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ENVIRONMENT FOR LEARNING, A RESEARCH STUDY IN SECONDARY SCHOOL DESIGN.

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DESCRIPTORS- *BUILDING DESIGN, *CONTROLLED ENVIRONMENT, *FLEXIBLE FACILITIES, *SPATIAL RELATIONSHIP, *WINDOWLESS ROOMS, BUILDING INNOVATION, BUILDING OPERATION, COMPARATIVE ANALYSIS, CONSTRUCTION COSTS, DESIGN NEEDS, SECONDARY SCHOOLS,

A STUDY OF THE SCHOOL ENVIRONMENT AND THE PREPARATION OF A MODEL DESIGN SOLUTION HAS BEEN CONDUCTED BY AN ARCHITECTURAL FIRM. THE SOLUTION USED DATA FROM AN EXISTING COMPARISON SCHOOL IN THE REDESIGN OF THE EDUCATIONAL FACILITY BASED ON THE INDEPENDENT CONTROL OF THE INTERNAL ENVIRONMENT AND THE ELIMINATION OF CLASSROOM WINDOWS. THIS APPROACH ALLOWED THE REDISTRIBUTION OF SPACE AND FACILITIES WITHIN THE BUILDING PROVIDING A GREATER FLEXIBILITY AND ECONOMIES IN COST, SPACE, AND TRAVEL TIME, AS WELL AS A MORE EFFECTIVE ENVIRONMENTAL CONTROL. THE MODEL SOLUTION HAS COMPARED WITH THE EXISTING SCHOOL IN TERMS OF (1) SITE USE, (2) FLOOR PLAN, (3) CONSTRUCTION COSTS, AND (4) OPERATING COSTS. THE SOLUTION ALSO INCLUDES SPECIFIC CONSIDERATIONS OF (1) ENTRANCES, (2) CORRIDORS, (3) FLEXIBLE CLASSROOMS, AND (4) ENGINEERING FACTORS. (DM)

Environment For Learning

A RESEARCH STUDY IN SECONDARY SCHOOL DESIGN

Sponsored by

Carrier Corporation, Syracuse, New York

Prepared by

Golemon & Rolfe, Architects • Engineers

Houston, Texas

FOREWORD

During the past several years the need for thorough-going research into the subject of American school design has frequently been expressed by architects, educators and editors of publications that serve both fields. At least some professionals have come to the conclusion that further refinement of designs already popular and well developed is not likely to produce the kind of schools demanded by the crisis in education that confronts the nation today. An entirely new order of educational productivity is the vital need, they believe, and the school structure should contribute to it. Hence, new design directions should be explored, and the exploration must be preceded by the kind of purposeful research for which America is noted.

It was against this background that Carrier Corporation decided to sponsor a study in school design as a public service. The research assignment was turned over to Golemon & Rolfe of Houston, Texas — a firm of architects and engineers with broad experience in school design. No restrictions were placed upon them. This was to be practical research with the architects and their educational advisors in complete charge. The value and validity of the project is rooted in the free hand accorded the investigators and the challenge to them to seek ultimate solutions.

The research school that has emerged from this study is described in detail in this report. It is also compared with a conventional school on which its educational specifications are based. The research school clearly demonstrates the value of fresh concepts which, at the very least, are worthy of the most careful consideration on the part of all who are concerned with school design. Perhaps the most important of these is the usefulness of a new basic approach to the problem of school planning.

CARRIER CORPORATION

Syracuse, New York
February 1, 1960

Environment For Learning

A RESEARCH STUDY IN SECONDARY SCHOOL DESIGN

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I. THE PROBLEM

A shortage of at least 130,000 public school classrooms today exists in the U. S., according to Secretary of Health, Education and Welfare Arthur Fleming. The National Education Association estimates the teacher shortage at 135,000. And barring depression or war, the national population is expected to increase by 30 million in the next ten years.

If these stark realities were all that concerned American educators, there still would be an educational crisis of serious proportions. The classroom shortage, the teacher shortage and the population explosion, however, are only three ingredients of a ferment that is bubbling in every school district in every state in the union. To these must be added militant communism, the sudden emergence of the age of science and space, and an economy that is well along in the second decade of spiraling inflation. All of these forces are exerting mounting pressure on the whole educational system.

The reaction of educators to these powerful challenges has been vigorous. They are re-examining every facet of the teaching-learning process in search of more efficiency and more productivity. The curriculum is under intensive study. Basic philosophies involving the length of the school day, the length of the school year and new class groupings are being carefully reviewed. The old order is changing and, with change, educators see the need for a more flexible kind of school that will be hospitable to the new programs. The school building itself requires re-examination and one such re-appraisal, perhaps the first of its kind, is the research in school design reported here.

This study was conducted and is reported by Golemon & Rolfe, A.I.A., a firm of architects and engineers of Houston, Beaumont and Orange, Texas. It was sponsored by Carrier Corporation of Syracuse, New York. The specific objective of the study was to determine impartially whether a new approach to the problem of designing a school building might produce an educational facility which, in the judgment of educators, would be better for the teacher, the pupil and the educational program today and tomorrow, and would cost no more — or perhaps less — than schools currently under construction.

The statement of objectives contained five guideposts that helped to chart the course of investigation by the Architect. A fresh approach, unrestricted by old conventions and prejudices, was inherent in the assignment. The research was to be educator-oriented. Some means of comparing the research design with contemporary school design was required. A workable definition of what constitutes a better school for today and tomorrow should be whittled out with the educator. Cost must be a major design consideration.

A fresh approach

The conventional approach to school design is based on the age-old concept of natural ventilation and a mixture of natural and artificial lighting. This inevitably complicates problems concerning use of land, site orientation, plan selection, room arrangement, light control, sound control and structural design without satisfactorily resolving the problems of ventilation, temperature control, humidity control, air purity and circulation. The price tag on "free" ventilation and "free" light is much higher than it appears to be. The real cost can be measured only in terms of the major adjustments and compromises, involving practically every phase of the design, which use of natural light and ventilation entails.

Modern technology makes practical a new approach to school design that completely frees the architect from these limiting considerations. Here he decides at the outset the new school can create and control its own internal environment, completely independent of all outdoor elements. Once this stand is taken, the architect finds his solution can be determined solely by educational requirements present and future, by the basic needs of pupils and teachers, and with the utmost regard for broad educational philosophies and human aims. The "Environment For Learning" (EFL) research school which is an integral part of this project was developed through application of this new approach.

An educator-oriented study

Because the new design approach freed the Architect to concentrate on the problems of the educator, the teacher and the pupil, it was obvious from the beginning of the project that many educators at the state

and local level should be interviewed so that direction and program could be established. The methods employed were those of practical research. After the initial interviews, many plan studies exploring various design alternatives were made by the Architect. These were submitted to the educators for criticism and comment. Final plans were drawn only after the opinions of the educators had been fully evaluated and their ideas had been incorporated into the design criteria.

During the course of the study, teachers, pupils and specialists in various fields were also interviewed. In addition, the Architect analyzed and interpreted architecturally information contained in reports and publications dealing with school buildings and educational trends. A partial bibliography will be found at the conclusion of this report.

A control school for comparison

If concrete results of specific value are to be expected from a project of this nature, then the scope of the project necessarily must be held within practical limits. For this reason, the Architect decided to design the research school to a specific educational program, to a specific enrollment limitation, and to a specific site.

In 1954 the Architect designed a senior high school for the Houston Independent School District in Bellaire, Texas. This school is known as Bellaire Senior High School. It is considered a typical senior high school in the Houston area and was an award winning design in 1956, the year after its completion. After discussion with the local school administrators it was decided to use this particular school as a comparative study for the new research design. The EFL school is comparable in all aspects to Bellaire.

A better school, by definition

The American secondary school facility has been under intensive professional development for almost a century. Progress, particularly in recent years, has been remarkable. What, then, can be done now to effect substantial improvement without sacrificing hard-won gains?

An answer to this difficult question began to take shape during the initial interviews with the educators, as they carefully compiled lists of their most pressing secondary school problems. A consensus of these major problems follows:

1) Passing on to pupils a tremendously expanding body of knowledge.
2) Attracting and holding highly qualified teachers.
3) Operating within a budget that is seldom more than adequate, and often less than that.
4) Preparing for the tidal wave of scholastics who will reach secondary school age in the 1960s.
5) Adapting programs, personnel and facilities to new educational methods and techniques as they are developed and approved.

Obviously, even a greatly improved school structure could not, of itself, provide a complete solution to any one of the five problems above. But careful study of the list from a design point of view did reveal to the Architect some very interesting—even exciting—possibilities.

For example, major improvement in school environment (and there is much room for improvement in this area) would contribute substantially to the solution of Problems 1 and 2. Simplification of plan and structure would simultaneously reduce the dimensions of Problems 3 and 4. Increased flexibility of space usage might well be the key factor in helping educators to solve Problem 5. And so on. Working with the freedom afforded by the new approach to school planning, and with the list of educational problems as prime targets, the research project quickly evolved into a stimulating exercise, full of surprises and unexpected rewards.

Educators, however, are not yet ready to accept a school whose only claim to superiority is the solution of knotty tangible problems. They still insist on a building that is esthetically attractive and stimulating. They are loath to swap efficiency for drabness. "The secondary school, ideally, should be as comfortable and as architecturally appealing as any place in the community," according to one of the educators interviewed.

By definition, then, a better secondary school is one that helps to solve educational problems hitherto unsolved, and does so with style, good taste and true economy. That was the goal of this project.

II. THE COMPARISON SCHOOL

Bellaire Senior High School was completed in 1955 by the Houston Independent School District to serve the community of Bellaire and surrounding residential subdivisions. The site consists of approximately 9 acres, which the School Board recognized was less than the 15 acres recommended by the Texas Education Agency for such a project. The site fronts on an east-west residential street and is adjacent to a main thoroughfare. In addition to the building area, approximately one-half of the site at the west end of the property was reserved for recreation and the school track.

The school was designed to accommodate 2200 pupils. The program is typical of the combination college preparatory-terminal type offered by Texas secondary schools. The program brief:

1) Administration and services
2) Library and services
3) Auditorium for 1200, stage
4) Teaching Section — Classrooms for 60 groups (average 30)
5) Student Center —
   a. Food service to accommodate 2200 in one hour
   b. Recreation and lounge
   c. Meetings — student and public
   d. Parties
6) Music and Dramatics —
   a. Orchestra
   b. Band
   c. Chorus
   d. Dramatics
7) Counseling and Guidance
8) Physical Education —
   a. Boys
   b. Girls
   c. Pool
   d. Boys clinic and first aid
   e. Girls clinic and first aid
9) Teachers lounge and work areas
10) Services —
   a. Mechanical room and maintenance station
   b. Building custodian
   c. Incinerator

The Bellaire plan developed from consideration of prevailing breezes, orientation of the rooms for natural light, isolation of quiet from noisy areas, and the flow of students through a typical class schedule from arrival until departure.

The main structure is a three-story academic building which contains 36 classrooms, including arts and science, laboratories, the administrative suite, and the library. The height of this building is effective in capturing the prevailing breezes which hit the building broadside. The multi-story, compact planning of the classrooms was required by the limited size of the site.

The middle building group contains the cafeteria and kitchen at the center of the plan. The gymnasiums, swimming pool, and adjoining athletic department facilities are at the west end, adjacent to the recreation field and track. The auditorium, music and drama classrooms are at the east end adjacent to the major street, for ease of access. Furthest from the academic building, at the back of the site, are the shop building and boiler plant with a direct service connection to the major street. These buildings are separated by open patios but are connected by covered walkways.

The project architect was Golemon & Rolfe, A.I.A. and the coordinating architect for the School District was Milton McGinty, A.I.A. of Houston. The general contractor was American Construction Company of Houston.

III. THE SOLUTION

The Environment For Learning research school is a compact, rectangular, one-story structure which is equally at home in any geographical location. It knows no season or hour of the day. Light, temperature, humidity, ventilation, air purity and circulation are constantly controlled at optimum levels according to the needs of the occupants and the tasks they perform. Sound is bridled as never before in a secondary school.

One glance at the exterior tells the viewer that something new and different has arrived on the scene. Form, color, texture and structural shapes make the exterior interesting and attractive. Fenestration has been deliberately restricted. Exterior glass is used only at nine entrances, three of which are boldly big and inviting. These three are sheltered by dramatically executed student loading piers. One of them admits directly to the auditorium-administration area for the convenience of parents and the general public.

Immediately inside, the main corridors are spacious to the point of luxury. They could easily double as a community art gallery since they are 20 feet wide along much of their length. Sheer length, however, has been visually relieved by eye-catching murals, dioramas, and island displays. A colorful circular student snack bar extends partly into one of the corridors from the cafeteria-student center. The main corridors also afford space for the four principal toilet facilities which, in these locations, are particularly convenient to all areas.

Four secondary corridors serve the academic core and inter-connect the main corridors. Free-standing lockers, gaily painted in a variety of contrasting colors, are located in three of the laterals. The fourth extends the full width of the building, serving the shop area. The scheme has been to locate the chief traffic areas in the center of the building and to permit lesser traffic to radiate outwards. Administration should be able to control traffic very easily.

New classroom flexibility

The room layout (page 11) provides natural zones for the various educational departments, for the control of sound and for the combination school-community usage that is anticipated in all seasons of the year. Structurally, the building has been planned so that all teaching units likely to require flexibility of size and shape can attain it simply by adjustment of movable partitions, while those elements that probably will not require change in size were set as permanent shapes. Hence, the rooms in the home economics, commercial and art departments in the academic core make use of fixed partitions while the other academic areas are extremely flexible. The cafeteria-student center also can be subdivided at will.

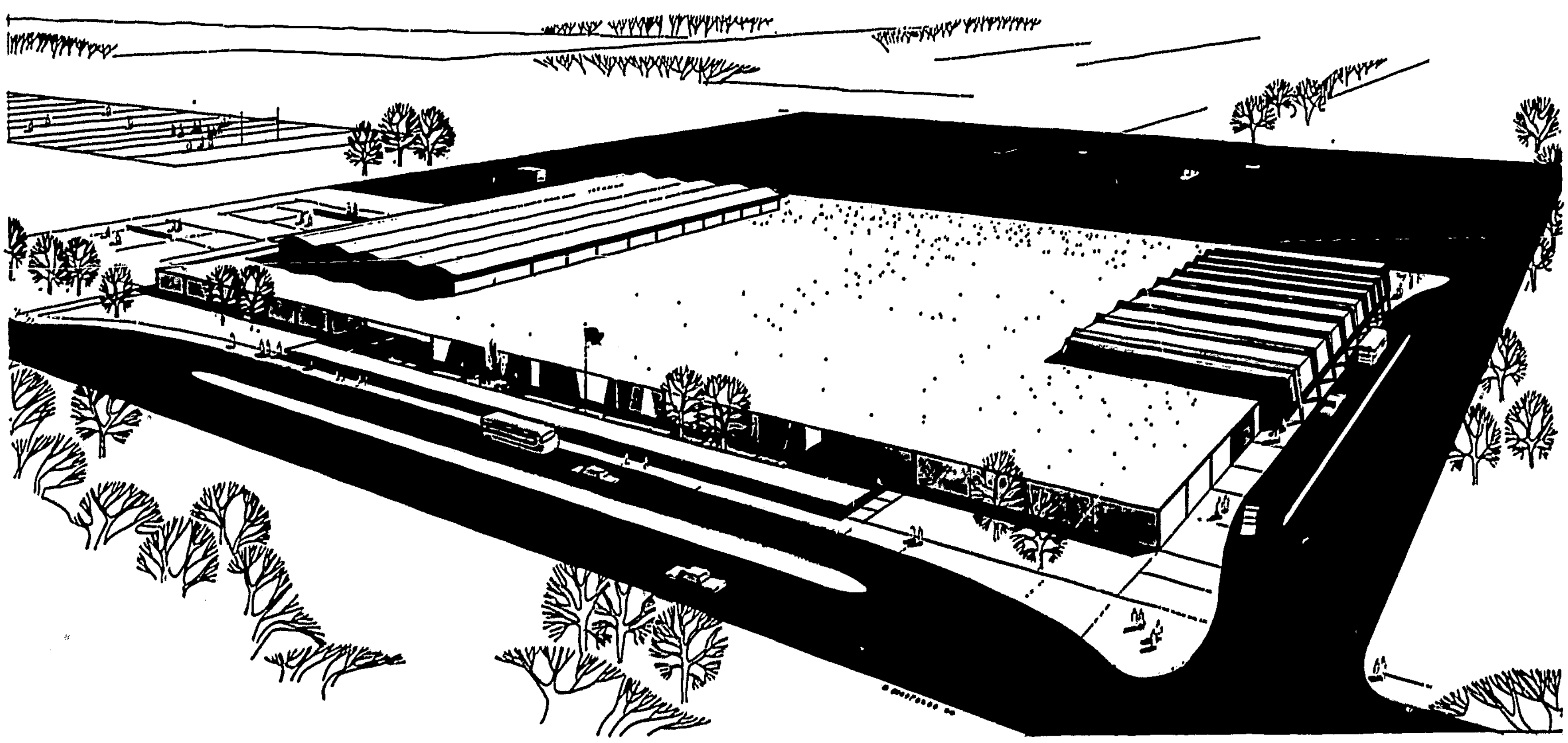
Use of the most advanced mechanical teaching aids has been anticipated. Blackout for audio-visual instruction is attained in any room at the flip of a switch. A special intimate theater is located adjacent to the choral and band rooms. This small theater-in-the-round can be used for closed-circuit TV and sound film instruction as well as for drama department activities.

Classroom benefits

The EFL design automatically assures other important new educational benefits in the classrooms. For example, chalk board, peg board and tack board space is substantially increased. Teaching stations and pupil desk placement can be arranged to suit the requirements of the instructor, since the old "light over the left shoulder" limitation has been overcome. The bothersome problems of adjusting shades and blinds, raising and closing windows, and monitoring the corridor door for ventilation purposes are also eliminated.

Esthetics, already discussed from the standpoint of the exterior and the corridor treatments, have been a major design consideration in the development of this building. The natural beauty of simplicity has been accented by careful selection of colors and materials and by capitalizing on opportunities for interesting interior vistas. Internal glazing has been widely employed to achieve the latter. The whole interior has been treated from the standpoint of creating a varied, dramatic atmosphere calculated to appeal particularly to adolescents.

Although the exact effect of a controlled environment on the productivity and efficiency of pupils and teachers has not yet been properly measured by objective tests, no one questions the fact that it is sure to be beneficial. Such measurements as have been made by private industry and the U.S. Government have been extremely



favorable. A carefully controlled study made by the General Services Administration revealed that "the work output of employees in an air conditioned space is greater, on the average, by more than 9% than that of employees in similar space which is not air conditioned."

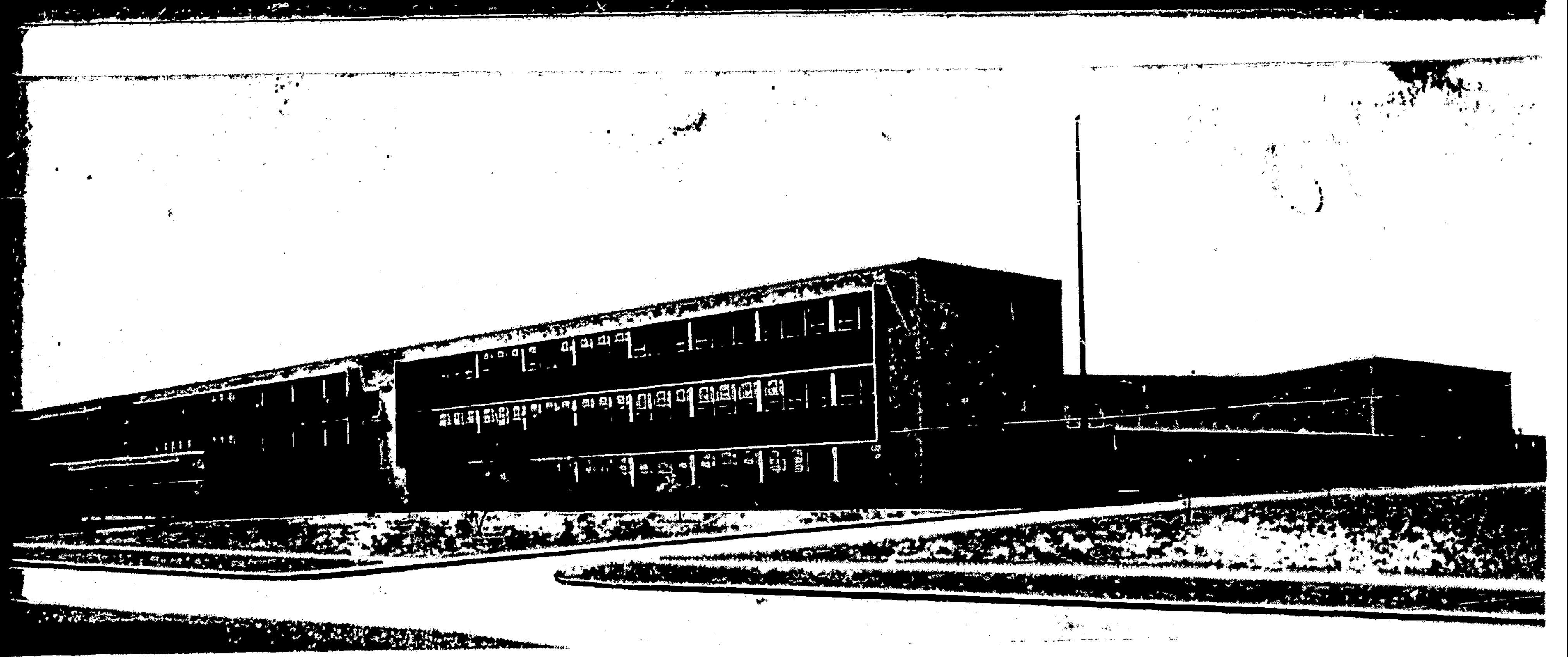
Cost benefits

The factor of cost—presented in detail in the concluding sections of this report—cannot be measured solely in terms of the cost comparison given, as favorable as it has turned out to be. There are hidden factors additionally favorable to the EFL design. Conservation of land, for instance, is a major item. Creation of a building that is far more useful as a community center also can be evaluated in terms of public expense.

In summary, the solution presented by the EFL design provides a new kind of secondary school which assures these major benefits:

1) Ideal indoor climate for teaching, learning and good health.
2) Flexibility and adaptability of classroom size and space.
3) Stabilization of teaching-learning efficiency year-round.
4) Better control of light and sound for mechanical teaching techniques.
5) Maximum administrative control.
6) Minimum travel distances.
7) Control of noise-generating activities.
8) Improved ratio of classroom space to corridor space.
9) More usable wall space per classroom pupil.
10) More educational space per site-acre.
11) Expansion without need for additional land.
12) Lower first cost, lower owning and operating cost.

The validity of the solution can be measured by placing these benefits alongside the major problems facing educators in secondary education.

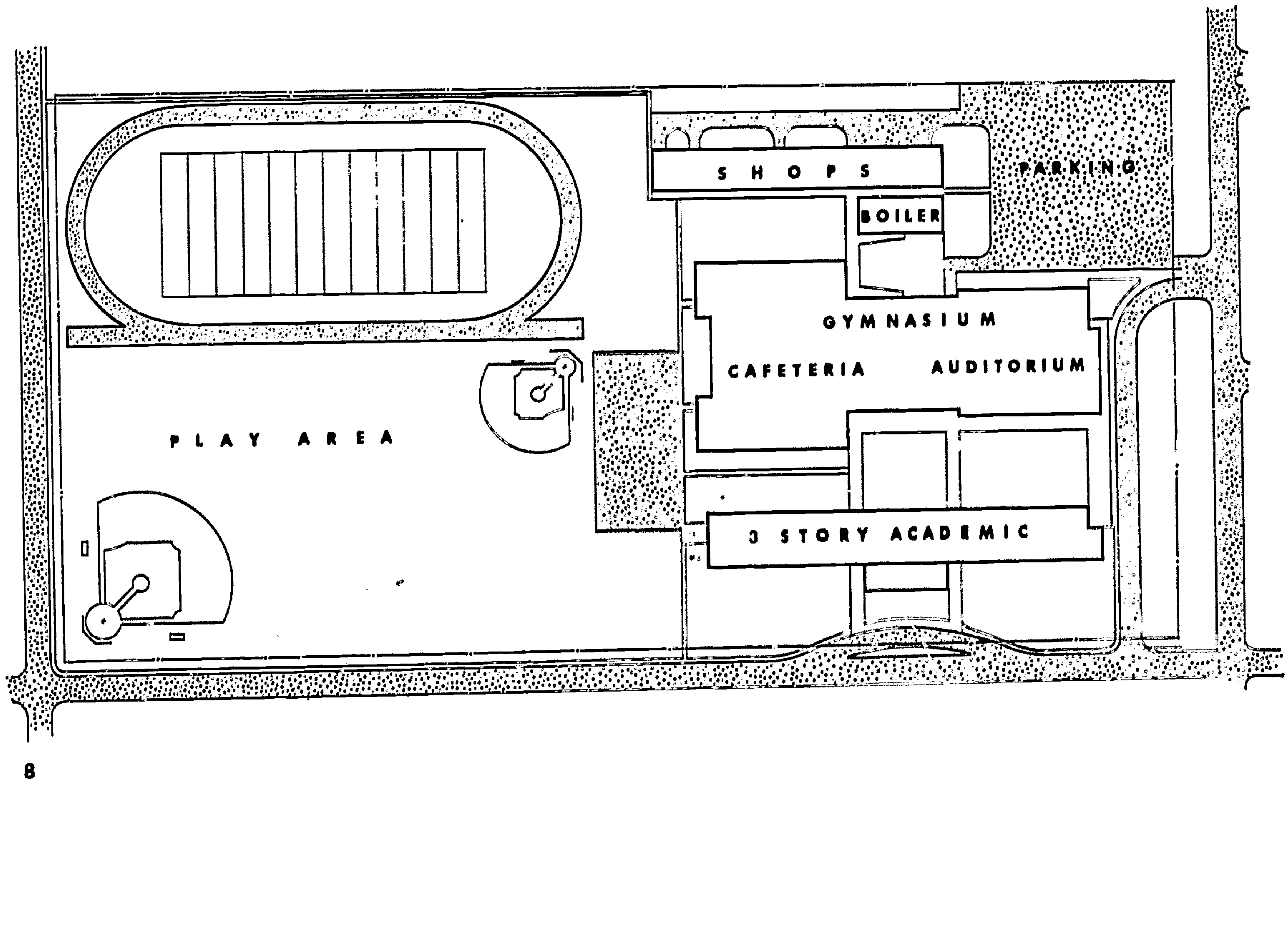


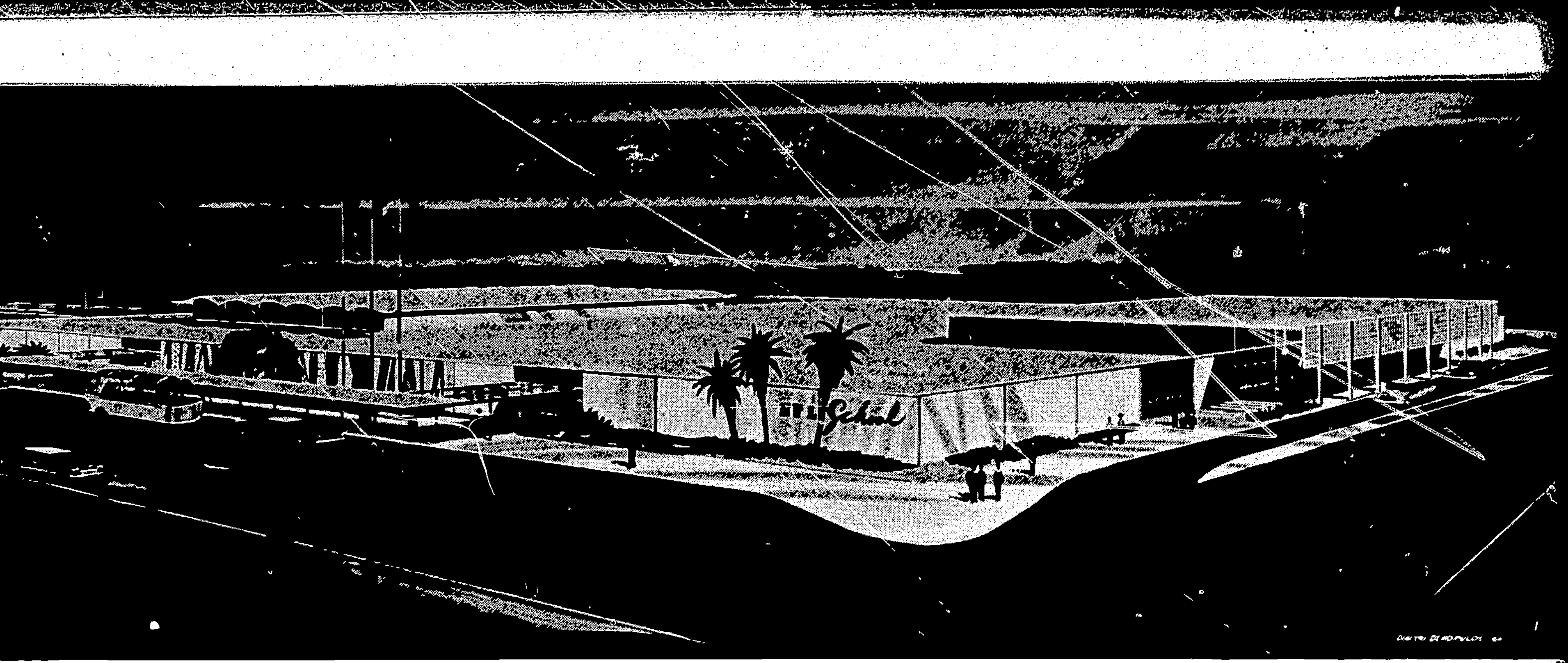
A Graphic Comparison of Bellaire Senior High Scho

Here are two secondary school facilities designed to identical educational programs, to the same enrollment of 2200 and to the same 9-acre site situation in suburban Houston, yet it is difficult to imagine two more different kinds of schools.

Bellaire, with its modified campus plan, occupies about a third more acreage than the compact, one-story EFL plan even though the academic building of Bellaire rises to three stories. As a result, the EFL parking space is almost double that of Bellaire. More important, from the standpoint of education, is the enormous extra distance that pupils, teachers and administrators at Bellaire are required to travel over a normal school year. The length of corridors and covered walkways of Bellaire is 3,999 feet, compared to the 2,552 feet of EFL—a difference of 1,447 feet.

It seems almost impossible that the single floor of EFL could contain all the facilities of the Bellaire complex of buildings, yet this indeed is the case. And EFL does so with a little more elbow room in the corridors — a little more usable educational space. The compact rectangular EFL plan accounts for the difference. Bellaire exterior



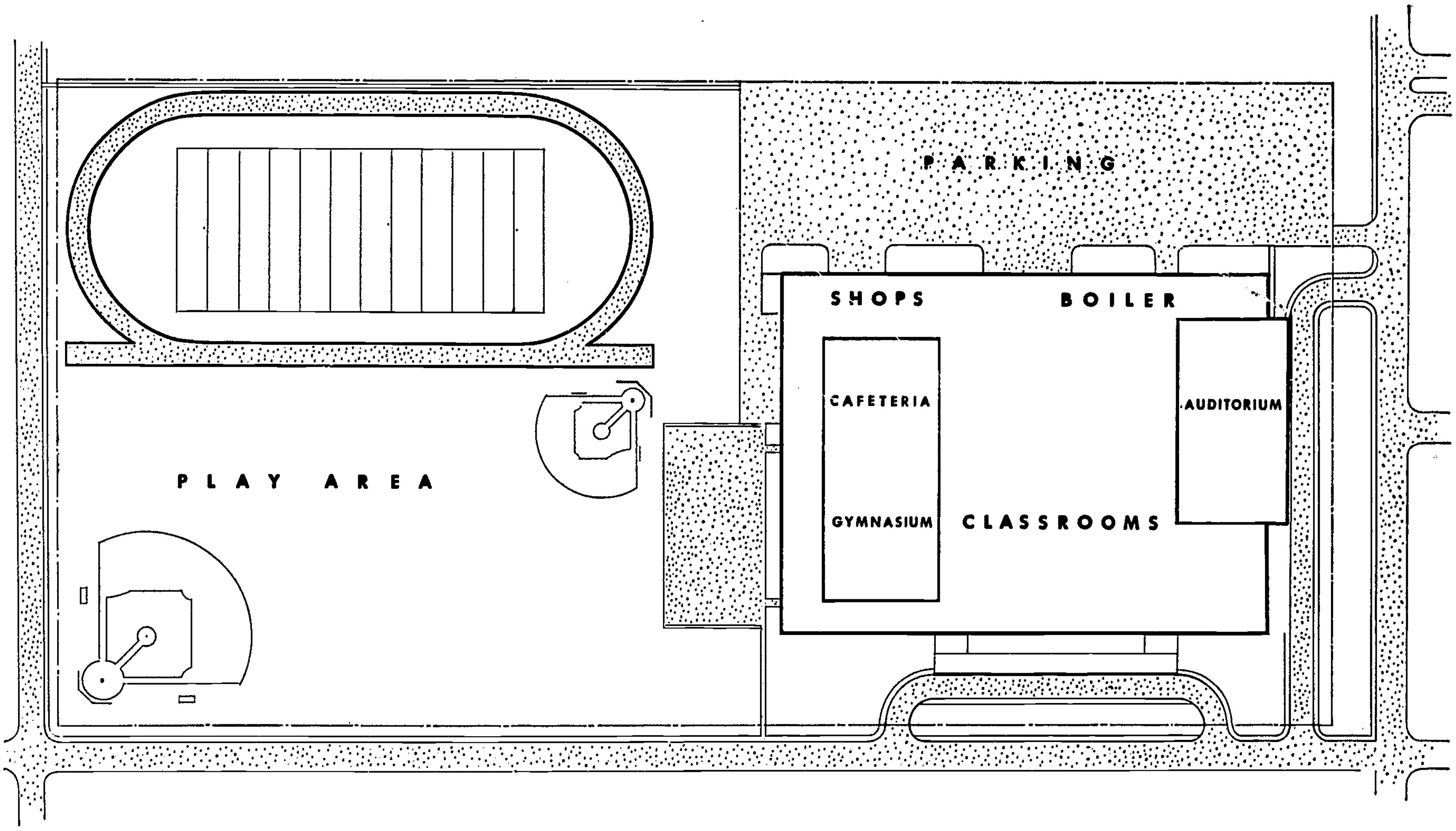


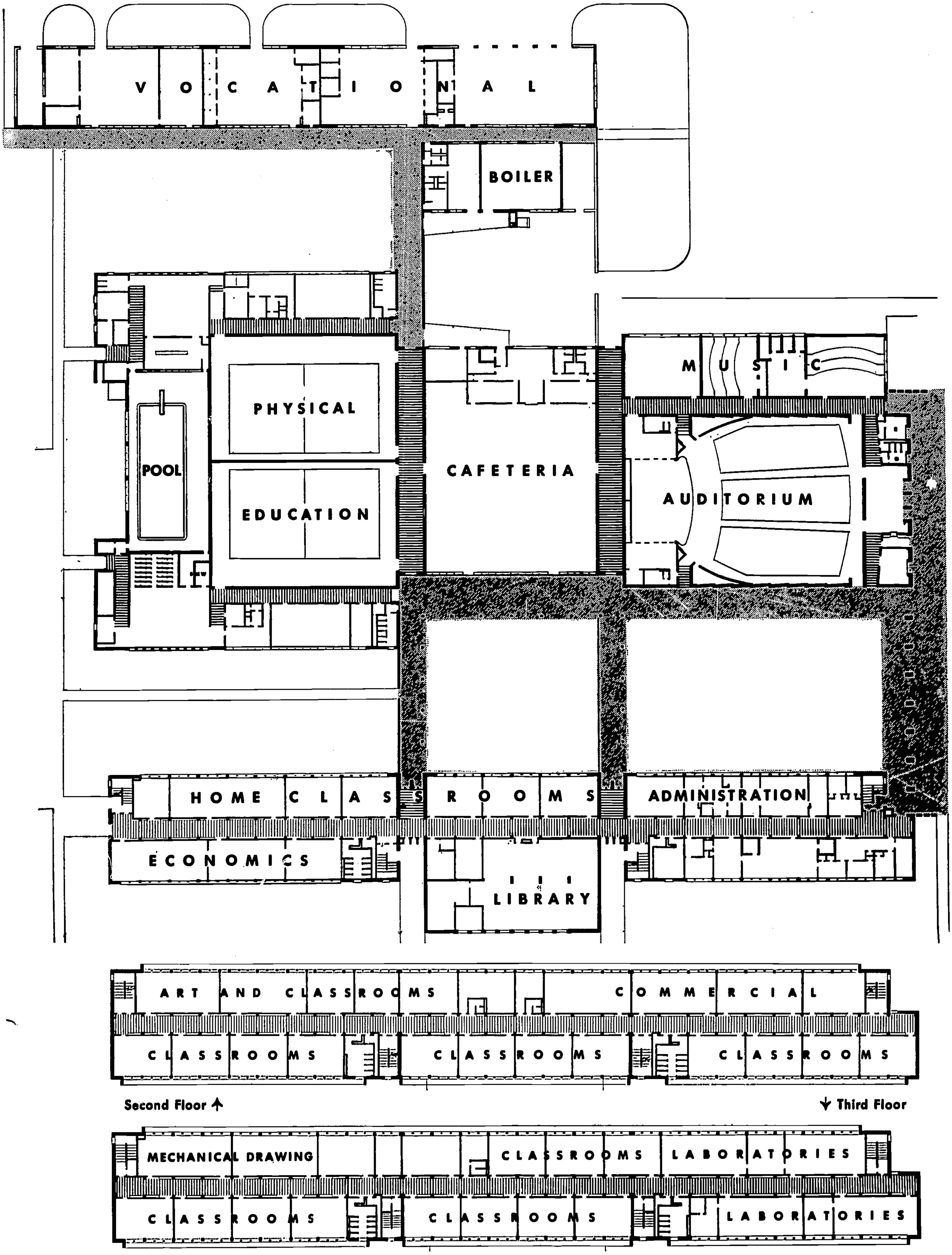
h the Environment For Learning Research School

walls measure a total of 86,199 sq ft, as compared to 38,232 sq ft for EFL — a particularly important comparison, as the cost analysis on following pages reveals.

The whole comparison story, however, cannot be told in statistics or dollars and cents, as dramatic as these chapters may be. The educational efficiencies of the two schools, although more difficult to measure, are more significant not only to educators but also to teachers, pupils and parents as well. The EFL design, with its completely controlled environment, is perpetually hospitable to the teaching-learning processes, no matter what the time of day or time of year. EFL has completely eliminated problems of glare and gloom, heat and cold, airborne dust and airborne sound.

Differences in educational flexibility are equally marked. The EFL plan is ready for any type of curriculum, any type of teaching technique. It is particularly suited to audio-visual methods. It can be expanded, up or even down, without the use of additional land. It can be oriented on the site in any way, to make maximum use of the land. It is a completely new kind of school, designed to an entirely new concept in education.




VOCATIONAL
BOILER
PHYSICAL EDUCATION
POOL
CAFETERIA
MUSIC
AUDITORIUM
HOME ECONOMICS
CLASSROOMS
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LIBRARY
ART AND CLASSROOMS
COMMERCIAL
CLASSROOMS
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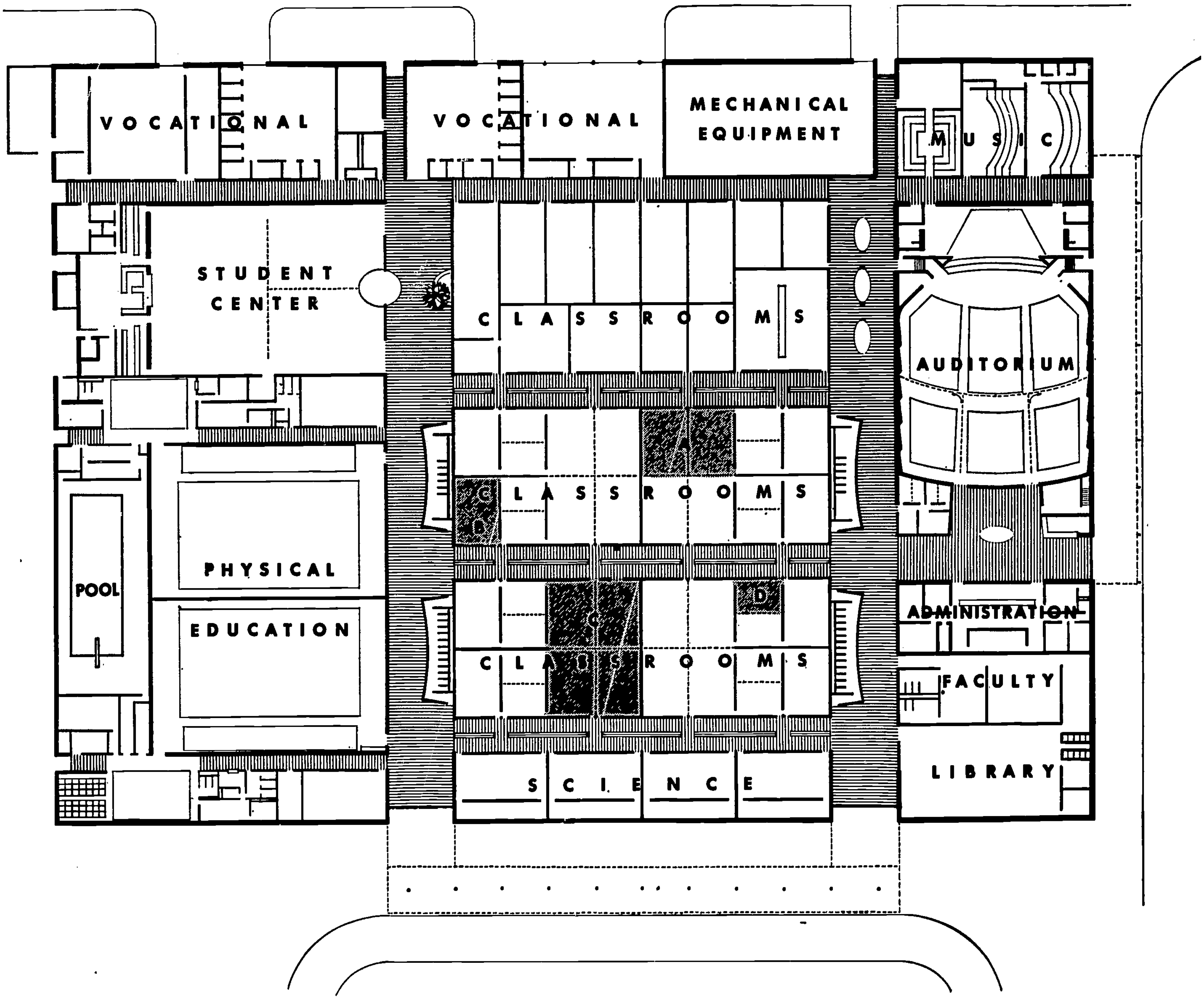
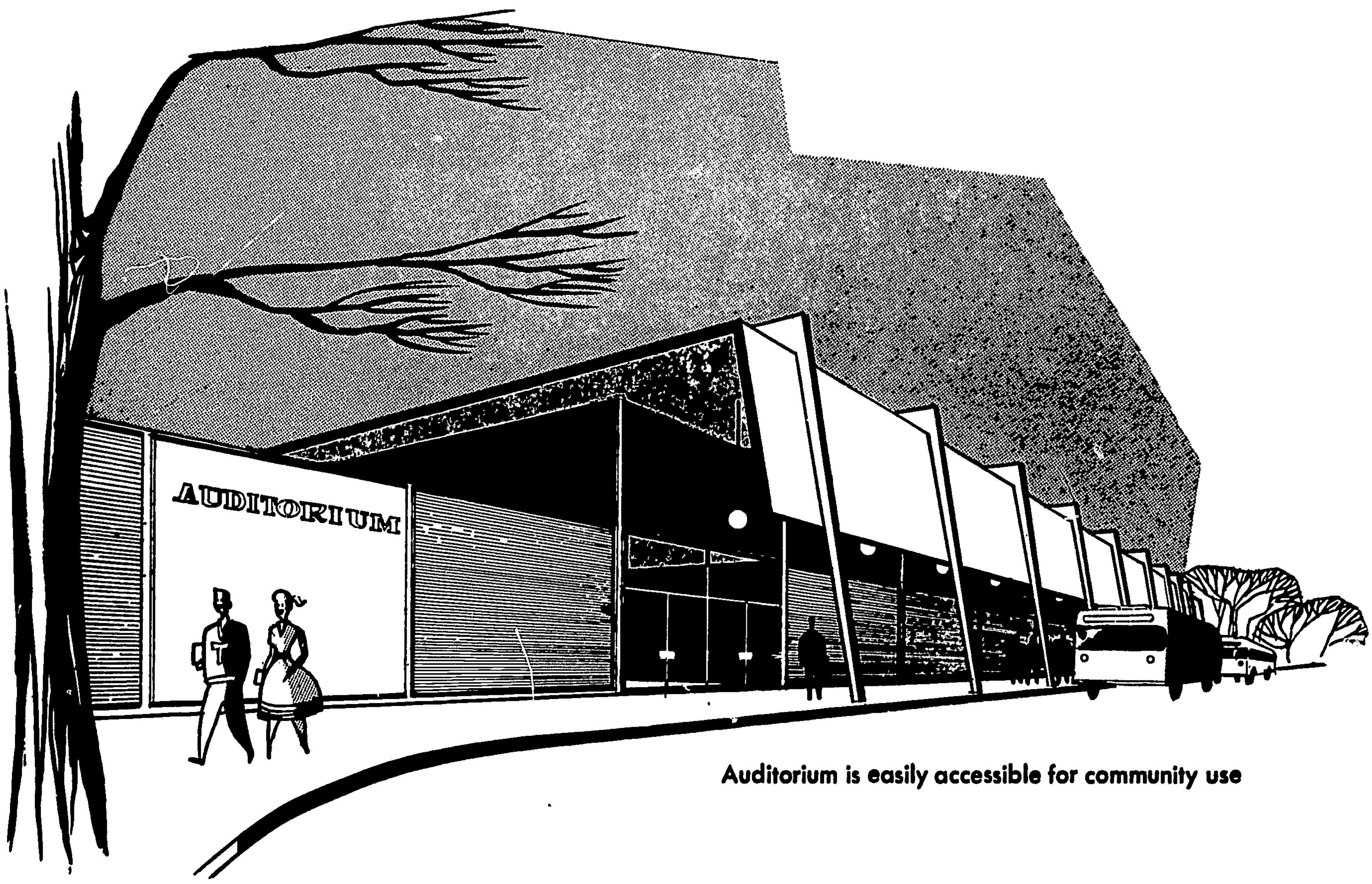


The Advantages of a Simple Rectangular Plan Are Clearly Demonstrated by the EFL Design

The plan of Bellaire Senior High School, at the left, and the plan of the Environment For Learning research school, above, are presented in the same scale to provide another startling demonstration of the space economy and flexibility inherent in the simple rectangular shape.

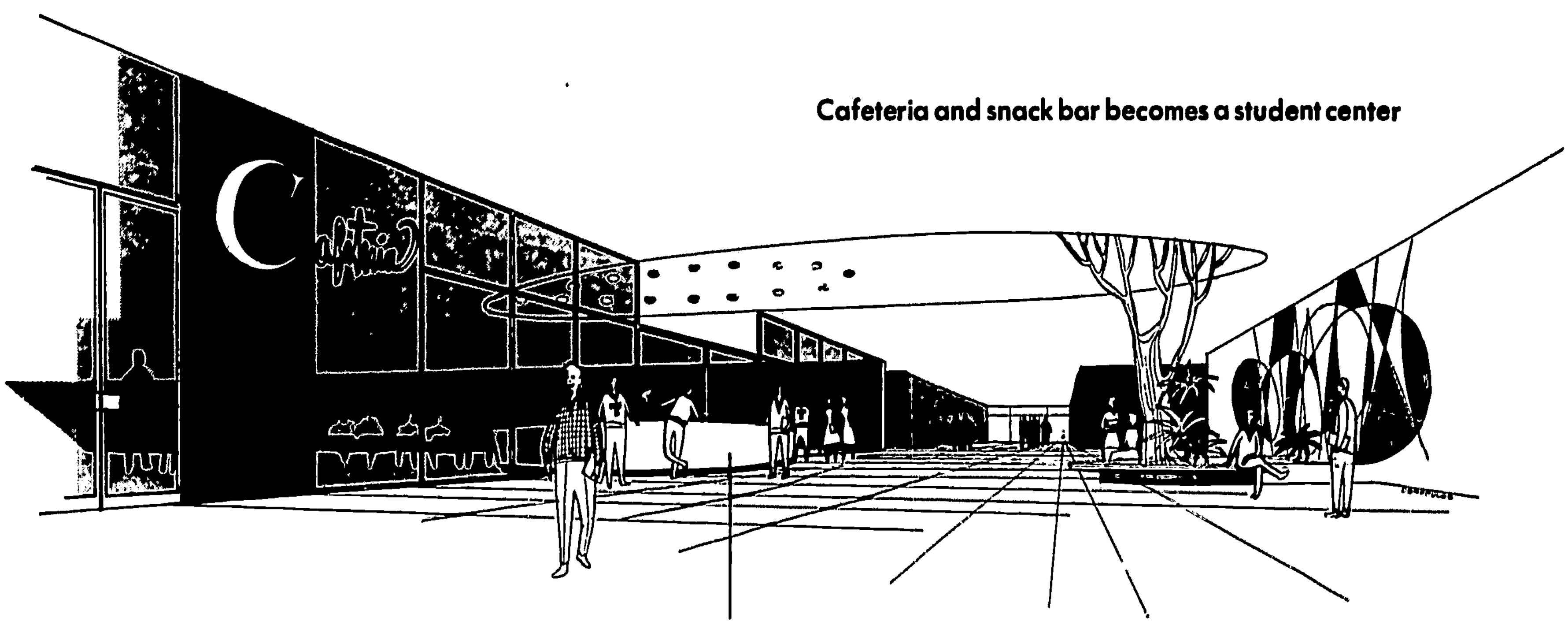
In EFL, the classrooms are located in the central core while auditorium, administration and library are placed near the main entrance for convenience and control. The cafeteria-student center and physical education facilities are segregated for better sound control. All shops, although conveniently under the same roof, are adjacent to the main service drive. This layout assures extremely simple student circulation, ease of administration and direct public entrance to the areas planned for community use. Main corridors vary in width up to 20 feet and terminate in sheer glass entrances. The four main toilet facilities are both convenient and economical.

Partitions in the classroom area are non-load bearing and movable to permit extreme flexibility of space usage. In the shaded areas above, A accommodates 100 pupils, B is a classroom 22 feet by 32 feet for 30 pupils, C is a space for 250, while D is for a discussion group of 15.

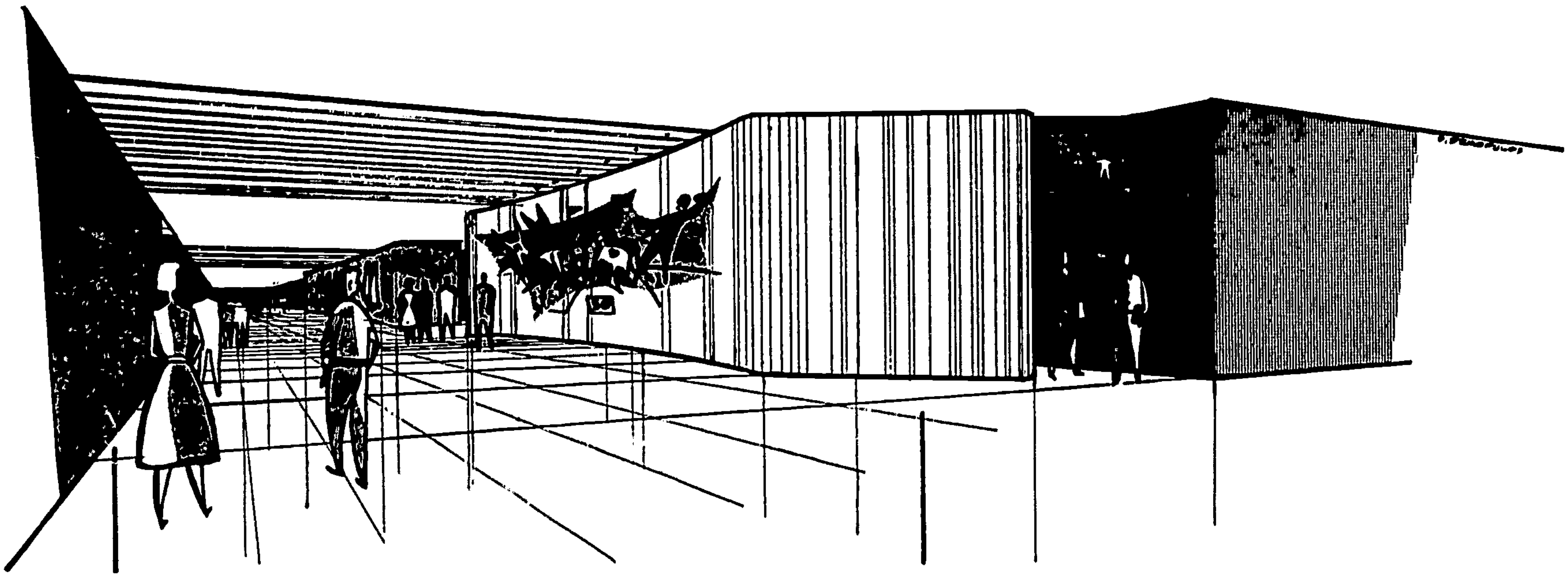


Auditorium is easily accessible for community use

EFL Architectural Features



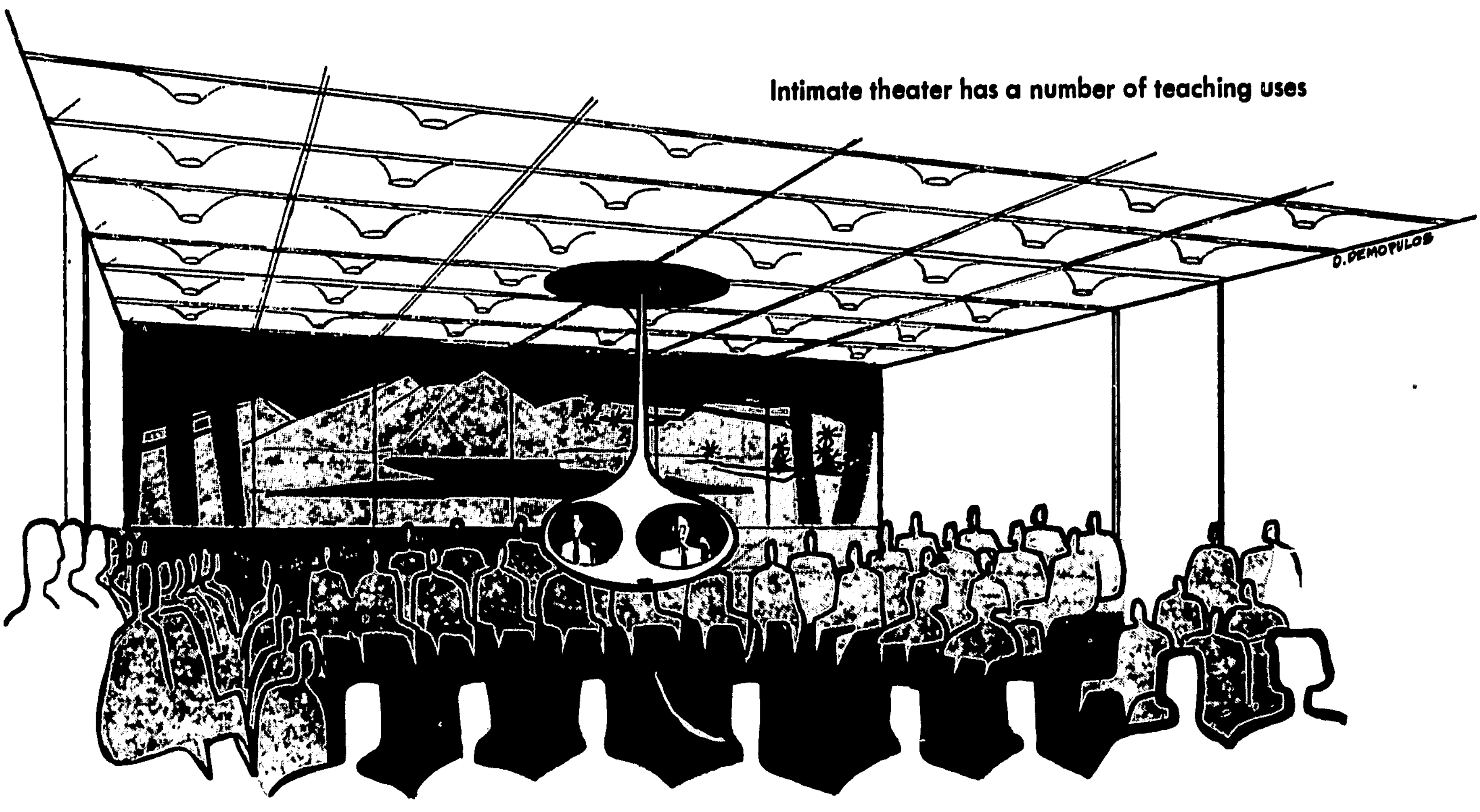
Cafeteria and snack bar becomes a student center

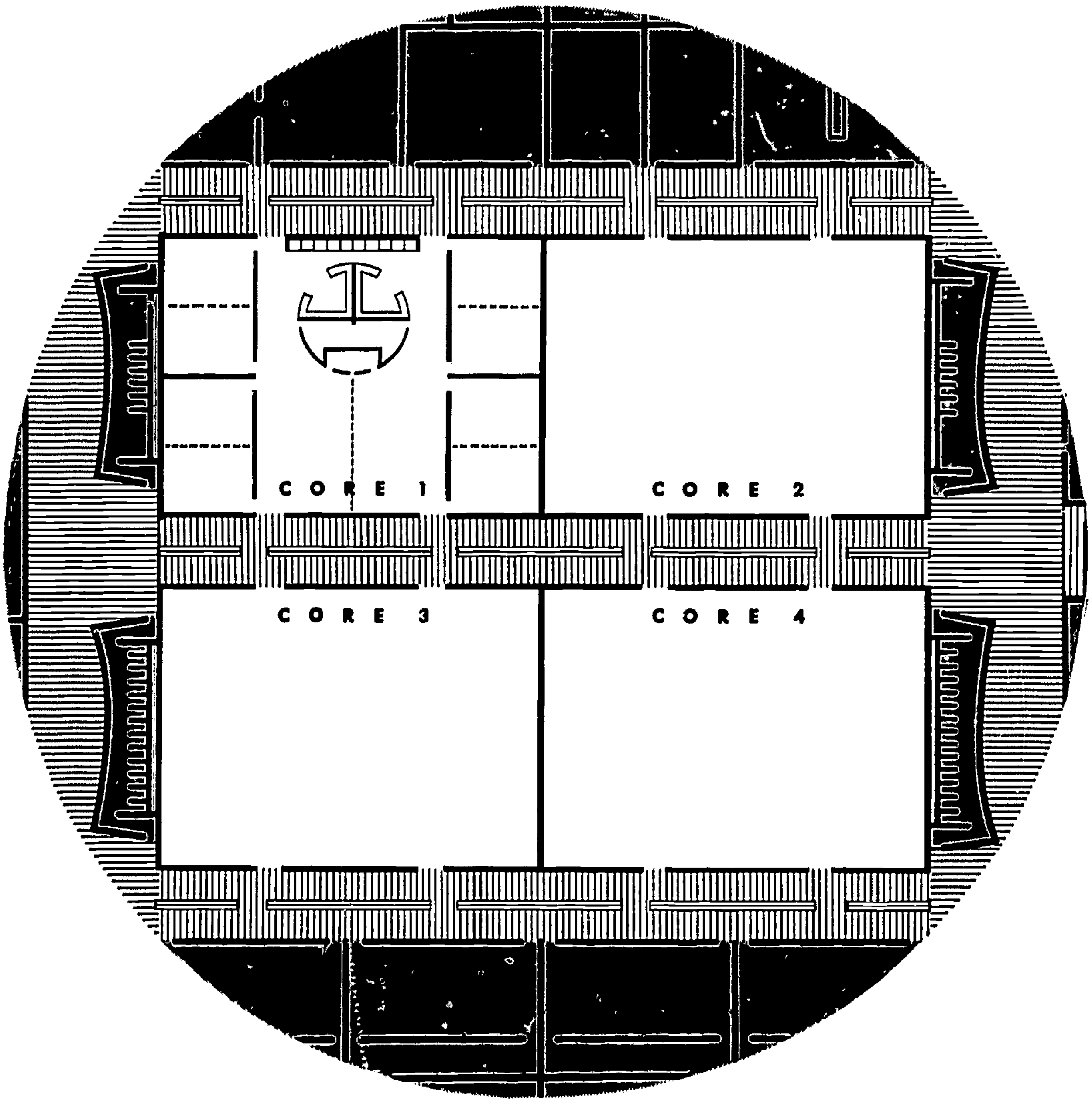


Murals, bright colors and sculptural forms enrich the interior

Avenues of circulation take on a variety of uses

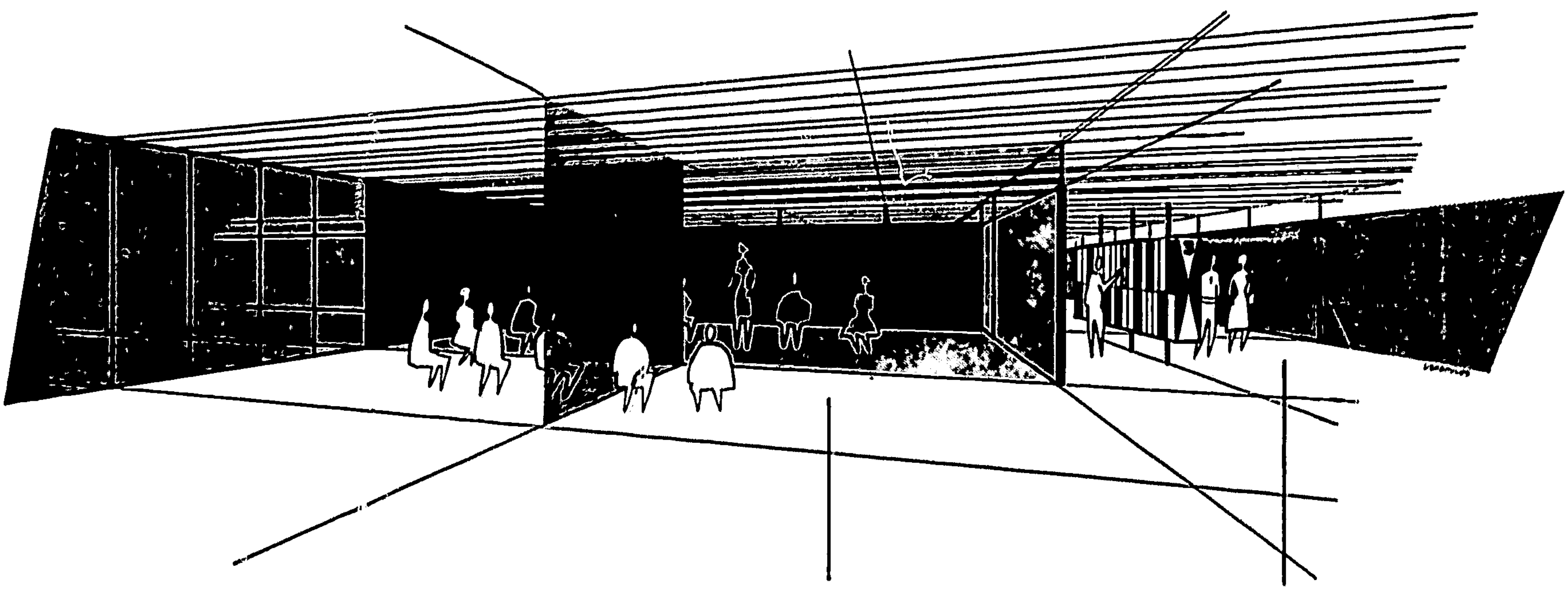
Intimate theater has a number of teaching uses



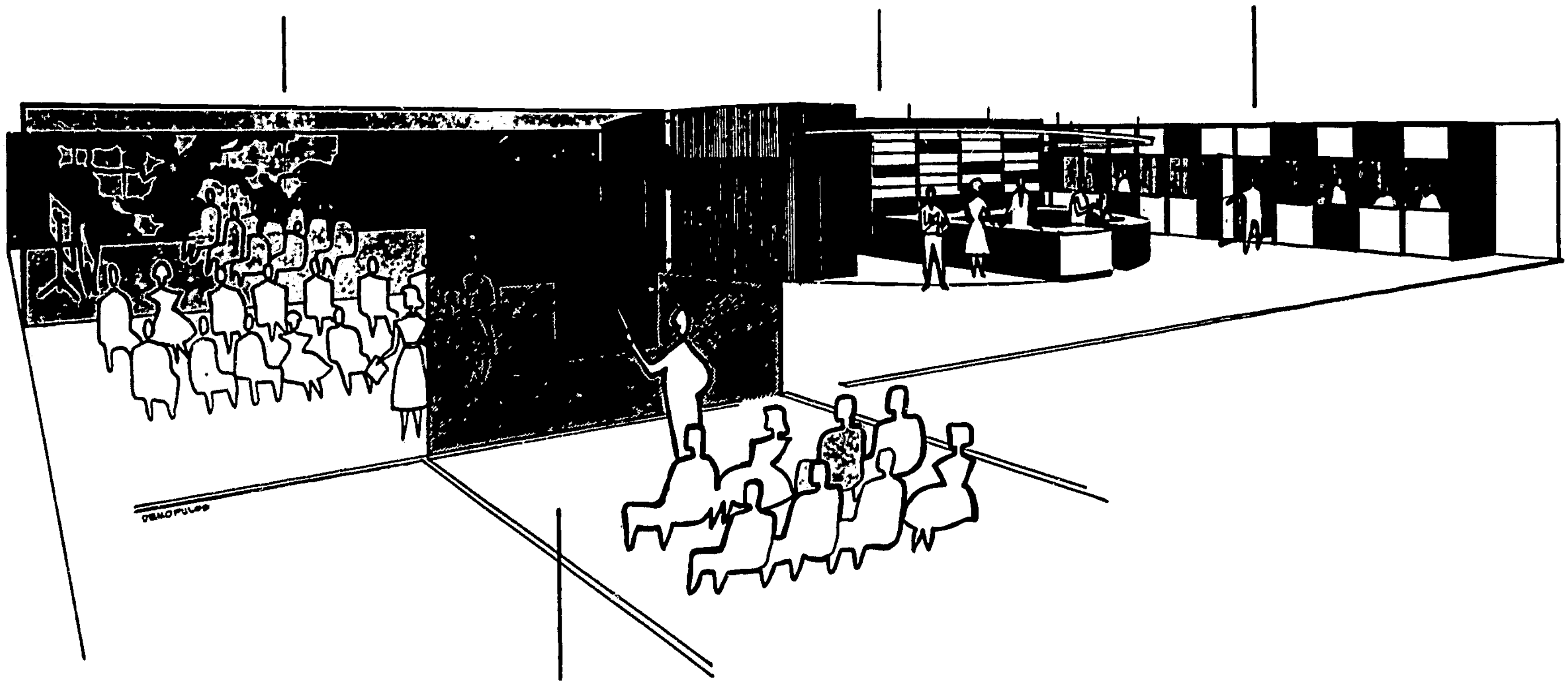


Possible changes in curriculum and program pose no problems for the EFL school. Shown at the left is a section of the academic area arranged for Core Curriculum. Core 1 has been detailed to indicate the layout for groups of various sizes, the audio-visual center, faculty and guidance areas, library and laboratory, and cubicles for study.

EFL Is Prepared for Any Educational Development — Any



The multi-size classroom is available for any type of curriculum. Groups of pupils from 15 to 250 are possible within a basic structural module. Corridor arrangement permits easy access to all types of space.



This perspective of the Core Curriculum in action shows how the core space can be changed at will to meet the needs of varying activities. Space expansion or contraction is a built-in feature of EFL.

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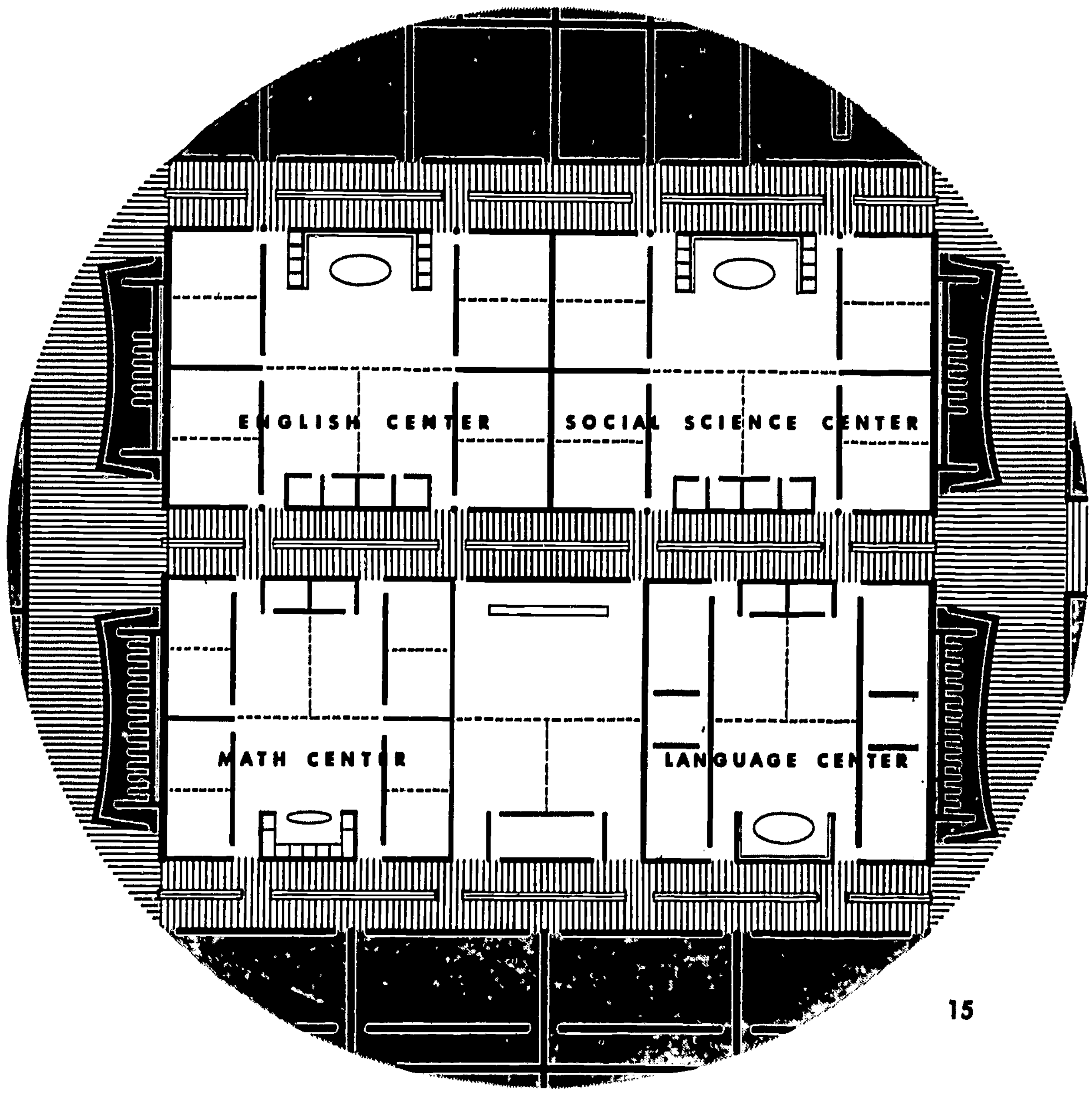

Here the central section of the academic area is arranged to accommodate a Subject Curriculum. EFL may be built originally for a conventional secondary school curriculum and then converted. The non-load bearing partitions and complete freedom from natural light and ventilation considerations make the switch both practical and economical.

IV. ENGINEERING CONSIDERATIONS

The EFL design concept is an engineer's dream come true. This was the opinion of the technical staff assigned to the project, who quickly discovered that dozens of complex problems were either solved outright or greatly simplified by the controlled environment idea.

For example, the traditional school lighting problem consists of working out a balance between sunlight that is often in the magnitude of thousands of foot candles and an internal system that provides from 35 to 100 foot candles. EFL completely eliminates this problem, along with the eye strain, chalkboard glare, shades and blinds that are part and parcel of it.

Good lighting is one of EFL's long suits. High intensity, glare-free lighting is used in some areas, low intensity lighting in others, depending upon the tasks performed and the moods desired. Changing light patterns, achieved economically today with standardized luminous ceilings, can easily be worked into the EFL lighting scheme. This type of building also lends itself readily to a high frequency (840 cycle, 600 volt) system, at big savings in distribution, fewer lamps for a given travel, greater lamp life, reduced heat and increased stability.

The lighting actually specified for the research school is directly comparable to that of Bellaire. This was done so as to validate cost comparisons between the two schools. On this basis, classrooms and general administrative areas use fluorescent luminous indirect of an average intensity of 55 to 60 foot candles. The gym areas are served by high bay, color-corrected mercury vapor fixtures. Shops use typical industrial fluorescent fixtures. Hall lighting is from recessed matte finished plexiglass lense fixtures, placed so as to provide an illusion of additional width. Distribution voltage used is 480/277 with transformers to provide 120/208 volts where required.

Air conditioning made easy

Mechanical engineers who have long struggled with downdrafts from cold external wall glass, rapid radiation from pupils to windows in winter and direct radiation from the sun's rays in summer will welcome EFL. The school ventilating engineer who long ago learned that it is impossible to keep classroom temperatures from soaring whenever the outdoor temperature passes above the 60 degree mark will also welcome this concept that incorporates full year-round air conditioning in its basic plans.

The cooling load is positive practically all year long in the EFL research school. The net gain of the internal load (lights and people) over transmission loss on a 20 degree day is 1,940,000 BTU, or 162 tons. On such a day, 42 tons would be supplied by ventilation air, the remainder mechanically. The EFL school requires no boiler in Houston. Lights can be turned on automatically early on Monday if a cold weekend should require it.

The peak refrigeration load is 400 tons, or one ton per 427 sq ft. This is almost half the rule-of-thumb in Houston of one ton per 250 sq ft.

For all practical purposes, the EFL school is just one big internal zone. Hence, the problems of zoning are eliminated, and the control system is greatly simplified.

A high velocity, dual-conduit, all-air system was selected for EFL because it centralized mechanical equipment in one location, permitted positive ventilation at all times, assured efficient air cleaning, allowed much closer control of temperature, humidity, and noise, and simplified installation. A recently developed air purifier was specified because it has a continuous cleaning characteristic, removes odors and can add moisture when needed on cold days.

Outside air is provided at the rate of 6 cfm per person. Total cfm is 125,000; outside air supplied, 14,000; return air 111,000. All outside air and recirculated air passes through the Carrier purifier.

The air conditioning was designed with 12-month operation in mind. The breakdown of the load during summer months follows: Lights, 48.3 per cent; human, 22 per cent; outside air, 17.8 per cent; transmission losses, 9.5 per cent; motors, 2.4 per cent.

Other engineering benefits

Because of the compact nature of the building it was possible to limit the main toilet facilities to four locations at tremendous savings in plumbing. The space-saving characteristic of EFL similarly simplified and shortened electric lines.

Sound engineering problems were reduced two ways. External noise, of course, has been all but eliminated. In addition, noisy internal areas are under better control because doors can be kept closed with no discomfort to room occupants.

Structural engineers found the rectangular plan allowed a very direct framing system that was easy to lay out and economical.

Questions may be raised concerning the probability of power failure and the effect of such failure on the EFL school. In the opinion of the Architect, the probability of power failure is very small, with power fed into most areas from many possible sources. Power company records substantiate this opinion.

Exiting is very easy from the EFL school, because of the relatively short distances involved, the single story plan, the very generous corridors and the large portals. Each of the nine entrances is completely glazed. These would light the way in case of power failure by day. In addition, each enclosed space would be provided with one or more B-battery emergency lights. In the event of power failure, these would be turned on automatically.

V. COST COMPARISON

The Architect was commissioned to produce an educational facility which, in the judgment of educators, would be better for the teacher, the pupil and the educational program today and tomorrow, and would cost no more — or perhaps less — than schools currently under construction. The $580,877 estimated savings in first cost and $834,540 estimated savings over a twenty-year amortization period speak for themselves on the subject of cost.

The Architect decided to engage cost specialists to make the final comparison between Bellaire and EFL in order to insure an impartial and expert result. The Construction Service Company, 4907 Ohio Garden Road, Fort Worth, Texas, who are professional cost estimators, made and compiled the comparative cost data for both schools. The Bonded Maintenance Company, Houston, Texas, who are professional maintenance contractors, presented bona fide bids for the janitorial services of both schools.

It is important to note that construction materials used in EFL are equal to those used in Bellaire, except that steel structural frame is used throughout EFL as compared to concrete structural frame that was used for the 3-story classroom building of Beiiaire.

	Bellaire	EFL
Areas		
Building, sq ft	174,760	171,336
Covered Walks, sq ft	19,828	9,508
Total	194,588	180,844
Exterior Walls, sq ft	86,199	38,232
Corridors and Passages		
Inside, lineal feet	2,656	2,074
Outside, lineal feet	1,343	478
Total	3,999	2,552
Unit Costs		
Per sq ft (covered walks at ½)	$ 14.02	$ 11.59
Per student	$1,177.00	$927.00

Percentages

Gross building floor area . . EFL = 98% of Bellaire
Covered walk area . . . . EFL = 48% of Bellaire
Total floor and walk area . . EFL = 93% of Bellaire
Corridor and passage length
EFL = 64% of Bellaire
Building exterior wall surface
ELF = 44% of Bellaire

FIRST COSTS

EFL is estimated to save $580,877 on first cost.

	Bellaire	EFL
1960 Contract Price	$2,588,710	$2,040,713
Architect's Fee @ 6%	155,323	122,443
Total First Cost	$2,744,033	$2,163,156

ANNUAL COSTS

EFL is estimated to save $41,727 annual owning and operating cost, or $834,540 over the 20-year amortization period.

OWNING AND OPERATING COSTS	Bellaire	EFL
20-year Amortization 5%	$ 137,202	$ 108,158
Insurance 1½% per year	41,160	32,447
Interest 4%	57,625	45,426
Total Annual Fixed Costs	$ 235,987	$ 186,031
Maintenance and Service	$ 1,000	$ 3,100
Gas	2,177	991
Electric (12 months)	12,517	23,285
Water (12 months)	2,156	2,523
Janitorial (12 months)	46,680	45,600
Custodian (12 months)	4,380	4,380
Maid (12 months)	1,932	1,932
Repairs and Painting (½%)	12,944	10,204
Total Annual Operating Costs	$ 83,786	$ 92,015
TOTAL ANNUAL OWNING AND OPERATING COSTS	$ 319,773	$ 278,046

Detailed Cost Breakdown

Description	1/1/1954 Bellaire Actual Cost	1/1/1960 EFL Est. Cost
Bond	$ 23,456	$ 20,407
Job Overhead	100,605	73,939
Clear Site	3,850	
Exec., Filling & Grading	42,230	
Storm Drainage	21,410	
Cinder Track	13,158	125,000
Bermuda Mulch Seed	18,645	
Paving & Sidewalks	30,350	
Misc. Sitework	10,200	
Concrete, Forms, Finish	236,546	126,769
Reinforcing Steel	89,750	30,240
Structural Steel	109,350	189,765
Misc. Iron & Steel	116,280	7,397
Metal Doors & Frames	20,580	26,475
Metal Windows	46,350	none
Masonry	334,000	188,845
Carpentry	26,250	29,391
Millwork	68,880	52,800
Finish Hardware	20,900	21,850
Roofing & Sheetmetal	48,200	32,278
Waterproofing, Caulking	21,530	7,805
Insulrock Roof Deck	46,720	75,610
Tile & Terrazzo	43,775	67,043
Finish Flooring	17,560	15,782
Blackboards & Tackboards	6,850	8,300
Lath & Plaster	74,360	10,259
Glass & Glazing	26,680	1,748
Marble	1,550	6,325
Window Shades	2,445	none
Painting	50,060	32,270
Plastic Roof Lights	1,250	1,500
Roll-away Gym Seats	6,655	7,250
Metal Lockers	25,390	26,625
Gym & Pool Equipment	7,260	11,000

Description	1/1/1954 Bellaire Actual Cost	1/1/1960 EFL Est. Cost
Stage Curtains	$ 8,550	$ 9,300
Auditorium Seating	11,340	12,000
Laboratory Equipment	77,765	81,000
Kitchen Equipment	26,265	29,400
Electrical	202,780	274,000
Plumbing & Heating	305,900	88,297
Overhead Doors	none	1,660
Folding Partitions	none	10,345
Pre-cast Deck	none	13,340
Air Conditioning	none	205,677
Acoustical Work	none	51,068
Misc. Items	none	8,515
Change Orders	29,288	none
Profit	....	59,438
TOTALS	$2,374,963	$2,040,713

Bellaire Cost in 1954	EFL Estimated Cost 1960	Difference
$2,374,963	$2,040,713	$334,250

Costs of labor and material in the Southwest have increased approximately 21⅓% since 1954. Because of the competitive market in Houston at this date and because the Architect wished to be conservative with this comparison, an increase of only 9% in the cost of Bellaire High School is being used to bring its cost up to the market as of January 1, 1960.

Bellaire Est. Cost 1/1/60	EFL Estimated Cost 1/1/60	Difference
$2,588,710	$2,040,713	$547,997

Estimated and attested by
CONSTRUCTION SERVICE COMPANY

VI. CONCLUSIONS

The merit of the Environment For Learning concept and the EFL research school that grew out of it must be judged by educators, school boards and, ultimately, by the American public that supports our educational system. Time alone will prove the value of EFL.

Meanwhile, the Architect and his client take satisfaction in the favorable reaction of the educators who have been briefed informally on the ideas behind the project, and who have seen the sketches and plans as they came off the boards. This group of Texas and New York state professionals in the educational field have been encouragingly enthusiastic.

Educators everywhere will understand that the EFL study was deliberately pushed all the way. A research project loses much of its value if there is any holding back for one reason or another. The big idea is to explore ideas. Variations and modifications are possible later on.

In conclusion, we would like to point out that this kind of architectural research in the educational field appears to us to be very useful. American education, we believe, would benefit by much more of it. The fields that require exploration are many. Here is a challenge for all of us.

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Houston, Texas
February 1, 1960

Bibliography

Architectural Record
"The Individual School"
July 1956

Progressive Architecture
"Glare Control in Schools" by Doyt Early
March 1955

Architectural Forum
"Loft Plan High School"
January 1956

Architectural Forum
"A School for the Future?"
November 1959

School Planning
"Windowless School . . . As Seen by its Consultants"
September 1958

Potential Economies in School Building Construction—
A Report of Research
Sponsored by The New York State Education Department 1958

The Florida Architect
"Air Conditioning for Florida's Schools?"
November 1959

School Planning
"The Stress of Learning"
Fall 1959

School Management
"School Building Costs Can Be Cut"
August 1959

Architectural Forum
"The Productivity Push in Schools"
November 1959

Images of the Future
A New Approach to the Secondary School by J. Lloyd Trump.
Commission on the Experimental Study of the Utilization of the Staff in the Secondary School — 1959

Schools by Lawrence B. Perkins and Walter D. Cocking
Reinhold Publishing Company — 1957

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