



PEB Exchange, Programme on Educational Building 2004/07

Science and Technology  
Facilities

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## SCIENCE AND TECHNOLOGY FACILITIES

At the recent meetings of the OECD Committee for Scientific and Technical Policy and of the Education Committee at ministerial level, ministers endorsed reinforcing the capability to make science and technology more appealing and attractive from the early stages of education as a means of increasing human resources in these areas.

These four articles relate to science and technology infrastructure for secondary and tertiary institutions. The first article presents a view on approaches to teaching science in school and illustrates ideal science facilities for secondary education. The second piece reports on work underway to improve the Science Complex at the *Université du Québec à Montréal*. The third describes a secondary level vocational training centre devoted to new technologies in Quebec. The fourth article visits an Australian science and mathematics specialist school.

### *Science-teaching areas: from educational approaches to appropriate facilities*

#### Education and the "Missions Decree"

On 24 July 1997, a decree was issued defining for the French Community of Belgium the priority missions of primary and secondary education (the compulsory levels of education in Belgium, covering ages 6-18). In Articles 16, 25 and 35 of the decree, the government defined the basic skills to be taught and gave them force of law. University teachers, specialists in the field of education, inspectors and teachers in the three education networks that co-exist in Belgium (the French, German-speaking and Flemish Communities) worked together to prepare this legislation which covers general, technical and vocational education. Certification will attest that schools teach basic skills effectively. The programmes are "frames of reference for learning situations, compulsory and optional curricula and methodological approaches defined by the relevant authorities to ensure that the targeted skills are attained".

It then remained to define the methodologies to be used to achieve these unanimously established objec-

tives. Each network supported, in its programmes and methodologies, an approach that would encourage pupils to become active participants in the learning process and to acquire standardised scientific knowledge. The teacher guides this process, becoming more a facilitator of active learning than a dispenser of knowledge.

Activities are placed within a context and are more holistic in order to make them meaningful. With regard to our specific topic of the sciences, scientific education is organised around three subjects: biology, chemistry and physics. The methodological objective is to:

- Foster a more dynamic learning relationship between teachers and pupils.
- Build bridges between the concepts and approaches learnt in biology, chemistry and physics.
- Save time and gain in consistency by teaching scientific approaches common to the three fields.
- Involve teachers more actively by giving them greater flexibility in implementing the programme.

According to one programme, pupils are enabled to master skills when they are encouraged to become "active learners". It is this concept of active learning that has been predominant in primary education that must now be adapted to the secondary level. Six converging pathways will be used to reach this goal: comparing perceptions



with established theories, modelling, experimenting, mastering knowledge, building a rational argument and communicating.

In any event, this approach will require that in any scientific practice, pupils show intellectual honesty, a balance between open-mindedness and scepticism, curiosity, and willingness to work within a team – seemingly indispensable qualities.

All science programmes present experimentation not only as a “verification” process but as a means of assimilating models, laws and theories. The use of simple material should be encouraged. Some experiments might also provide an opportunity for genuine research and others for exploration in the field.

One of the key objectives of education is linked to communication. Through the education process, pupils come to understand the benefits of acquiring a language, concepts and standardised models as well as a degree of socialisation to which science courses should also contribute.

One of the programmes visited by the author prefaced its presentation with a quotation by Albert Einstein, which is particularly relevant to the approach promoted here: “A young mind must not be crammed with facts, names and formulas. These can be learned without taking courses, since they can be found in books. Education should concentrate solely on teaching young people how to think, on giving them this training that no manual can replace.”

We also think that that if science is being taught in a traditional lecture class format, there is no need for a laboratory – any ordinary classroom will do. According to the dictionary, a laboratory is a facility equipped for performing experiments, conducting research and making scientific preparations. The word’s Latin origin, *laborare*,

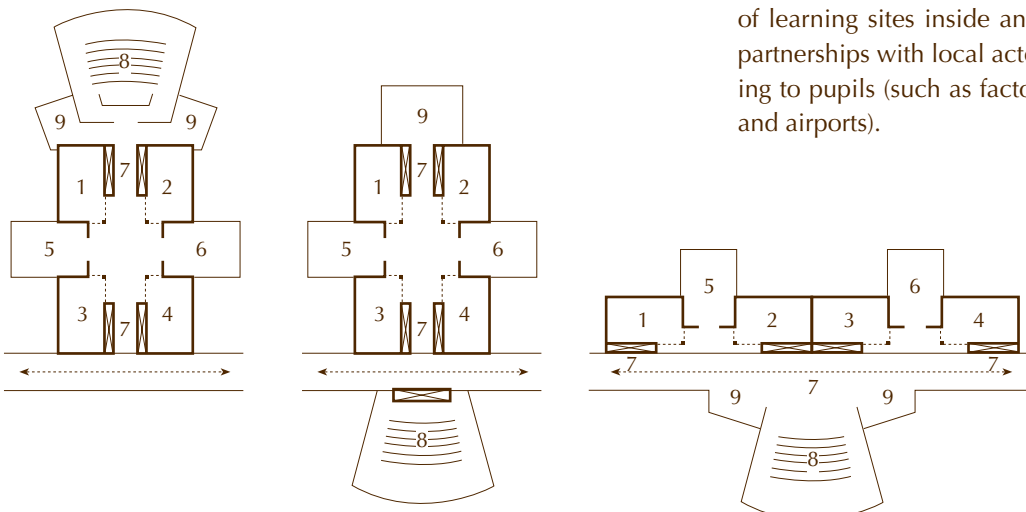
means “to work”. This underscores the active dimension that should be an integral part of laboratory work.

All of the comments above, which clearly reflect a definite educational philosophy, have not been selected at random. They express a fundamental truth, which also applies to the educational building sector as a whole. Buildings are genuine educational tools. When well designed, they unquestionably help promote original participatory approaches to achieving the sought-after objectives. On the other hand, buildings can be a major handicap if they make it difficult to develop attitudes and material and intellectual approaches aimed at understanding the laws that govern the physical and organic world.

We can readily agree that a place of learning that requires rigour, method and concentration cannot tolerate a disorderly approach on the part of its occupants or in its facilities. What we would like to see are specialised spaces assembled according to needs and resources on the basis of a concerted plan for their use, making school buildings places where pupils can learn through experience, observation, reasoning and research, share their successes and failures, and communicate with the outside world through computer-based tools.

We must bear in mind that this approach, although it enjoys wide support, is seldom put into practice, for it is too different from the traditional approach that has prevailed in secondary education. It is new kinds of behaviour that we need to invent, experiment with and evaluate by dint of our efforts and creativity and the support of various authorities that participate in the work of education.

We do not claim to be developing a new methodology for learning the sciences. As G. de Landsheere wisely said about other educational reforms, there can be no objection to individual schools adopting a method that simply reflects a universal approach to teaching scientific knowledge, but that is also fuelled by the contributions of all concerned, both teachers and learners, by the potential of learning sites inside and outside the school and by partnerships with local actors that will often be motivating to pupils (such as factories, SMEs, national defence and airports).



These diagrams illustrate the text below. They are not intended to serve as architectural plans.

## Facilities

We wanted to illustrate, in partnership with an architectural firm, the various components that a science-teaching area should have in a secondary institution having approximately 1 000 pupils. Ideally, a science-teaching area should consist of the following facilities:

1. Chemistry laboratory.
2. Physics laboratory.
3. Natural science laboratory.
4. Laboratory for geography, environmental studies, ecology, etc.
5. Preparation area.
6. Dedicated room for project-based research (accommodating 4 x 5 pupils).
7. "Museum" area for the school's science collection.
8. Auditorium for conferences and outside courses (guest teachers, preparation for higher education).
9. Informal meeting area.

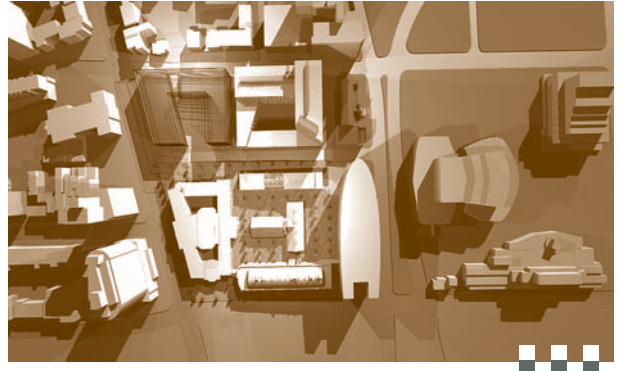
In these facilities, strong emphasis would be placed on safety and effective ventilation of any toxic fumes in the event of an accident.

Special attention would be given to acoustics and sound-proofing, so that small teams working on a specific project could move from one area to another.

The diagrams presented above are deliberately of a non-architectural nature, and are aimed only at giving an idea of the spaces involved. They show alternatives that can be reproduced in an infinite variety of ways depending on the available space in new or renovated buildings. We have estimated the cost per square meter at approximately EUR 1 000, not including tax, both for newly constructed and renovated buildings, depending on the techniques involved.

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## The Science Complex at the Université du Québec à Montréal



The *Université du Québec à Montréal* (University of Quebec at Montreal, UQAM) is carrying out two major projects to improve its Science Complex. UQAM is constructing a biological sciences building and is renovating four existing buildings as part of the "Cœur des sciences" project ("Heart of the Sciences"). These projects are being carried out using an accelerated method under the responsibility of a construction manager and are aimed at contributing to the development of Montreal. The new building will be a "green building".

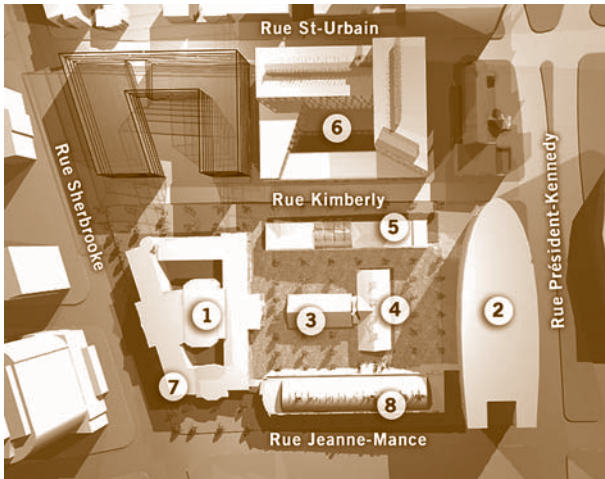
The Science Complex, also known as the West Campus, houses the Faculty of Sciences, one of UQAM's seven faculties. The complex currently consists of seven buildings located in the centre of the city of Montreal, near the university's central campus. UQAM, with its 40 000 students, is the main branch of the University of Quebec. UQAM is celebrating its 35<sup>th</sup> anniversary this year.

### The Biological Sciences Building

The construction of the Biological Sciences Building is essential for the future of sciences at UQAM, since the Biological Sciences Department is a key actor in the field of the environment, biochemistry and biotechnologies. It is the university's response to the need to promote and accelerate the development of a specialised labour force in biotechnology in Montreal, which is a major centre in this field.

The Biological Sciences Department is currently located in an outdated building in the city centre. Moving the department to the Science Complex is designed to improve working and learning conditions for its staff and





- 1. Old Auditorium
- 2. President Kennedy Building
- 3. Boiler Room Building
- 4. Old Forge
- 5. Kimberley Wing
- 6. Biological Sciences Building
- 7. Sherbrooke Building
- 8. Chemistry and Biochemistry Building

students and promote higher quality and more coherent departmental and interdisciplinary relations between the units of the complex.

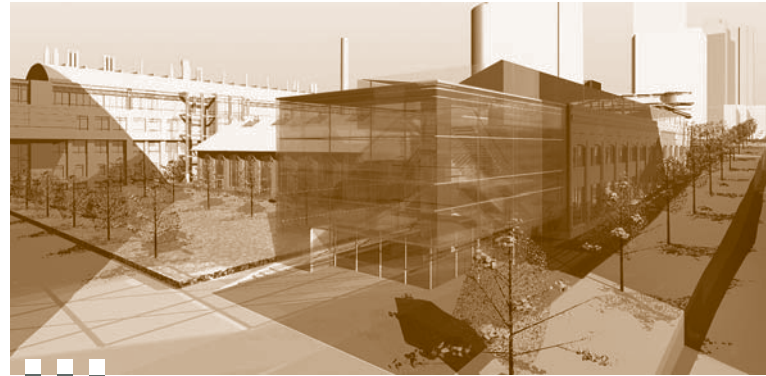
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The new building will have a total gross floor area of 42 000 m<sup>2</sup>, of which 17 500 m<sup>2</sup> will be for the department and 9 000 m<sup>2</sup> for rentable space. The building will also include an underground car park with 450 places. This building will be spiral in shape and at its highest will be 11 storeys. The part devoted specifically to academic activities will be spread over five floors. Its total cost is estimated at CAD 75.5 million and it is scheduled to open in September 2005.

The construction of the Biological Sciences Building has been registered with the U.S. Green Building Council in order to obtain LEED certification (Leadership in Energy and Environmental Design). Since the project's inception, UQAM has targeted the objective of including the largest possible number of criteria defined in the LEED specifications used for accrediting "green buildings". For example, special attention is being given to the building's location and rainwater management. The building's design is aimed at optimising inside air quality and the energy performance of the building envelope and air processing systems.

### The "Heart of the Sciences" area

Within the complex, the "Heart of the Sciences" area is intended to be a permanent, multi-purpose site for



The future Biological Sciences Building

disseminating scientific discoveries and breakthroughs. Promoting scientific activities and holding events will also be given an important role. This area will be focused particularly on providing young people with information and promoting their interest in science and scientific careers. The main goal is to make the "Heart of the Sciences" area rapidly become the major centre in the field of science and technology in Quebec. More specifically, the project will include the following facilities: a science forum, a media library, a 350-seat auditorium and a 450 m<sup>2</sup> multi-purpose room. The renovation of the auditorium, combined with the classrooms available in this building, will make it possible to hold conventions.

Within the "Heart of the Sciences" area, four old buildings<sup>1</sup> located on the site will be preserved and renovated. These buildings once housed the *École technique de Montréal* (Technical School of Montreal), and each one was dedicated either to practical, industrial activities or theoretical aspects. This duality in the treatment of the buildings, which highlighted the specific nature of each of its parts, confers an architectural and historical interest on this group of buildings. The university thought that this historical heritage had to be preserved.

The project also entails relocating the science library to the "Heart of the Sciences" area, thereby freeing up some 3 000 m<sup>2</sup> of floor area in the President Kennedy Building, which houses the Departments of Earth and Atmosphere Sciences, Mathematics and Computer Sciences and the Institute of Environmental Sciences.

The budget for this project is CAD 20 million.

1. These buildings are the auditorium located in the Sherbrooke Building, the Boiler Room Building, the Old Forge and the Kimberley Wing.

## Accelerated construction method

In order to meet the project's completion date set for mid-August 2005, UQAM has implemented an accelerated construction procedure. This means that construction can start while work on plans and specifications is still under way. This will involve dividing the construction into separate work items and sub-items to be carried out successively or simultaneously, thereby reducing the duration of work by one year. A process of competitive bidding for each work item will make it possible to comply with the same rules of transparency and competition as when bids are submitted as a single item.

The accelerated construction process requires awarding a contract to a different contractor for each item or sub-item. It is currently estimated that there will be a maximum of 50 items and sub-items, for a total amount of CAD 95.5 million (CAD 75.5 million for the Biological Sciences Building and CAD 20 million for the "Heart of the Sciences" project).

## Construction manager

In order to effectively co-ordinate this process in which plans and specifications will be issued while construction is under way, UQAM has hired a construction manager as a member of its team of professionals, who was selected through a competitive bidding process. Under the university's authority, the construction manager is responsible for co-ordinating contractors and ensuring that the costs of each work item and sub-item stay on budget (prior review of calls for tenders and strict monitoring of each stage of construction) and that work deadlines are met. He will participate actively in meetings with architects and contractors to make recommendations regarding materials, construction methods and fittings in order to reach optimum solutions that are economical and best adapted to the project. Also, he will be responsible, in co-operation with other professionals, for analysing the results of calls for tender. As UQAM's legal representative, he will sign and manage the contracts with the various contractors.

## Integration into the city

UQAM will contribute to the urban development of the district in which the Science Complex is located. In accordance with the city's master plan, the block on which the Biological Science Building is to be located, which has long been used as an outdoor car park, will now have a building on it. Parking will be moved to underground levels, and this new building located on a major artery going into the city centre, rue Saint-Urbain, will give the area a more urban aspect. The overall plan

will give the campus a higher profile within the city. A north-south road going through the centre of the site can still be used by cars in an emergency and provides a visual axis, but it will mainly be used as a pedestrian street. There is also access from east to west through the campus, which forms a vast external courtyard encircling the old buildings being restored.

The area north of the new building will remain vacant for the time being, pending construction of future university residences. The objective is to build residential areas for students that can be rented at a reduced rate in summer, thereby contributing to the mix of population groups, as targeted in the city's master plan.

Underground and above ground pedestrian networks are planned. The underground network will interconnect UQAM's various buildings and provide direct access to the *Place-des-Arts* metro station. However, the above ground network will be designed to provide a pathway system that will encourage users to walk between the different buildings as well as between the neighbouring streets, thus maintaining the traditional model of a campus crisscrossed by numerous footpaths.

Special care has been taken to minimise the impact of construction work on neighbours. An historic building, the church of Saint-John-the-Evangelist, is located next to the future Biological Sciences Building, and precautionary measures have been taken to protect it, particularly when the piles are being driven.

*A short 3-D visit to both projects and a visual presentation of the model of the Biological Sciences Building are available on the site [complexedessciences.uqam.ca](http://complexedessciences.uqam.ca)*

*Information on UQAM is available at [www.uqam.ca](http://www.uqam.ca)*

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### INVITATION TO VISIT THE SCIENCE COMPLEX

Individuals who register for the PEB seminar to be held in Montreal in November 2004 (see page 2) will be able to visit the Science Complex and see in person the entire complex and the progress of work on the Biological Science Building and the "Heart of the Sciences" area.

## The Centre de formation des Nouvelles-Technologies in Quebec



A secondary level vocational training centre devoted especially to new technologies has been established in Quebec. The *Centre de formation des Nouvelles-Technologies* (New Technologies Training Centre, CFNT) provides an environment that is in close contact with the reality of the labour market in the way it was designed, its training programmes and its international accreditation.

The three-storey building reflects an educational and functional concept in which space is organised horizontally in two parallel wings separated by an atrium acting as a meeting area and connected by two walkways. Each wing of the building houses a vocational training sector. The sectors arranged in a linear layout converge on the meeting area, which has glass walls on two sides that maximise natural light.

The CFNT's vocational training programmes consist of alternating training periods in class and traineeship periods in the workplace. This feature, combined with a dynamic environment, enables CFNT pupils to study in a setting that prepares them for the world of work.

The centre is part of a worldwide network recognised for its expertise and competence in the fields of computer-assisted design, computer science, office automation and network infrastructure equipment. Through its association with partners of international standing, the CFNT ensures that it is at the cutting edge of new developments. The CFNT has also distinguished itself by winning the "Americas Award" presented by Autodesk, Inc., a first for an exclusively French-speaking training centre.



This project has made it possible to bring together at a single site training activities that were previously scattered across a number of sites. Located at the heart of a rapidly expanding educational crossroads only 30 minutes north of Montreal, the CFNT opened in August 2002. Primarily funded by the Quebec Ministry of Education, this building, which cost CAD 8 million and has a floor area of 6 800 m<sup>2</sup>, was built by the School Board of *Seigneurie-des-Mille-Îles*.

For further information, consult the centre's Internet site, [www.cfnt.qc.ca](http://www.cfnt.qc.ca), or contact:  
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## At the cutting edge of maths and science

Geoff Maslen visits an Australian science and maths specialist school where academics are working with teachers to ensure that what they teach is at the frontier of learning. This article, which appeared in the *Times Educational Supplement ePaper* on 23 March 2004, concerns the ASMS school presented in PEB Exchange no. 46, June 2002.



Nigel Hancock travels almost 2 000 miles to go to school. For his friend Ray Dolan the distance is only 700 miles but both boys would not want to be educated anywhere else than at the Australian Science and Mathematics School (ASMS).

The two 17-year-olds heard about the unique school, located in the spacious grounds of Adelaide's Flinders University, before it opened early last year and applied to enrol. Nigel Hancock had dropped out of high school in his home town of Katherine in the Northern Territory while Ray Dolan was attending Cobar High School in the far west of New South Wales.

"I'd heard how it was going to be more university-based, with more lectures and we wouldn't be working out of textbooks," Ray Dolan says. "I thought that was really good 'cos I hate textbooks... everything they were saying matched up with what I always wanted in a school."

Nigel Hancock nods agreement: "This school offered me the chance to re-enter the education system. I thought it would encourage different ways of learning, that it would cater for kids who didn't fit into the formal classroom – which was me down to a T."

At ASMS, students devise their own learning plans and decide what level of difficulty to work at, and teachers use more varied methods than in traditional schools. In a unit on communications systems, for instance, pupils might have a lecture from a teacher on the principles of electrical circuits, go to the laboratory to carry out group experiments to develop understanding and report back to the entire group by creating a multimedia presentation.

Nigel and Ray are among 265 teenagers and 25 teachers occupying the AUD 14 million, two-storey ASMS building on the university campus. By 2005, student numbers will have grown to 450, of whom 100 will be young people from other parts of the world. By that time, they both expect to be studying for degrees at the university. In an Australian – and possibly a world – first, Flinders established the specialist school as a joint venture with the state Education Department.

In part, it is intended to counter the 50% decline over the past 20 years in the number of young Australians studying physics and chemistry. ASMS pupils are not selected on IQ or high performance in maths and science, but on the basis of showing a strong interest in the subjects.

With its plans to have students spend time in different workplaces as part of their studies, the school should also create new relationships between teachers, students,

scientists, mathematicians, business, industry and the local community. For instance, at the university pupils take more demanding modules delivered jointly by teachers and academics.

Core studies at ASMS include sustainable futures, technological world, energy, food and materials, the human body, biotechnology, nanotechnology, communication systems, the earth and the cosmos, mathematics and abstract thinking.

ASMS is typical of one of the models of future schools presented by the OECD at the Dublin conference (see page 4), in which schools become organisations where staff research and the involvement of professionals from other walks of life, in this case academics, constantly updates teachers' knowledge and professional development.

Academics are already working with ASMS teachers in developing the inter-disciplinary curriculum. Their expertise ensures what is being taught is at the frontier of learning, says John Rice, former director of the Flinders Institute for Research in Science and Technology.

Professor Rice proposed establishing such a school in 1998 and later worked with the present principal, Jim Davies, in developing the idea and negotiating the joint operation with university and department officials. "We wanted a school where there was a commitment to take account of the technological revolution and its impact in mathematics and science," he says.

Jim Davies says the architect-designed, open-plan building accords with this goal. Within the nine major learning areas, students have their own desks and computers alongside their teachers who do not have a staffroom to escape to.

Facilities include laboratories, a fully-equipped multimedia centre and a student recreation area as well as access to the university's libraries, sports grounds and gymnasium.

"Each student has his or her own learning plan and a tutor," Davies says. "But the school is also a resource for every teacher in the state through our programme of professional development and curriculum enhancement."

