, has already started. As a result of this survey a great number of documents was obtained (either in hardcopy or digital format) mainly referring to the environmental variables influencing school response and students performance. Meanwhile it is important to continue this survey in order to update and deepen knowledge in such areas. Besides the current access to publications, for a better knowledge and understanding of the state of the art in those different areas, it is foreseen the participation in workshops.

2.5.2. Task 2 – Methodology: Sampling, instruments and pilot study

Expected results: This task will allow the construction of the instruments to evaluate schools in all above mentioned parameters (school response, space use and appropriation, visual and thermal comfort). The pilot study will allow an adjustment of materials and methodology on school buildings evaluation.

The sample construction will be done according to several stratified conditions, namely, geographical region, grades, school building typology (public basic education: 1st to 3rd educational level).

Task description: The methodological section of this study will include the sample construction, the preparation of inquiring materials (physical parameters evaluation, behavioural settings characterisation and official education statistics regarding academic achievement and school response) and the development of a pilot study in one public school (city of Lisbon or Lisbon Metropolitan Region) in order to test the produced materials and instruments and, if necessary, introduce modifications in methodological section. The instruments design for this study will include the following parameters: 1) Indoor air quality; 2) Temperature/humidity: 3) Lighting; 4) Day lighting; 5) Age of school building; 6) Quality of school building conditions; 7) Size of school building; 8) School class size; 9) School building aesthetics; 10) Space use and appropriation (behavioural settings); 11) Space functional organization; 12) Type of urban insertion.

2.5.3. Task 3 – Data collection: Public schools evaluation

Expected results: This task will allow the characterisation of a nation wide sample of public schools (basic education: 1st to 3rd educational levels) regarding environmental variables above mentioned in Task 2 and school response (current official statistics - Ministry of Education).

Task description: This task is predominantly characterised by an intensive and extensive fieldwork across five Portuguese regions in order to obtain a public school network evaluation in all defined parameters previously defined in Task 2 (Methodology: Sampling, instruments and pilot study). The constructed sample will include schools from several educational levels (1st to 3rd educational levels according to Portuguese nomenclature).

2.5.4. Task 4 – Data analysis, report and results diffusion

Expected results: Information analysis will allow schools characterisation regarding environmental parameters and also the production of technical recommendations. A final report and a workshop will be prepared in order to discuss the main results of this project with technical staff and other institutions (public and private) involved in educational processes.

Task description: Quantitative and qualitative techniques will be used in order to analyse the impact of environmental and physical variables on students' achievement and other indicators of school performance. Regression analyses will permit the identification of school response main predictor dimensions. The final report will include a section with technical recommendations regarding school buildings improvement. Based in an interdisciplinary perspective, school buildings characterisation will be displayed by using Geographical Information System software, which supports a global portrait of the current school facility situation at national level. The results of the discussion of this task will be presented in national and international articles and papers.

Lisboa e Laboratório Nacional de Engenharia Civil, em Janeiro de 2010.

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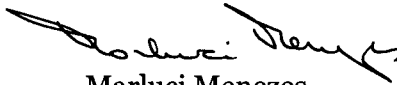
O Chefe do Núcleo de Ecologia Social

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