## Attitudes, expectations, and practices in the portuguese secondary schools' science laboratories

#### **Project Summary**

The current plan for the modernisation of the portuguese secondary schools' buildings, the fourth of this size since the beginning of the twentieth century, established a new school building model with a prioritary intervention in the so called Center for Science and Technology. The new concept of schools' science spaces included in this Center aims to support a variety of teaching strategies, linking theory and practice (Parque Escolar EPE, 2009), aligning itself with the principles of the reform of secondary education and science curricula in particular (Ministry of Education, 2003; Jordão et al., 2006).

Unlike the anglo-american model of science learning spaces, formalised in a single laboratory for all classes with daily activities of observation and / or experimentation, the portuguese model included both "regular" classrooms for lectures and laboratories for practical work, especially for students in the final years of secondary education, with older schools also including amphitheaters for teacher's demonstrations. This separation of spaces corresponded to a separation of teaching strategies, with the first devoted mainly to instruction and problem solving, and the later to practical work, near its origins in the university model of science teaching in the nineteenth century (Santa-Bárbara & Leitão, 2006). This bipartite model contrasts with the new model, in line with the learning studios and classrooms / environments for active learning (Beichner et al. 2007; Brooks, 2010), a hybrid space to support instruction and practi-

Taking advantage of the opportunity offered by the modernisation plan, along with the emergence of a new area of research into active learning environments for scientific subjects (Beichner et al., 2007; Brooks, 2010; Dori & Belcher, 2005; Kohl & Kuo, 2009; Whiteside et al., 2010), this project proposes to investigate the attitudes and expectations of teachers and students about the elements of the new model of science learning spaces as well as inquire about the current situation of teaching and learning activities in these new spaces.

A digital survey will be distributed to all teachers of the schools involved in the modernisation plan. Twelve case studies will be also carried out in 12 schools already intervened, with focus groups involving teachers and students. Schools will be selected from the phases 1-3 of the modernisation plan, distributed in equal number by the northern, central, south and Lisbon regions.

The survey will resort to digital photographs of the elements of the concept applied in schools, a presentation of the arguments involved in the choice of these elements, Likert items and open questions. The case studies will be performed in the new spaces for science in the selected schools, including touring walkthrough interviews and focus groups with teachers from each subject group students as well as class observations.

Working sessions with the science departments involved in the case studies will take place, both in schools and online, to develop a online course structure and materials to support the organisation, management and use of schools' science spaces. Besides this, four schools with outstanding work in the organisation and management of science spaces will be supported to develop exemplary science facilities as role models for the schools of the modernisation plan.

The proposed project is considered a critical element necessary to inform the improvement of the spaces' model, assess its implementation in the completed phases of the modernisation plan, provide an empirical basis for future studies that address this issue, including the impact of the elements of the concept in schools' practices, and the design of teacher training programmes around the organisation, management and use of the schools' science laboratories.

## Keywords

science, education, learning, spaces, active learning environments

# Team

Fundação da FCTUNL	UIED	FCTUNL	Parque Escolar EPE
Vítor Duarte Teodoro	vdt/IR	UIED FCTUNL	
João Fernandes	jpsf	UIED FCTUNL	
João Correia de Freitas	jcf	UIED FCTUNL	
Rui Neves	rn	UIED FCTUNL	
Teresa Heitor	tvh	IST PEepe	
Margarida Saraiva	ms	ESFB	
Maria da Luz	mluz	ESDD	
Celeste Calado	СС	ESB	
Filipa Silva	fs	ESGB	
Carlos Cunha	СС	ES	

### **Research questions**

**RQ1.** What attitudes and expectations do teachers and students have towards the new science learning spaces?

**RQ1.1.** What elements of the concept are more and less valued? Why?

RQ 1.2 How do teachers and students compare the new model with the previous spaces available in schools?

**RQ 2.** What teaching and learning activities are being used in the new science learning spaces?

**RQ 2.1.** To what extent, if any, do these spaces facilitate or inhibit these

RQ 2.2. What are teachers and students perceived needs regarding the organisation, management and use of the new science learning spaces?

**RQ 2.3.** How do these activities contrast with previous data from the White Book of Physics and Chemistry?

**RQ 3.** What are the differences between the idealised and the applied science learning spaces model in the intervened schools?

# Goals

- A. Extend the field of active learning environments research to secondary education
- **B.** Inform the improvement of the concept of the science learning studios
- **C.** Identify teachers' meanings attributed to the science learning studios **D.** Analyse teaching and learning activities in the science learning studios

activities in the science learning studios

- **E.** Develop a Science Learning Studio's Pedagogical Methodology (SLSPM)
- F. Develop a Science Learning Studio Activity Analysis Inventory (SLSAAI) to analyse
- G. Create an empirical snapshot for future research and training on teachers' profes-

#### Literature review

The 2005 Eurobarometer survey "Europeans, Science and Technology" revealed that 60% of the portuguese respondents believes that "Science classes at school are not sufficiently appealing" to students (Eurobarometer, 2005, p. 102). The ROSE study also suggested a lack of appeal of school science, with Portugal ranking the lowest score for "I like school science better than most other subjects" for boys, and for girls, among the lowest results in the set of countries studied (Schreiner & Sjøberg, 2004). Besides these negative attitudes, low average students' performance in PISA (OECD, 2007, 2010) add up to the picture of a school science that is both unappealing and innefective.

Data suggests that science teachers' dominant classroom practices in "regular" classrooms resort mostly to textbooks and exercise solving, and in the the laboratory to recipe-like lab worksheets (Ambrósio et al., 1994; Martins et al., 2002; Moreira, 2003; Sequeira, 2004). Evidence also suggests a link between students disenchantment with school science and this dominant pedagogy of transmission (Lyons, 2006; Osborne & Collins, 2001).

Responsibilities for this situation have been attributed to several factors: the weight and type of the final secondary examinations (Eurydice, 2006; Jordão et al., 2006); inadequate spaces and infra-structures with several functional problems due to bad design (Heitor et al., 2008); lack of security, insufficient financial resources and audiovisual, technological and scientific equipment (Martins et al., 2002); inexisting technicians to the laboratories, large classes and inadequate teacher training (Oliveira, 1999; Valente, 1999).

In the last ten years, Portugal has invested large sums of public funds to address several of these issues, with programmes such as Ciência Viva, the Technological Plan for Education, Experimental Teaching of Science, Computers Internet and Networks in Schools, reforms of secondary education and secondary science curriculum and, more recently, the schools buildings modernisation plan by Parque Escolar. These initiatives, however valuable, have not been integrated in an overall strategy for changing teachers' pedagogy to improve learning, associated with a systematic de-investment in teacher training at the secondary level. Portuguese teachers lack training, but they don't lack the will

One of the aims of the new hybrid model of schools' science spaces proposed in this rebuilding plan is to support research-based pedagogies, linking theory and practice in the so called science learning studio (Beichner et al., 2007), a critical element in the the field of active learning environments. For the last decade this field has been developing conceptual frameworks and methods to improve undergraduate science programmes. The Student-Centered Active Learning Environment for Undergraduate Programs (SCALE-UP) is one of the most emblematic examples, with an holistic approach that combines curricula, pedagogy, assessment, technology and learning spaces innovations.

The findings of comparison studies between Scale-Up and Lecture/Laboratory classes are summarized below (Beichner et al., 2007, p.37)

- · "Conceptual understanding is increased;
- The top third of the class show the greatest improvement in conceptual understanding;
- Ability to solve problems is as good or better;
- Attitudes are improved;
- Class attendance is higher, typically > 90%;
- Failure rates are drastically reduced (typically 50%), especially for wom-
- Performance in the second semester physics class is improved, whether taught traditionally or in SCALE-UP;
- Failure of at-risk students in a later Engineering Statics class is cut in

The field has been mostly concerned in showing the effectiveness of the approach, with a pre-post test design to compare students' performance. However, a research design of this type was not considered for this study for two reasons: (1) the rebuilding project is still not part of an integrated approach of school science reform; (2) a considerable body of evidence has shown significant improvements in learning (Beichner et al., 2007; Dori & Belcher, 2005; Brooks, 2010; Kohl & Kuo, 2009). What the field lacks though, is empirical evidence that (a) measures attitudes and expectations and assesses needs of teachers and students to improve the elements of the science learning studio (b) transfers the knowledge gathered in the undergraduate level to the secondary level and (c) guides teacher training programmes to improve the organisation, management and use of spaces aligned with the envisioned curriculum, pedagogy and assessment.

The project will build upon the experience of the team, mainly on:

(1) schools' science teachers (Maria da Luz, Celeste Calado, Filipa Silva, Carlos Cunha) with experience in active learning environments and as teacher trainers, e.g. in a training course that took place in the summer of 2010 with the collaboration of DGIDC and Parque Escolar involving 119 teachers from 66 schools across the country concerning the use of the new science spaces; (2) visits to schools in other countries (Finland, UK, Sweden) and to more than 30 schools during and after the modernisation plan; (3) analysis and discussions with architects, technicians, companies, researchers, teachers and students to develop the science spaces model, adapt it to each school and communicate the rationale and listen to concerns (seminars, meetings, comments to building documents, working sessions in schools with teachers); (4) development of supporting materials for teachers and schools (freely available in the website http://laboratoriosescolares.net); (5) development of pedagogical methodologies (Teodoro, 2006; Teodoro & Mesquita, 2004; Teodoro & Neves, 2011; Teodoro et al., in press) and online training (Fernandes, 2008b); (6) the involvement in the secondary schools' modernisation plan as member of the board of Parque Escolar E.P.E. and as consultant and young researcher (Heitor et al., 2008, 2009; Fernandes et al., 2009); participation in the IN\_LEARNING project, funded by FCT, concerned with how the configurative properties of learning settings influence the users' experience of spaces and their interaction. The development of a space-use analysis tool and the framing of the RQ is more concerned with the impact of the physical properties of the space. The proposed project develops a complementary approach, focusing on the patterns of understandings, and expectations associated to the spaces (Harrisson & Dourish, 1996).

#### **Plan and Methods**

Common approaches to teachers' professional development start from mistaken assumptions that teachers' learning can be transformed by prescriptive approaches. The view of the team is based on a more complex view of professional learning (Fullan, 2007; Spillane, 1999) that sees the development of new spaces connected to new practices of organisation, management and use of the schools' science spaces and to a science education reform that addresses improvements in pedagogy, curriculum and assessement (Osborne & Dillon, 2008). A strong commitment of the team on supporting teachers and students in schools drives the current project, to take advantage of the unique opportunity provided by the modernisation plan, for both research and development. Opportunities of this kind only happen every 30 years and the concern of the team is that a space change without further work will wither on the vine. This concern guides the overall project design, pursuing the improvement of the concept, the development of exemplary science departments and a teacher training course structure with supporting materials. Knowledge gathered in the project is considered useful also for policy makers and researchers as it provides both with data on teachers' needs, practices, attitudes and expectations related to the new spaces for science learning.

The involvement of the PI and other members of the project in the design of the concept and in the modernisation plan by Parque Escolar and their experience in visiting schools and meeting with teachers concerning the new Ispaces will provide valuable inputs and networks to support the development of the project. The state of the art in active learning classrooms will act as a guide to transfer the knowledge to the secondary school level, one of the main goals of this project.

In task 1, the literature review will look at several fields, mainly Active learning environments/classrooms, Post Occupancy Evaluation, Learning environments more broadly, and several national studies concerned with teachers practices (Ambrósio et al., 1994; Moreira, 2003; Sequeira, 2004) such as the White Paper of Physics and Chemistry (Martins et al., 2002). This report provided an important snapshot of practices in the science classrom and laboratory. Diagnostic data gathered from the year 2000 characterised teaching methods, student work typologies, out of the classroom activities, assessment and professional practices and teachers conceptions and perspectives about experimental work. These data will be also be useful as a reference for tasks 2-3.

To develop the survey proposed in task 2, a pre-pilot and identification and itemizing of subsidiary topics will be made with support of consultants that participated in the White book of Physics and Chemistry, science teachers and researchers in the field of active learning environments. The elements of the schools' science spaces concept that will integrate the survey will be based on the official document (Fernandes et al., 2009). The population to which the survey will be addressed will be all the secondary science teachers in all schools involved in the modernisation plan. The science departments will be contacted and information will be provided to teachers to allow use of data and answering to the digital survey. Data will be exported to a statistical analysis software.

Concerning task 3, the 8 case studies will be located in different regions of the country, following Parque Escolar's administrative structure, with centers in Lisbon, and the north, centre, and south regions. The selection process will be based on feedback gathered by Parque Escolar about teachers' satisfaction with the intervention, with a balance of positive and negative positions, and schools that participated in the 2010 training programme on the use of the new science spaces. Both criteria for sample definition and details of the inquiry process will be developed with support of consultants from both schools and higher education institutions involved with active learning environments. The pilot study will be undertaken in a school in the Lisbon region, with an history of collaboration with the PI. Schools' science departments will then be contacted to check for availability to participate in the study, and later work in schools will be scheduled in the school year's third term, with teachers more available to work in the project.

Elements of the team will travel to the 8 selected schools for field work in task 3. The interpretive paradigm in educational research is more concerned with interpretation of subjective meanings which individuals place upon their own actions, and how these views shape the actions they take within a social reality (Cohen et al., 2005). Touring walkthrough interviews with teachers will take place in the new science spaces, providing a spatial agenda for participants to respond to. Interviews will be documented with notes, photographs and voice recordings and data will be organised and analysed using NVivo. Focus groups will explore in greater depth common and conflicting issues raised in the teachers' survey. Prompts will also be informed by the field of learning environments, such as instruments to measure students' perceptions of the classroom (Fraser, 2002), e.g. the Science Laboratory Environment Inventory (SLEI). The focus groups will be arranged with at least two teachers, one from each subject group, the head of science department/head of science facilities, and four students. For the remaining time, observation of activity in the spaces will be carried using an observation schedule.

The involvement of science teachers in the intervened schools will be key in task 4. Teachers that participated in the training workshop that took place in the summer of 2010 will be contacted for inputs. The project will have an intervention dimension based on the results of tasks 1-3, supporting the creation and dissemination of four exemplary science departments in the organisation and management of schools' science spaces. The team will also gather contributions from these teachers to develop an online teacher training programme and supporting materials for all the national schools' science departments, such as templates for a plan of management and organisation of schools science spaces, inventory and chemicals labels. These materials will be made available in the website of the schools science laboratories project at http://

Vitor Teodoro will coordinate the global execution of the project. João Fernandes and João Correia de Freitas will provide support in every task, Margarida Saraiva in task 2, 3 and 4, and Rui Neves in task 4, Parque Escolar in tasks 1, 2 and 3. The consultants will also provide support particularly for tasks 2, 3, and 4. The team will meet periodically and collaborate online to achieve the proposed aims. Meetings will also be held after each milestone to assess the project development. Task 1 is expected to end in m3, task 2 in m12, task 3 in m17 and task 4 from m22 to m24 followed by a final meeting to discuss the final project report. In the dissemination phase for each task, the team will aim to publish the research results in peer-reviewed national and international journals and to present them in national and international conferences. Reports will be made available with creative commons licenses on the project website. The work with such a large number of schools is also expected to seed a community around the development of schools' science spaces.

#### **Project Tasks and Timeline**

TASK NUMBER AND DENOMINATION Cost (€) m1-2 | m3-4 | m5-6 | m7-8 | m9-10 | m11-12 | m13-14 | m15-16 | m17-18 | m19-20 | m21-22 | m23-24 Task 1. Literature review A. Identification and selection of relevant studies about active learning environments 2000 Bibliography and related themes **B.** Synthesis of the literature review C. Report writing and dissemination Report dissemination MILESTONES: SUBTOTAL 3000 Report 1 (M1) Paper 1 (M2) Paper 2 (M3) Task 2. Survey A. Inquiry process definition Consulting **B.** Questionnaire development and validation Questionnaire dev. and valida-2500 C. Field work Questionnaire administration D. Results synthesis and analysis 3500 and data analysis 1000 E. Report writing and dissemination Report dissemination F. Paper writing and submission for publication MILESTONES: SUBTOTAL Report 2 (M4) Paper 3 (M5) Paper 4 (M6) Task 3. Case studies A. Inquiry process definition B. Interview and focus groups methodology planning and dev. of obs. schedule Consulting 3000 C. Pilot study Pilot study 1000 D. Field work Visits to 8 schools 4000 3500 E. Results synthesis and analysis Data analysis F. Report writing and dissemination Report dissemination 1000 **G.** Paper writing and submission for publication MILESTONES: SUBTOTAL 12500 Report 3 (M7) Paper 5 (M8) Paper 6 (M9) Task 4. Exemplary science departments and teacher training programme development Development work with 4 school A. Selection of sites and development process definition

### Task description, expected results and team on task

### Task 1. Literature review

**B.** Development work

C. Report writing and dissemination

In this task, the team will develop a literature review around the research questions through a search of national and international databases, gueries to national and international specialists in the identified areas and libraries searches. A framework for identification, selection and analysis of literature will be developed and applied in the production of the report. Papers, books and technical reports will be acquired when needed. The outcome of this task will be a report (M1) and two papers (M2, M3), ready in the end of m2. The report will be updated if needed, following new inputs gathered in the next phases of the project.

This task is expected to inform the survey and case studies design, the identification of elements and processes that characterise exemplary science departments and the structure and contents of the The selected schools will be contacted with the help of Parque Esteacher training development programme.

### Task 2. Survey

Task 2 will start by defining the inquiry process with consultants from the field of active learning environments, researchers involved in the White book of Physics and Chemistry and science teachers. An online VOIP meetings and face-to-face meetings in FCTUNL. Pre-piloting and identification and itemizing of subsidiary topics will be made, resulting in a pilot survey. The validation of the questionnaire will involve science teachers in the Lisbon area.

After the validation process, schools' science departments previously contacted with the help of Parque Escolar will receive instructions to answer the questionnaire, made available in a digital format. Data will then be exported to a statistical analysis software and analysed data from the interviews and focus groups.

This task is expected to answer to all RQ and elicit common and conflicting issues to be later inquired in the interviews and focus groups in task 3. It will also be useful in the teachers training programme development as it will provide a snapshot of some of the needs and expectation of teachers about the new spaces. The outcomes are a report (M4) and two papers (M5 and M6) to be submitted to a peerreviewed journal. The dissemination will involve the publication of the report and participation in a conference related to the theme.

### Task 3. Case studies

The inquiry process definition will again gather contributions from consultants from the field of active learning environments, reseach-

ved in the White Book of Physics and Chemistry and science teachers. The criteria for school selection will be defined, following a development of a template for a Plan of Organisation and Manageuniform national distribution following Parque Escolar's administra- ment of Schools Laboratories, new in schools, will be developed with tive structure and feedback gathered by Parque Escolar about teachers' satisfaction with the intervention, with a balance of positive and ronments and research in science education. Based on the outcomes negative positions. Schools that participated in the 2010 training of tasks 1-3, the PI and João Fernandes will organise one meeting programme made with the support of DGIDC and Parque Escolar on with the teachers and consultants, later developed online, to define the use of the new science spaces will also be considered due to the this vision. The selection of sites for intervention will be based on established contacts and some knowledge of the schools' situation.

m1-2 m3-4 m5-6 m7-8 m9-10 m11-12 m13-14 m15-16 m17-18 m19-20 m21-22 m23-24

YEAR 2

MILESTONES:

Report 4 (M12)

Paper 7 (M13)

YEAR 1

Exemplary science departments (M10)

Online course structure and supporting materials (M11)

After the development of the interview and observation schedules, a pilot will take place in a school in the Lisbon area with prior collaborations with the research unit. Changes in the instrument will be

colar to check for their availability to participate in the study. Two elements of the team will travel to the 8 selected schools and spend an inventory template and other supporting materials. one day in each. A touring walkthrough interview with teachers from the science department will be arranged, with priority given to the head of science/facilities. These will be documented with notes, photographs and voice recordings and data will be organised, trancollaboration area will be used to manage the work, together with scribed and analysed using NVivo. Focus groups will follow, with at least two teachers, one from each subject group, and the heads of science department/science facilities, and four secondary students, exploring common and conflicting issues raised in the questionnaire data analysis. For the remaining time, the researchers will record activity in the spaces using the developed observation schedule and gather some of the departments' documents related to the organisation and management of the science spaces.

This task is expected to develop the answers to the three proposed by the research team. Data gathered will later be triangulated with RQ, building on the data gathered in the survey. It will also be of particular use in the teacher training programme development as the results of the observations, interviews and focus groups will guide the structuring of the course and provide photographies and documents illustrating several of the solutions used by the schools to organise and manage the spaces. The outcomes of the task are a report (M7) and two papers (M8 and M9) to be submitted to a peerreviewed journal. The dissemination will involve the publication of Attached the report and participation in a conference related to the theme.

#### Task 4. Exemplary science departments and teacher training programme development

Teachers that participated in the training workshop in the summer of 2010 will be key elements in the definition of the vision of a exemplar

their help, and with consultants in the field of active learning envischools involved in the training workshop in 2010, with schools in the four Parque Escolar's administrative regions. The PL and João Fernandes will be in each school for at least 3 days, helping the science department to take initial steps to implement the vision developed previously. The entire process will be documented with photographs, videos, materials and notes, and several templates will be developed such as labels for chemicals to be used by all schools, a safety checklist, posters, a waste management checklist, labels for the cupboards,

science departments

dissemination

M11

Website development and report

SUBTOTAL

TOTAL

4000

2500

14500

**Project Budget** 

The team will also gather contributions from science teachers and the consultants to develop an online teacher training programme and supporting materials for all the national schools' science departments, making use of the development of the examplary science departments. All these materials and the course structure will be made available in the website of the schools' science laboratories project at http://laboratoriosescolares.net with a Creative Commons license, so that it can be used by all schools and institutions that provide teacher training. Parque Escolar will help in the dissemination of the results of this task to the national schools. The dissemination will also involve the publication of the report.

This task is expected to provide concrete results resulting from this research project to the schools involved in the modernisation plan and others that are not included in the plan, such as keystage 2 and 3 schools and other educational institutions in the private sector, he outcomes of the task are a report (M12) and two papers (M13 and M14) to be submitted to a peer-reviewed journal.

### References