LEAGUE CITY INTERMEDIATE SCHOOL - A STUDY IN ENERGY-EFFICIENT DESIGN

JEAN T. LONGSERRE
Conservation Consultant
Houston Lighting & Power Co.
Houston, TX

LUCRETIA AHRENS
Conservation Specialist
Houston Lighting & Power Co.
Houston, TX

ABSTRACT

For many design professionals, standardization of design and engineering strategies has become a key element in the construction of institutional facilities. Conservation features, such as innovative building design, and energy efficient electrical and mechanical systems are often considered "extras". An increase in these "extras" can mean an increase in budget, leaving the energy conscious customer with the responsibility of weighing additional investment against possible future savings. This paper is an account of the design features of a southwest Texas school project in which energy conservation was an integral, not an "extra", design factor. The result was an aesthetically pleasing, energy savings institutional facility, built within a standard budget.

In 1979 the Clear Creek Independent School District began planning for a new intermediate school in response to the growing school-age population in the Bay Area. Facing steadily rising utility costs, the district desired a building which would incorporate energy-saving features. At the same time, durability and ease of maintenance had to be considered.

Site constraints required the building to be located on the corner of a block of land shared by a large high school, and school district administration, transportation, maintenance and athletic facilities. At this location, the building could serve as a future high school annex for ninth grade students. The building area was further decreased by the necessary inclusion of bus and faculty parking areas, tennis courts, football practice fields, and space for a future metric track.

The Houston architectural firm of McKittrick Richardson Wallace Architects, Incorporated, with the assistance of Grunewald Engineering, was selected to design the facility for 1400 students.

PROJECT RESULT

Adhering to the requests of the school district and following local building codes, MRW designed the compact, two-story, 153,000 square foot League City Intermediate School.

The project cost was $8,080,000, or $52.75 per square foot. Due to the architectural firm's careful planning and use of a computer analysis to evaluate potential energy usage, the budget was not increased for energy efficient systems. No "extra" cost can be attributed to energy conservation measured incorporated into the design.

The primary energy conservation features of the building are:

1. Building orientation and operable shaded windows allowing for natural ventilation.
2. The installation of an efficient heat pump system with a modular air conditioning design.
3. Indirect lighting in classrooms and the use of high pressure sodium (HPS) lamps to produce maximum lumens per watt.
4. A well insulated building shell.
5. Control by an energy management system.

The school, which opened during the summer of 1982, was designed to operate at an energy consumption rate of approximately 45,000 BTU/SF/YR. Actual energy usage for 1983 resulted in a consumption rate of approximately 32,000 BTU/SF/YR. The yearly energy consumption rates of several comparably sized Clear Creek schools, using electric heating and cooling, range between 60,000 and 70,000 BTU/SF/YR. Older structures, of comparable size, using gas equipment often exceed a consumption rate of 100,000 BTU/SF/YR.

BUILDING ORIENTATION

The long axis of the building runs from southwest to northeast. Less than 10 percent of the building envelope surface is glass or insulated skylights.

All exterior glass is dark gray in operable sash, except at the lobby where clear glass is used in fixed frames. Most windows are located on the long southeast and northwest exposures. Since the prevailing breeze is from the southeast, the orientation of the operable windows creates

excellent cross ventilation capabilities.

Glass areas are shaded by aluminum sun shades which span between the vertical brick sun control fins, or by roof overhangs. Mini blinds are provided on all windows for further control of sun infiltration.

HVAC

In selecting a cooling and heating system, both low operating costs and simple maintenance capabilities were of major importance to the school district. The district decided on a series of reverse-cycle units (heat pumps) connected to a water loop which circulates tempered water at 60 degrees to 90 degrees Fahrenheit. All units are mounted above the ceiling and possess self-contained heating and cooling capabilities. The conditioned floor area of the building encompasses 152,500 square feet of space, resulting in a maximum cooling load of 298 tons, and a maximum heating load of 2,250 MBH.

The heat pumps reject heat from the spaces into the water loop when cooling, and extract heat from the water loop into the spaces when heating. Heat energy is not wasted as long as it is needed somewhere in the building. This is useful during cool weather, when some areas of the building require cooling, while others call for heating.

Water flows through the system by means of 30 and 40 horsepower circulating pumps. No additional mechanical equipment is needed, as long as the water temperature remains within the operating range of 60 to 90 degrees Fahrenheit. When necessary, closed cycle evaporative coolers (cooling towers) can cool loop water, or a simple immersion water heater can heat loop water to the nominal operating range.

The building is divided into eleven zones providing additional opportunities for conserving energy. Each zone can be cooled or heated independently of the others, allowing extra-curricular activities to take place in one area of the school without affecting the entire building.

In addition to the conservation features, the system has proven advantageous from a maintenance standpoint. No more than two classrooms are served by an individual unit; therefore, repairs and replacement of units can be accomplished with minimal interruption of school activity. General maintenance of the system is facilitated by the simple nature of the small reverse-cycle machines, requiring normal filter changes and seasonal service.

The outside air exchange rate is 7000 CFM, or 5 CFM per person, meeting the standard ventilation requirements. The heating, ventilation and air conditioning cost for the project was $704,286.00, or $4.60 per square foot.

LIGHTING

It is in the area of lighting that conservation features are most visible. Natural lighting is used where practicable and is provided by shaded windows and insulated skylights. Skylights in the resource center, located at the center of the facility, permit borrowed light to enter through operable windows into interior classrooms.

The primary source of electric lighting is color corrected, high pressure sodium (HPS) designed to provide approximately 50 footcandles without natural lighting. Classrooms, gyms, the commons and resource center all utilize HPS lighting. One 250 watt and two 400 watt wallmounted indirect fixtures illuminate each classroom. Separate switching allows teachers to turn off the 400 watt lamps on sunny days, thus using the single 250 watt lamp and outside light to provide the needed illumination.

400 watt HPS fixtures are used in the two gyms, the commons, and the resource center. In these areas rows of lights can be turned on and off independently, again allowing the utilization of natural light. For example, total lighting in the gyms was calculated at less than 1.2 watts per square foot. By turning off half the lamps and using light coming through the skylights, the operating wattage in these areas is reduced to approximately 0.6 watts per square foot.

The aesthetic effect of the high pressure sodium lighting mixed with natural light is quite pleasing. In the resource center, for instance, the lighting and tropical landscaping contribute to a mood of warmth and comfort. Students find the room a congenial place to read and study.

Four-foot, two lamp, lay-in, fluorescent parabolic reflector fixtures are used in the offices and teacher workrooms. Hallways are lit by 2' x 2' lay-in parabolic reflector fixtures with standard wattage, U-shaped fluorescent lamps. Entire blocks of lighting can be switched on and off from a console in the administrative offices. Exterior lighting consists of 400 watt high pressure sodium lamps controlled by a photo-cell timer combination. Incandescent lighting is used only in small interior spaces.

Total connected load for lighting is 1.15 watts per square foot.

INSULATION

Facility insulation levels were carefully considered by the building designers and school district personnel. The roof, designed for both energy conservation and ease of maintenance, consists of a 3-ply fiberglass built-up roof structure. The structure encompasses a combination of fiberglass insulation board on a lightweight concrete roof deck, with fiberglass batt insulation below the deck.

For the roof of the gymnasium, a 2½-inch rigid insulating board was added between the tectum deck and the built-up roofing, providing for a 0.6 U-value. A U-value is the measure of heat transfer into a building, whereas the R-value is the measure of the resistance of insulating material to the transfer of heat. A rating of .06 is equivalent to R-17.

Throughout the rest of the building, 6-inch batt-type insulation is held beneath the roof deck by wire mesh. The result is a U-value of .04 and a R-25 insulation level.

A typical wall section of the facility consists of 3-inch brick veneer, 2-inches of rigid board insulation, and a 6-inch concrete block, resulting in a .10 U-value. An air space between the brick veneer and insulation provides an additional retardant for heat transfer.

Less frequent exterior walls of brick, gypsum sheathing board, batt insulation, and gypsum board interior skin have a U-value of .06.

All ducts are externally wrapped with 1-inch fiberglass, heavy density, sectional molded insulation. The tempered water A/C loop requires no insulation.

ENERGY MANAGEMENT CONTROL SYSTEM

An energy management control system was included in the design stage to optimize the operation of the heat pump system, exhaust fans, outside air dampers, water heaters and lighting system. The operational control enhances the energy savings of the efficient design and mechanical engineering of the building.

ARCHITECTURAL LAYOUT AND BUILDING PERFORMANCE

Figure 1 is a photograph of the League City Intermediate School. Figure 2 shows the monthly KWH consumption for 1983. Note that the peak energy consumption occurs in September when the building is fully occupied and when the weather is still very hot. The low values of energy consumption in June and July is because of summer vacation for the students. Figure 3 is the site plan for the school. Figure 4 shows the first floor and Figure 5 shows the floor plan for the second floor. Figure 6 is an architect's sketch of the resource center.

CONCLUSION

League City Intermediate school is truly a study in energy efficient design. The building was a Grand Award winner in Houston Lighting & Power's fourth annual Energy Conservation Design Awards competition held in March. The school was awarded for aesthetically pleasing architectural design, competitive cost of utilized materials and, most importantly, effective energy conservation design techniques.

In a country of decreasing natural resources and increasing costs, the efficient use of energy becomes more important with each passing day. The energy consciousness of school districts, such as Clear Creek I.S.D., and design professionals, such as MRW Architects, Inc. and Grunewald Engineering, is a giant step toward energy insurance and a BRIGHT future.

REFERENCES

1. McKittrick Richardson Wallace Architects, Inc.; Houston, Tx.
2. Grunewald Engineering; Houston, Tx.
3. Clear Creek Independent School District; League City, Tx.
4. Houston Lighting & Power; Houston, Tx.

Information for this paper was supplied by the above.

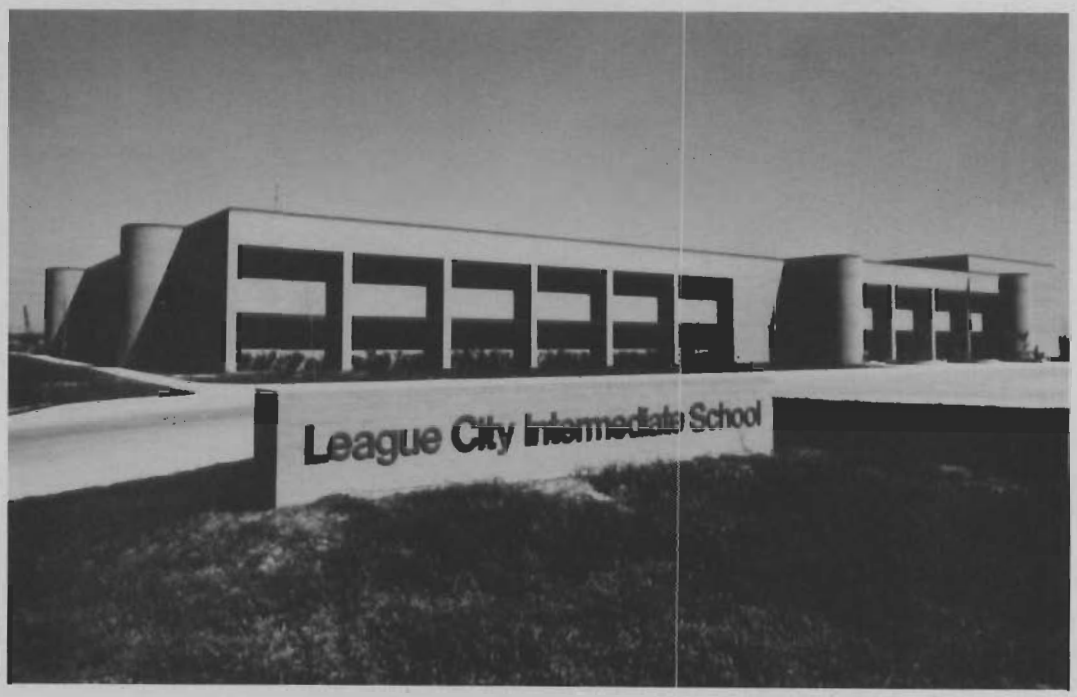


Figure 1 Photograph of League City Intermediate School

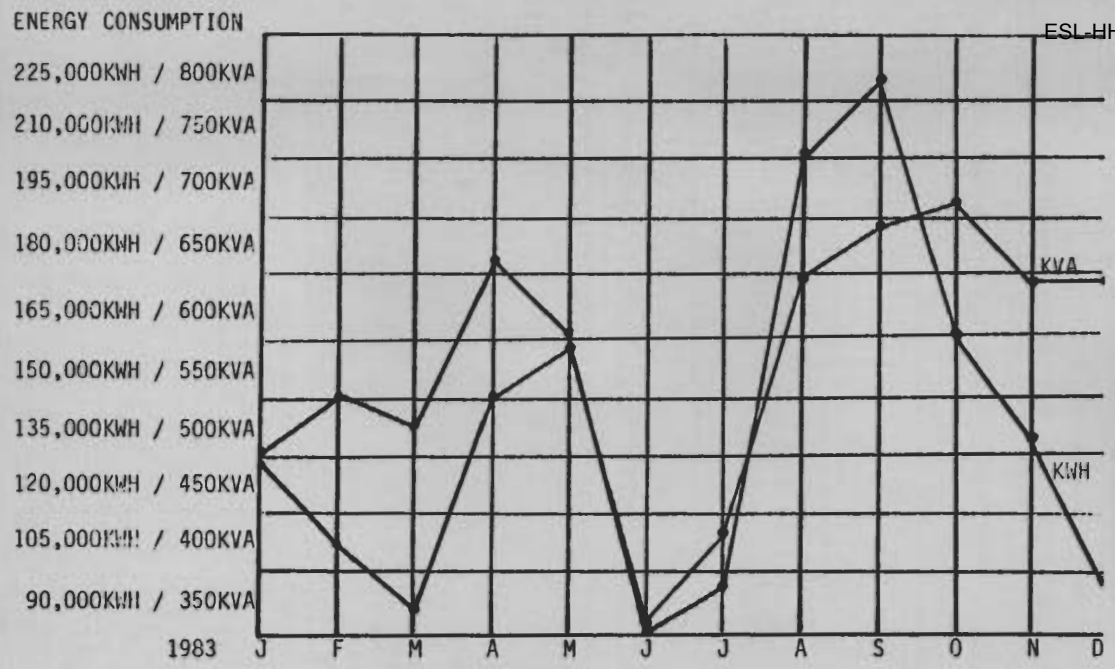


Figure 2 Energy Consumption for Year 1983

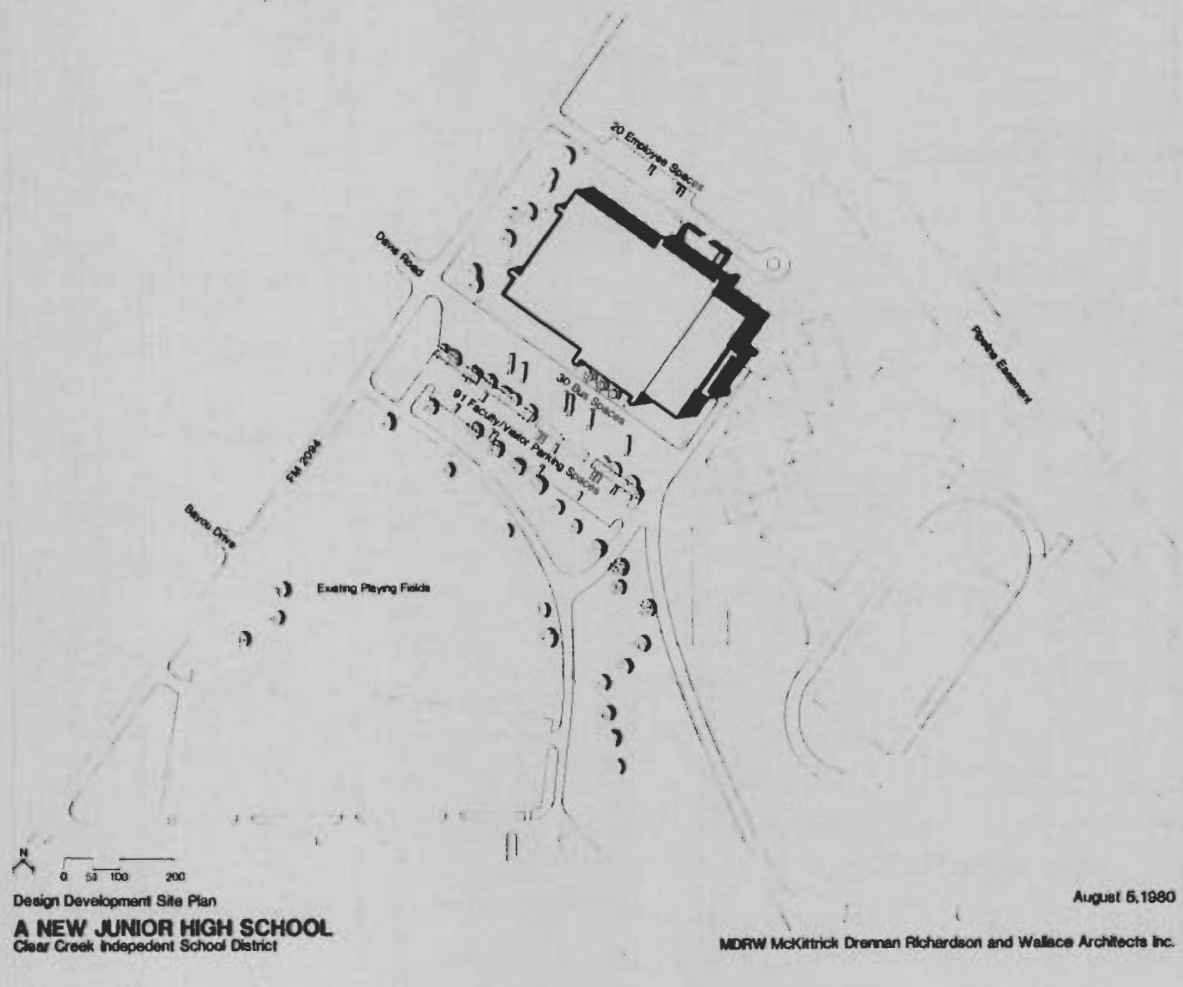
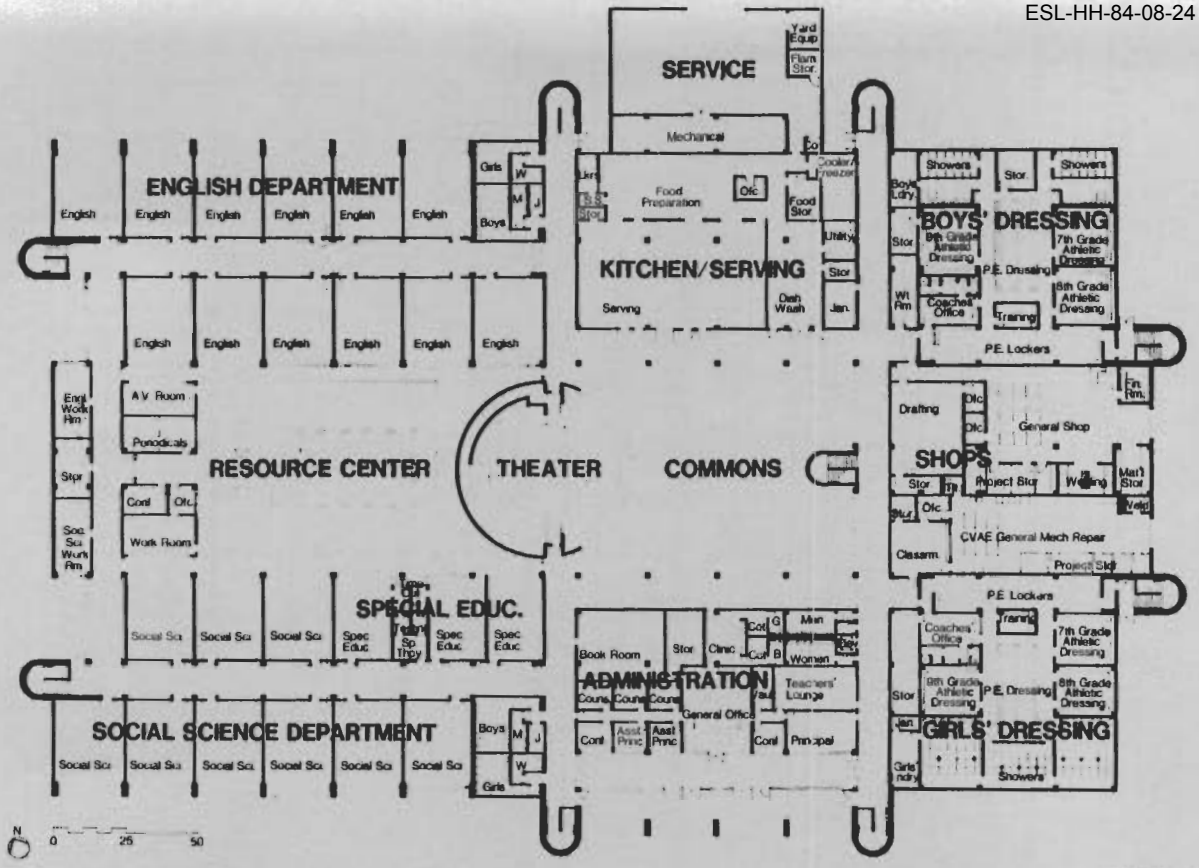


Figure 3 Site Plan of Junior High School



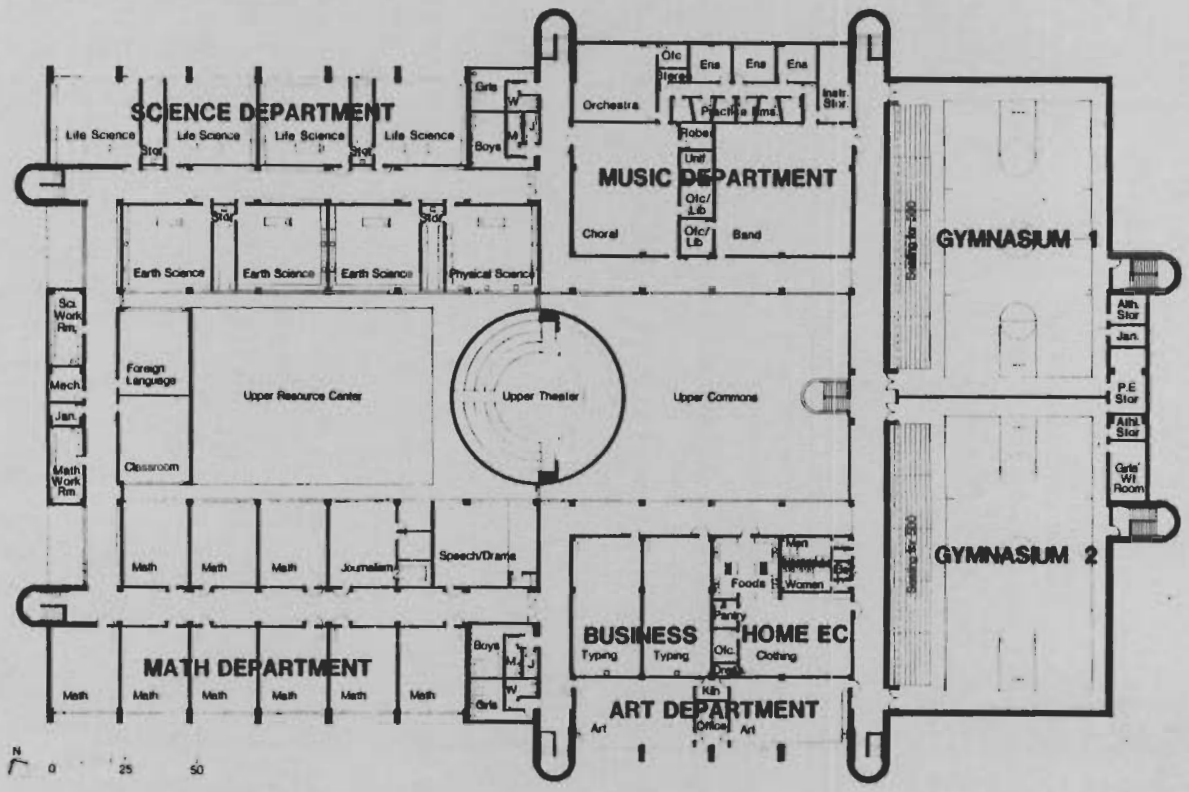
Design Development First Floor Plan

A NEW JUNIOR HIGH SCHOOL

Clear Creek Independent School District

August 5,1980

Figure 4 Floor Plan of School's First Floor



Design Development Second Floor Plan

A NEW JUNIOR HIGH SCHOOL

Clear Creek Independent School District

August 5,1980

Figure 5 Floor Plan of School's Second Floor

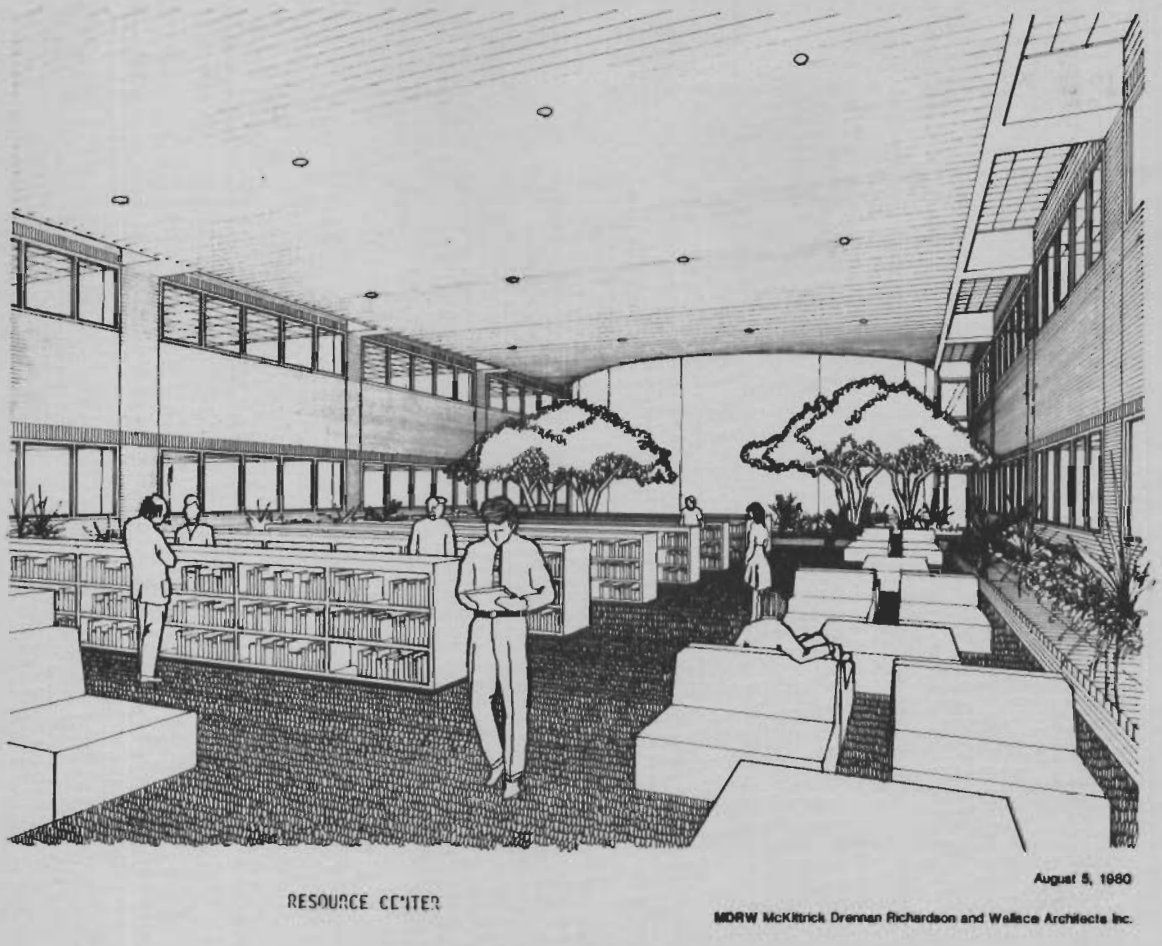


Figure 6 Architect's Sketch of Intermediate School's Resource Center