DESIGNING RELOCATABLE ELEMENTARY CLASSROOM FACILITIES

by

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ABSTRACT

Social and economic changes have led in many areas of the U.S. to decreased taxpayer support for school funding, especially capital improvements such as new schools. Rapidly changing teaching ideas and technology compounded by expanding enrollment in many areas have made many schools inadequate to meet growing demands. Together, these factors have led to the use of relocatable classrooms as one pragmatic solution. Relocatable facilities have all the amenities of a normal classroom, but are placed on the school grounds, detached from the main school building(s). In this context, it is surprising that the physical appearance of a relocatable classroom has changed very little since the first units were erected after World War I. Despite the fact that these structures are permanent fixtures in many schools, they are still labeled as "temporary," and little attention has been devoted to the systematic application of environment-behavior research on classroom design to such relocatable structures.

This thesis has developed a set of design guidelines for relocatable elementary classroom units which can assist architects and administrators in the design and implementation of future relocatable facilities. The preliminary set of guidelines was framed after an extensive review of the research on the impact of classroom environments on student behavior, attitudes and achievement, a review of literature concerning relocatable classrooms, and a case study of an existing relocatable unit in Manhattan, KS. The format used for each of these guidelines included a statement with an adjoining figure, and a rationale that formed a basis for the guideline. These preliminary guidelines were then tested on eleven third year interior architecture students at Kansas State University to evaluate their applicability, scope, practicality, generality and clarity. The results of this evaluation were used to further refine and modify the guidelines, which can be used to create elementary classroom environments with opportunities for movement, investigation, concentration and social interaction. These design guidelines should enable architects to design future facilities that are sensitive to the needs of elementary school children.

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STATEMENT OF THE PROBLEM

Social and economic changes have led in many areas of the U.S. to decreased taxpayer support for school funding, especially capital improvements such as new schools. Rapidly changing teaching ideas and technology compounded by expanding enrollment in many areas have made many schools inadequate to meet growing demands. Together, these factors have led to the use of relocatable classrooms as one pragmatic solution. Relocatable facilities have all the amenities of a normal classroom, but are placed on the school grounds, detached from the main school building(s). Although a part of a playground is sacrificed to provide space for these classrooms, their ability to deal with space limitations in the existing building makes them a feasible and viable solution.

These relocatable facilities can be moved from site to site for temporary relief of rising enrollments until permanent facilities are built. On the other hand, if the school need is temporary or if enrollment decreases, the school can be downsized just as quickly. This concept of planning and constructing parts of a school for potential mobility from one site to another has proved to be reasonable and practical.

The advances in building technology which have made relocatable facilities a reality mean more educational facilities for more students at a faster schedule can be provided. The four basic types of relocatable facilities that are currently in use are: portable, mobile, divisible, and demountable. The purpose of the thesis is to develop and test empirically behaviorally-based design guidelines for designing these relocatable facilities. The main focus of the thesis is divisible classrooms, due to their extensive use in accommodating the increasing numbers of children. These classrooms are constructed using structural patterns for mobile (trailer) homes, applying mass-production technology to a space enclosure with a high degree of mobility. Divisible classrooms, moreover, differ from the other relocatable structures in the way in which they are moved, and in some of their physical characteristics. Since similar planning considerations apply to all relocatable structures, regardless of type, these proposed design guidelines should apply to the broader category of relocatable school facilities.

The thesis comprehensively reviewed the research directly related to the effects of the elementary classroom physical environment on the social behavior and health of children, including: the effects of high density and crowding conditions, personal space, seating position, general physical design, noise, lighting and color, and presence or absence of windows. The review also included factors of particular concern for relocatable facilities, such as siting and forms of connection to or independence from the main school building. Additional background information was collected on the existing mobile classrooms, especially those used in the local school system of Manhattan, Kansas.

These research findings were synthesized to create design guidelines to assist architects and administrators in the design of future relocatable classrooms for elementary schools. The use of these guidelines was tested through a classroom design problem completed by third year interior architecture students at K.S.U. The information obtained through this application was used to refine the proposed guidelines.

REVIEW OF ENVIRONMENT- BEHAVIOR LITERATURE

This review summarizes existing research on the impacts of the educational environment on student behavior, attitudes and achievements, and their implications for design. It includes research on child-environment and general environment-behavior relations appropriate to classroom environments.

In addition to the interpersonal climate or the organizational structure of a classroom which includes size, acoustics, lighting and heating, the 'learning environment' has broadened to encompass other dimensions of the physical environment that might have an impact on students' behaviors and attitudes. Seating position, classroom design, crowding and density, personal space, presence or absence of windows, and color are additional environmental variables that affect the classroom experiences of children. Cohen & Trostle (1990) state that there is an association between children's preferences for environmental setting characteristics and varied forms of behavioral expression. They state that:

> "just as environmental characteristics are likely to influence the information perceived by the senses, educational settings that provide opportunities for movement, investigation, concentration and social interaction, will influence the messages children derive from their interactions within the educational setting, contributing to their understanding of their place within that environment, as well as to the manner in which one comes to understand the environment and its messages" (pp. 764-765).

Furthermore, Weinstein and David (1987) have found that environmental experiences of childhood continue to be influential in children's future lives. Thus, there is a need to view more carefully the physical environment as a means toward advancing developmental and educational processes.

However, it is noted that there is a lack of sufficient data on the particular relations between the physical environment and the behavior of children. Also, other than documenting relocatable classrooms, there are no studies on the effects of these spaces on children. How does the 'lack of connection' or a 'sense of detachment' from the main school building contribute to the environmental experiences of the children?

Designers who are responsible for classrooms such as the standardized relocatable units no longer can assume that educational programs will be equally effective in any instructional environment. There is a need to change approaches in viewing classroom environments and to look at them as "networks of interconnected and varied micro-environments" (Sommer, 1977, p. 175). There also is a need to evaluate existing designs on the basis of research done in various disciplines, such as architecture, sociology, psychology, and education. This review of literature brings together divergent strands of inquiry, and provides the overview of information that is necessary to design better classrooms.

The Effects of Crowding and High Density

In many schools, increasing numbers of children have to be accommodated in the existing spaces, or additional space provided temporarily. Larger numbers of children often must occupy the same existing area, or the same number use a smaller area. Existing research suggests that these changes in density may have detrimental effects on the children; thus, ways must be devised to ease this problem.

The effects of density and crowding on human behavior have constituted a major and lively area of research within environmental psychology and, to a lesser extent urban sociology (Fischer, Baldassare, & Ofshe, 1975). This field has included a considerable amount of research on children in school and residential environments (Wohlwill & van Vliet, 1985). As Weinstein (1979, p. 585) has noted: "Nowhere else (but in classrooms) are large groups of individuals packed so closely together for so many hours, yet expected to perform at peak efficiency on difficult learning tasks and to interact harmoniously."

Although this thesis focuses on the use of relocatable facilities as a solution to the crowding and high density effects in elementary schools, the impact of these types of classroom spaces on children's responses to high density and crowding remain unexplored. It is also essential to clearly understand the effects of crowding and high density on school children which have made the use of these facilities a necessity.

Crowding and Density

Altman (1975, p. 146) has stated that crowding occurs when privacy mechanisms fail to function successfully, causing a person to have more interaction than desired; that is, achieved privacy is less than desired privacy. Rapoport (1975) suggested that crowding stress occurs when one's perceptual or information processing capacity is overloaded by various stimuli in the environment. Stokols (1972) reasoned that crowding stress is associated with perception of too little physical and/or psychological space; other researchers have emphasized feelings of lost control over interpersonal interaction and undesirable or excessive contact with others (Altman, 1975; Milgram, 1970; Rapoport, 1975). Thus, how people, including children, 'perceive' a high density situation may be an important determinant of their behavioral responses (Verbrugge & Taylor, 1976; Schiarro, 1977).

Studies have found that when children are placed in either high social or spatial density conditions, they engage in less social interaction, display more avoidance behavior and exhibit more withdrawal and solitary play (Hutt & Vaizey, 1966; Loo & Smetana, 1978; P.L. McGrew, 1970; Preizer, 1972; Rohe & Nuffer, 1977 and Rohe & Patterson, 1974, cited in Aiello, Thompson, Baum, 1985, p. 98; Shapiro, 1975). In this context, several researchers have distinguished between "social density" and "spatial density" (Hutt & Vaizey, 1966; Loo 1973; McGrew, 1970).

> Spatial density involves comparisons of same-size groups in different size spaces--e.g. a six-person group in a large versus a small room. Social density involves constant-size space but different numbers of people--e.g. six-versus twelve-person group in the same size room. (Altman, 1975, p. 153)

P.L. McGrew (1970) observed higher frequencies of close peer proximity (wherein two or more children were observed within three feet of each other) behavior and increased amounts of solitary play under high spatial density conditions. This is particularly the case when high social density is combined with high spatial density (Altman, 1975, p. 153).

Density and Aggressive Behavior

Other relevant areas of research include the relationships between density level and children's aggressive behavior, and between density level and competitive behavior. Most studies have reported that children are more aggressive in higher density environments (Ginsburg et al., 1977; Hutt & Vaizey, 1966; Loo & Kennelly, 1979; W.C. McGrew, 1972; Rohe, 1976; Rohe & Patterson, 1974, cited in Aiello et al., 1985, p. 100; Shapiro, 1975). Similar studies have shown that children spent considerably more time in competitive play when they were in highly dense playrooms (Rohe & Patterson, 1974, cited in Aiello et al., 1985, p. 102). Aiello et al. (1985) have reviewed additional responses of children under high density conditions : higher levels of stress-related arousal (Aiello et al., 1979); decreases in locomotion and gross motor activity (McGrew, W. C. 1972); decreases in active play (Loo & Smetana, 1978); increases in proximity (P.L.McGrew, 1970); greater frequency of interruptions (Loo, 1972); and more fearful behavior and laughing (McGrew, W. C., 1972). In similar studies done with college dormitory students, Stokols & Ohlig (1975, cited in Bell, Fisher, Baum, and Greene, 1990, p. 288) observed an association between reports of high density and visits to the student health center.

Age of children

Most of the above mentioned studies have focused on children between the ages of two and eight. Aiello and his colleagues (1979) directly compared the responses and behaviors of children of various ages - 9, 13 and 16; whereas Loo (1978) compared her three studies of 5-year olds with her study of 10-year olds. The latter observed an inverse relationship between increasing age and the effects of density on the behaviors and perceptions of children. However, these results must be interpreted with caution, as her studies of the 5-year olds involved both boys and girls and the study involving the 10-year olds used only boys. The crowded environment in Loo's study resulted in more physical aggression, negative affect, distress, non-play, and desire to leave the crowded room for the younger children. The older children, on the other hand, exhibited more avoidance, no increases in aggression and anger, and generally more socially acceptable, non-aggressive attempts at avoiding each other in the situation. The study by Aiello et al. (1979), employing a high spatial density condition that interfered with any avoidance strategy attempted by participants, found that children and adolescents at the three age levels were similarly affected by exposure to crowding. Adolescents experiencing comparable stress-related arousal were just as bothered by the spatial intrusion, annoyed, tense, and uncomfortable due to the close proximity of others in the high density condition as were the younger children. This discrepancy in the two studies can be attributed to the use of children of different age levels; for a better understanding of the situation, it is essential to conduct more research on a wider scale. More research is needed with children older than age eight in order to study the development of coping and adaptation mechanisms of children under environmentally stressful conditions.

Sex of children

Another major issue which most research has not taken into consideration is the differences in sexes. Many studies employ children of one sex only. Although some differences have been cited in research relating to both the sexes, a clear pattern has not been noticed and, in fact, conflicting results have been observed. For example, Loo (1979) found that girls were more affected by high spatial density conditions, felt more crowded, and expressed a greater desire to leave the high density room. Aiello et al. (1979), on the other hand, reported that males under high spatial density conditions experienced greater spatial discomfort, more stress-related arousal and exhibited more competitive behavior. These results point to the lack of consistency in the research conducted so far, and the need for more research on the effects of high density on children as a function of their sex.

Culture

Culture has been identified as another important mediator of people's reactions to high density situations. For example, researchers have found that high density is related to social pathology in some places but not in others (Draper, 1973; Galle & Gove, 1979; Levy & Herzog, 1974 - cited in Bell et al., 1990, p. 307). The coping mechanisms in various cultures have been found to be different and Gifford (1987) has stated that as cultures evolve, ways are developed to cope with density, and negative effects may decrease. Although no research findings have been conclusive about the relationship between culture and high density settings in a classroom, children from cultures with high density environments can cope better with the negative effects of high density in a classroom.

Residential density

There also is a need for more research on the effect of residential density and student achievement in the classroom. Saegert (1985)'s research, which focused on the relationship between residential density for low income children and its effects for school performance, found children from high density homes were more apt to be rated behavior problems by teachers, and exhibited more evidence of distractibility and hyperactivity than children from low density homes. Also, these children from high density homes had lower reading scores and less developed vocabulary skills.

Situational changes

Some research has examined how situational changes may ameliorate some of the negative effects of high density. Rohe & Patterson (1974, cited in Aiello et al., 1985, p. 108) found that providing sufficient quantities of resources (i.e. toys and equipment) resulted in reductions in aggressive and destructive behavior and increases in co-operative behavior. In another study, Rohe & Nuffer (1977, cited in Aiello et al., 1985, p. 108) demonstrated that strategic placement of partitions within high density environments can increase the amount of co-operative behavior of children.

Control and children

Several researchers have proposed that high density can cause a loss of control and this loss is the primary mechanism by which density causes stress (Barron & Rodin, 1978; Baum & Valins, 1979; Schmidt & Keating, 1979; Sherrod & Cohen, 1979). Sherrod (1974) found that negative aftereffects were associated with exposure to high density only when control was not available. General descriptions of the ways in which control is threatened by crowding have appeared (Altman, 1975; Baron & Rodin, 1978; Sherrod & Cohen, 1979) and there are reasons to suspect that control is a relevant concern for children as well.

It is apparent that reduced teacher contact and control over children in high density classroom situations has consequences for both. Research has shown that if authority is not exercised and if obedience is not required, children will behave in ways that are totally out of control (Wolfe & Rivlin, 1987). Baron & Rodin (1978) found that as class size increases, individualized student-teacher interactions decrease; and this leads to negative consequences for performance due to learned helplessness, a syndrome in which "people who are exposed to uncontrollable settings learn that they cannot control the setting, and hence stop trying to do so (Seligman, 1975)".

An important study linking crowding to helplessness was conducted by Rodin (1976). Based on research indicating that chronic residential crowding involved a loss of control (e.g. Calhoun, 1962), she reasoned that prolonged exposure to high-density living would affect children's responses to choices and to the opportunity to exert control. Baron & Rodin (1978) have suggested that a similar process may occur in a classroom and play environments.

There is not sufficient research to suggest that control problems are associated directly with crowding in classroom environments for young children. However, on the basis of research conducted on college students, Aiello et al. (1985, p. 116) have suggested that loss of control over social experience in crowded settings may be responsible for crowding stress that is observed.

Implications of crowding and density on design

Thus, the design of a building affects how crowded people feel in a constant objective space. As Rapoport (1975) has suggested, it may be the perceived form of high density that leads to the crowding effects. Therefore, designs which lessen perceived density could be expected to be associated with less crowding and negative effects (Bell et al., 1990). Given the increasing numbers of children in many classrooms as a consequence of the increasing population and lack of space, architects should design classroom environments that can reduce the perceptions of crowding.

Some of the solutions offered above to address the complex problem of high density and perceived crowding involve changing the physical structure of the school. However, it is not always practical and cost effective to redesign existing schools, or construct new classrooms. A number of studies suggest alternatives that can be incorporated into existing structures or planned into new ones. Placement of activities in the center of rooms rather than in a corner or along a wall, and adding flexible partitions to rooms may lessen feelings of crowding (Dabbs, Fuller & Carr, 1973, cited in Bell et al., 1990, p. 310; Desor, 1972; Evans, 1979).

Savinar (1975) found that greater ceiling height was associated with less crowding in males. Similarly, Rotton (1987) observed that rooms with well-defined corners elicit less crowding than curved walls. In addition, Desor (1972) noticed in his findings that rectangular rooms seem to elicit less crowding than square rooms of the same area. High-rise structures have been found to elicit a more crowded feeling than low-rise structures.

Perceived crowding can also be lessened by the use of bright walls or appropriate lighting (Mandel, Baron & Fisher, 1980; Nasar & Min, 1984, cited in Bell et al., 1990, p. 310; Schiffenbauer, 1979). The presence of visual distractors (e.g. framed pictures, collages, displays on walls) leads to greater perceived space as well (Baum & Davis, 1976; Worchel & Teddlie, 1976). Seating arrangements may also contribute to perceptions of crowding. Wener (1977) found that socio-fugal seating arrangements, where people face away from each other; as opposed to socio-petal ones, where people face each other, are associated with less crowding. However, given the high percentage of inter-related activities in a classroom, this type of arrangement can prove impractical.

Personal Space

Personal space deals with the boundary around the self, described by Sommer (1969, p. 26) as follows:

> Personal space refers to an area with an invisible boundary surrounding the person's body into which intruders may not come. Like the porcupines in Schopenhauer's fable, people like to be close enough to obtain warmth and comradeship but far enough away to avoid pricking one another. Personal space is not necessarily spherical in shape, nor does it extend equally in all directions .... It has been likened to a snail shell, a soap bubble, an aura, and "breathing room".

Personal space has also been described as "the space surrounding an individual where within which an entering other causes the individual to feel encroached upon, leading him to show displeasure and sometimes to withdraw" (Goffman, 1971, p. 30).

Personal space behavior has been found to develop rather consistently from early childhood to early adolescence (Aiello & Aiello, 1974; Tennis & Dabbs, 1975). Altman (1975) states that among children's first steps in becoming individuals is the ability to distinguish themselves from others. This self-identity is possible only after the individual has learned to define his/her personal boundaries and limitations. However, school settings generally tend to show rigid structuring that create homogenous, impersonal environments in which children are not allowed to proclaim their individuality. Sommer (1969, 1974) has persuasively argued the adverse impact of such settings and has stressed the importance of allowing children to have their own things nearby, to personalize their living spaces, and to participate in decision making about the arrangement of spaces. In a study on the effects of the physical setting on the self identity of emotionally disturbed girls, Berenson (1967, cited in Weinstein & David, 1987, p. 8) observed a significant, positive change in appearance and behavior when each girl was provided with a mirror near her bed. Apparently, the mirror served to help define personal territory, thereby enhancing a sense of self.

Spatial characteristics

Spatial characteristics also are important in determining personal space. Using a naturalistic observation of school children and college students, Tennis and Dabbs (1975) found that one's needs for personal space tend to be greater in a corner than in the center of a room. However, few other studies have been done so far in assessing the role of personal space preferences, and these have used a simulation process which may not reflect everyday experiences.

It is also pertinent to mention a study conducted by Aiello and his associates (1977) on the relationship between crowding and interpersonal distances. Although this study did not involve children, the setting was analogous to a classroom environment. Aiello and his colleagues (1977) concluded that people with preferences for large interpersonal distances were more adversely affected in a high density situation with a lack of personal space than those with smaller preferred distances. Individuals who liked to sit far away from others showed greater physiological arousal, discomfort, and poorer task performance than those who preferred to sit closer.

"Whatever physical space conceptions, needs and expectations the child has developed in the home and neighborhood settings, must be fitted into the requirements, activities and normative demands of the classroom and social learning environment" (Proshansky & Fabian, 1987, p.33). However, the needs for control, supervision, order, and appropriate classroom settings have made it difficult to accommodate individual differences and attributes in classrooms. Although these group-oriented norms may be justifiable in terms of insuring all children will be treated equitably, one is led to wonder about the consequences of denying the children personal space and privacy and the inherent freedom of choice involved in both.

Some schools do provide opportunities for exploration, manipulation, and innovation in the physical environment. Students have spaces that belong to them -- their own personalized seating space with an individualized name assigned to it, free movement about the classroom at specific times, and an opportunity to decorate and personalize classroom spaces. Increasingly, provision is made for private personal places within a classroom for study, talk and simply being alone. These spaces take the form of enclosures produced by the children with blocks, cardboard boxes, movable furniture or permanent elements in the classroom created through low ceilings or other architectural features. Provision of cubicles in the classroom is another debated subject, with proponents stressing the increase in task performance, activity level and attentiveness; and opponents citing negative effects and increases in distraction (Weinstein, 1979, pp. 588-589). Thus, specific design guidelines in this area must be employed with caution.

Classroom Design and Furniture

The designed environment's function is to provide a climate which is conductive to both teaching and learning. Many designers had assumed that as long as certain minimum standards for size, acoustics, lighting and heating were met, suitable environments for the teaching-learning process have been created. The built environment only intrudes on the consciousness when it causes particular pleasure, harm, discomfort, or stress (Conners, 1983, p. 1). Zimring (1981, cited in Conners, 1983, p. 15) has stated that owing to the dynamic interaction of persons and environment, stress arises from a misfit between individual needs and environmental attributes.

Taking into consideration the fact that both children and teachers have needs and expectations that must be considered in design, it is important to design the spaces as complementary elements and not exclusively for one or the other. Maria Montessori (1912) has stated that "we habitually serve children and this is not only an act of servility toward them, but it is dangerous since it tends to suffocate their useful, spontaneous activity."

Children's dimensional characteristics

Classroom design must consider children's dimensional characteristics. The physical environment which includes storage areas, lockers, drinking fountains, sinks, toilets, and furniture should be convenient for a child's use and recognize the child's level of manual dexterity and muscle capability. Children should have maximum independence with the capability to adapt and interrelate their activities with the teacher's. Maximum provision for children's independence will also aid the teachers by minimizing the amount of assistance needed by the children. Quail (1965, cited in Osmon, 1973) stated that "not everything in the school environment should be made to adapt to the child. Teach him that he must adapt too, that he must use the adult as a resource person, that there are stepladders he can climb to reach things otherwise too high." At the same time, one should not ignore an elementary school child's lack of motor co-ordination, slow reaction time, general lack of experience, and hence judgment. Thus, safety considerations become very important. Use of slip-proof rugs and floors, shock-proof electrical outlets, and unbreakable furniture is recommended.

All of these above considerations imply that a relocatable classroom, or for that matter any school area, should be oriented toward the child, while also providing a convenient working environment for the teacher. In general, this will mean providing equipment at two different scales if the budget allows: sinks, storage units, windows, etc. A different approach is to bring the child into the adult realm for combined teacher/child activity.

Open education vs. open-plan schools

Much research on classroom design has focused on innovative spatial arrangements or layouts, such as open education classrooms and open-plan schools. Weinstein (1979, pp. 577-578) in her review of this literature, has described these concepts:

> Open education refers to a set of teaching practices that reflects the belief that children learn best when they can actively explore an environment rich in materials, when they are given the responsibility to make meaningful choices about what is to be learned, and when they are able to interact informally with their teachers and with one another. In order to achieve these the traditional rows and desks are replaced by a number of interest areas where children can work alone or with groups. Typically, there are areas for reading and writing, mathematics, science and crafts. Each area is supplied with materials and equipment, displayed on open, accessible shelves, and children are usually free to move from one area to another as they wish.
>
> The term open space schools, on the other hand, refers to the absence of interior walls. Although open space does not represent a philosophy of education so much as a trend in building design, such schools are often intended to promote or at least permit flexibility in scheduling and spatial arrangements, encourage interaction among students and teachers, facilitate team teaching, and allow for learning options that the self-contained classroom is unable to support.

Open education suggests changes in instructional methods and ideologies, which are not within the scope of this thesis. Proshansky and Proshansky (1978, cited in Proshansky & Fabian, 1979, p. 34) have stated that a changed physical environment, in this case a flexible classroom design that reflects open education, cannot improve the quality of education without corresponding changes in curriculum, teaching strategies, and methods of evaluation. As the guidelines are meant to serve the existing teaching practices in Kansas, where few open classrooms exist, recommendations related to the open education concept, in the light of the above observation, have little relevance.

The concept of 'open-space' can be used when the relocatable unit serves more than one classroom. Although no research exists on the specific impacts of open-space configurations in relocatable units, it can be hypothesized that a sense of being a part of a large school environment can be reinforced in the school children using these spaces. The visual and auditory effects can give the child in this classroom a sense of a connection between classrooms, integrating this setting with the larger school environment. The inherent problems of student distraction, class interruptions, high noise levels, and poor traffic flows can be reduced with the use of variable-height sound absorbent partitions (Weinstein, 1979).

In addition to the concept of 'open-space' planning, overall flexibility in design that allows adaptation to changing needs, demands equal attention. In this context, the basic idea of School Construction System Development Project (SCSD) developed by the Educational Facilities Laboratories (1967) has potential in relocatable units. One of the most important aspects of the performance specifications is that the structure, lighting, and mechanical subsystems are all contained in a 36-inch space between the roof deck and ceiling, called the 'service sandwich'. Here, wiring, lighting, TV conduits, air ducts, and plumbing are interlaced, rather than each being allowed a separate layer of space. This design allows for greater flexibility in the space leading to the use of demountable partitions which can be moved and rearranged to accommodate changing grades, programs or any other future developments.

Furniture arrangement

Weinstein & Woolfolk (1981) developed a slide presentation that depicted different elementary classrooms which varied in the type of furniture arrangement used (open versus traditional) and condition of the room (neat or messy). On judging these slides that created a simulation of walking into the room, elementary school children judged the occupants of the neat classrooms more favorably. However, they ascribed no impact to furniture arrangement.

Other studies have specifically addressed the question of the influence of design on achievement. Rosenfeld (1977) has stated that since students learn best in comfortable classrooms, design features that are essential to the development of a creative, intellectual environment should include windows, spaciousness, flexible seating arrangements, and decoration. This line of thought was first stated by Sommer (1974, p. 138) who believed that "there is a need for 'soft classrooms' that can encourage experimentation or, at least, can accommodate change." Sommer and Olsen (1980) augmented this thought by developing a more humanizing classroom, in a college setting, that replaced the existing traditional arrangement of rows of desks with three-tiered cushioned benches, carpeting, adjustable lighting, and various decorative items. Not only did the voluntary student participation increase substantially, but the satisfaction of the users also changed dramatically.

Sommer (1977) indicated that teachers should be able to rationally defend their arrangement of tables, chairs, and desks according to specific, predetermined educational goals; the contention being that the physical layout of the classroom (whether straight immoveable rows of chairs and desks or clusters moveable chairs and desks) is highly reflective of a teacher's attitudes and philosophies. He stressed that "the physical and social systems of the classroom are inextricably twined. Change one and you inevitably change the other" (p. 175).

Winett, Battersby and Edwards (1975) studied the effects of "architectural changes" - replacing single desk-chairs in rows with clusters of eight movable desks and chairs - as well as the effects of individualized instruction and behavior-modification techniques on the academic and social behavior of initially disruptive sixth-grade school children. The design changes by themselves produced no significant behavioral changes, although the authors felt that they had "facilitated the use of the academic programs" (p. 39).

Individual preferences

Lemmon (1985) studied the effect of design preferences on learning in elementary school children, in which, although each child was given a conventional seat and desk, the children were allowed to sit on the floor or on carpeting as they preferred. When assessed for basic skills, the students showed significant gain under the conditions that matched their preferences. This and similar studies prompted Dunn (1987) to advocate that schools respond to student's preferences for either a conventional desk and chair (formal design) or cushions, floor, carpeting, or an easy chair (informal design). Her contention is that students who cannot sit for a longer period of time will pay better attention, listen more intently, and remember more when they are permitted to lounge while learning.

Greabell and Forseth (1981) believe that a stimulating environment - rich with color, relaxed in mood, and imaginative in arrangement - creates a positive, encouraging climate that stimulates students. They illustrated their opinion by designing two classrooms, one in a traditional arrangement of rows of desks and chairs; and the other with clusters of desks and chairs, learning centers and quiet areas. The authors contend that a stimulating environment provides more opportunities to observe a child's interests, evaluate the child in terms of individual academic curriculum needs, and have creative outlets. This argument is reinforced by Loughlin and Suina (1982) who state that an arranged environment - containing a variety of classroom furniture and interest centers - can be used as an instructional strategy, complementing and reinforcing other strategies the teacher uses to support children's learning.

Degrella (1989) states that learning centers (within a classroom) are a good means to accommodate learning in a literate environment, wherein individual student differences and developmental levels are served. She further states that these should be equipped with manipulative and activity oriented materials pertinent to the content area or particular activity, along with general supplies and resources -- defined and housed by furniture and shelves. However, Creekmore (1987) states that the stimuli presented to the learner must be introduced with control and with purpose, thus avoiding confusion and over-stimulation. He illustrates his point in the specific organization of walls in terms of learning theory to enhance acquisition, maintenance, and generalization of material presented to students. Emphasizing the need for a focus in the classroom, especially at the elementary school level, he concludes that uncluttered, relevant material enhance learning and that over-stimulation reduces learning and increases off-task behavior.

Although research has been conducted on the aesthetic appeal of these alternative classrooms, few studies have looked into 'shape' factors of classroom design like the influence of circular, square or horseshoe arrangements on verbal interaction. Sommer (1967) examined verbal behavior in two seminar rooms, one with the tables arranged in a horseshoe and another with the tables forming a square, and in two laboratories containing fixed tables and stools in rows. Comparisons between the two kinds of rooms yielded equivocal results: a higher proportion of people participated in the laboratory, but there were more statements per class periods in the seminar rooms. Despite the limited evidence, the popular conviction is that circles, squares, and horseshoes are more conducive to verbal interaction.

Classroom height and size

Another important feature to investigate is the ceiling height of classrooms. It is often misconstrued that a low-ceilinged space (with an allowance for enough height for the teachers) will create an intimate environment. However, "an adult placed within such a space would appear excessively large to a child due to the adults' nearness to the ceiling and may result in a feeling of dominance (of size) by the teachers" (Osmon, 1973, pp. 20-21). This exaggeration of size seems to be supported by Millar (1968) who reported that young children overestimate the size of whatever objects they are looking at and that they are affected more by what immediately surrounds an object than adults are. Ceilings should be at a height where it is 'definitely' not perceived by the children. A normal 9'0" -- 11'0" height will minimize the teacher's presence. Thus, the ceiling height should be instead assessed in terms of economics (not too high) or acoustics (not too low).

On the horizontal plane, a similar effect would seem to occur if the teacher and children find themselves in a small room. Thus, the use of flexible partitions (height 7'0" +) can be utilized. The partitions could be in the form of storage units, display panels or chalk/tackboards that can be easily manoeuvered without much assistance. These partitions could be used to emphasize a teacher's presence while teaching or to de-emphasize it during play activities. De-emphasizing the teacher's presence can also be achieved by keeping the teacher's circulation paths as much as possible on a minor axis and the children's activities on the major axis of the room. In spite of the contradictory findings and the frequent lack of effects, the weight of the evidence suggests that design factors can have a significant influence on students' general behavior (such as movement patterns, disorderliness, and involvement) and on their attitudes toward the class and other students. Thus, these issues are important considerations in the design of relocatable units for elementary schools.

Seating Position

An examination of the research literature shows that seating position within the traditional classroom has been investigated more thoroughly than any other single physical variable, and it is the only physical variable that has been linked to differences in school achievement (Weinstein, 1979, pp. 578-581). The physical proximity as well as the visual angle between the teacher and a student in the classroom influences the amount of interaction and communication between the two. Adams and Biddle (1970) observed that interaction in the class is focused on the front and central rows. Children in the rear rows and on the flanks can converse among themselves without the teacher overhearing them, or communicate by facial expressions without the teacher noticing it --while they themselves receive only part of the teacher's message, as they are unable to read his/her facial expressions. Thus, the front and center seats, called the "action zone" by Adams and Biddle (1970), have been found to "facilitate achievement, positive attitudes, and participation, at least for those predisposed to speak in class" (Conners, 1983, p. 18).

This action zone phenomenon has also been observed by several other researchers. Koneya (1976) observed that more verbal behavior occurred in the triangle of centrality, which is composed of the front row and the seats in the middle rows closest to the front portion of the room. Schwebel and Cherlin (1972) observed the behavior of students from kindergarten to fifth grade in two elementary schools. They found that students who had been assigned seats in the front rows were significantly more attentive and engaged in more on-task behavior than students in other rows. On assigning seats randomly during the second observation period, a similar effect was observed, though the difference was not statically significant.

A study by Stires (1980) of college students, in which one class was assigned seats in an alphabetical order and the other was allowed to select their own permanent seats, also supports this theory that attitudes and grades are influenced by seating position. Minner and Prater (1989) state that physical proximity to a teacher helps keep some students on-task and generally improves the level of instructional control in the classroom. Informal observations of classrooms support these views, as proximity to the teacher leads to increased eye contact and greater opportunities for verbal and non-verbal communication.

Walberg (1969, cited in Weinstein, 1979, pp. 578-579) has stated that "students who preferred to sit in the front of the classroom were 'overzealous' and placed a high positive value on learning. Students who preferred to sit near friends revealed a high need for affiliation and sensitivity to criticism, while those students in the back of the room or near the windows had negative attitudes toward learning and their own capacity for success."

While the studies reported above examined physical proximity to the teacher, Wheldall and Olds (1987) examined the effect of mixed and single-sex seating on 2 different elementary classrooms. Results indicate that on-task behavior was higher and the rate of disruption lower when children were placed in opposite-sex seating.

Despite the above findings, it is the contention of Montello (1992), after extensive research, that seating location has no actual effect on course achievement. However, it has been found to have an effect on class participation, and on self-report variables such as attitudes towards the course and the instructor. Brooks and Rebeta (1992, pp. 400-401) note that "personality variables dispose students to choose seats in certain areas of the classroom, and that it is these variables, not location per se, that are responsible for course performance differences often found between students seated in different areas." They cite Hillmann, Brooks, and O'Brien (1991) to state that students seated in the front of a classroom scored higher on a test of self-esteem than those seated toward the back.

All these findings suggest that the behavioral ecology of classrooms can be used to support classroom management strategies. Recognizing the impact of proximity on involvement, teachers should make a concerted effort to interact verbally with students seated at a distance, and classroom design should facilitate such contacts. If seating position is permanent for an academic year, individual variables like gender, motivation and self-esteem become even more crucial. In the light of the studies by Wheldall and Olds (1987), and Brooks and Rebeta (1992), opportunities for mixed-seating arrangements should also be considered.

Presence or Absence of Windows

The topic of windowless classrooms has aroused varied and strong responses. Classroom windows have been used to light building interiors, to provide a form of air-conditioning, to provide a view, and to serve as a means of emergency escape from or emergency entrance into a building. However, recent technology has eliminated the need for windows to provide interior lighting and air-conditioning. Also, the use of windows to obtain the required light supplements is of little effect because ultraviolet light, which is the most significant component in natural light, is effectively filtered out by ordinary window glass (Hathaway, 1982). Therefore, the question arises whether or not windows are desired for other reasons, and if so - which, especially in a classroom environment where children stay for long periods of time.

One of the earliest studies conducted by The Architectural Research Laboratory of the Department of Architecture at the University of Michigan, to determine the effect of windowless classrooms on elementary school children, showed that children in the test school had very little personal interest in whether their classrooms had windows or not. However, the teachers preferred windowless classrooms because the children were not distracted by outside happenings and the extra wall space could be used to good instructional use, especially for display. However, later studies have shown that windowless classrooms reduce the "pleasantness of students' moods"

(Ahrentzen et al, 1982).

Collins (1975), in a comprehensive review of research on windows, reported that results of window preference studies in classroom settings are contradictory. Some researchers (e.g., Chambers, 1964-65) found a favorable reaction to classrooms without windows among students and teachers, while others (e.g., Tikkanen, 1972) reported a preference for classrooms with windows. However, Collins states that due to desirable functions of windows for people, they should not be overlooked in the design of energy efficient buildings.

Romney (1975) designed a study to measure the effect of windowless classrooms on rote learning, concept formation, and perceptual ability; and to observe student and teacher affective behavior. On the basis of the results from two classes of elementary school children, he concluded that the "students were significantly affected by their environment, but no clear relationship could be drawn" regarding the cognitive behaviors, as the responses of the two classes were totally different. However, in the area of affective behavior, he found the windowless environment was a definite negative factor associated with student aggression and teacher frustration.

Butler & Biner (1989) investigated window preferences across a variety of common spaces and examined reasons or factors that may underlie these preferences. Due to the vast differences in window preferences and factors among the respondents, they state that the amount of windows desired in a space can be reliably predicted by knowing how important specific factors (e.g., having a view, good ventilation) are to individuals in that space.

Lighting

According to both teachers and children, physical conditions in the classroom, such as temperature, lighting and noise tend to have an important effect on learning only when those conditions become extreme. Research concerning the effects of illumination on learning delineates the need for examining levels of appropriate lighting and incorporating this knowledge into classrooms (Weinstein & Weinstein, 1979; Wurtman, 1968).

Once illumination is made available through the efficient manipulation of natural and artificial light sources the ideal environment demands equal attention to the color and brightness of the surroundings. In one of the earliest studies on the effect of reflecting surfaces, Caudill (1954, pp. 72-74) found that in a unilaterally-lighted classroom it is essential to have very high reflective surfaces. He found that the intensity of light can reduce to as low as 39% in a room wherein the ceiling is painted dark. This put a greater emphasis on the ceiling in reflecting light. However, this is true only in unilaterally-lighted rooms. The importance of reflective surfaces has been found to be less in multi-laterally lighted classrooms. Birren (1969) stated that floors should range in reflectance from 20-30% and desks and equipment should range 25-40%. "Brighter finishes with higher reflection are only acceptable where all other areas of the room can also be made correspondingly high in reflectance" (p. 84).

Practical observation has shown that there should be sufficient light but not too much. What constitutes sufficient light will vary with what is needed for perception of the critical visual stimuli. "Excessive light can produce glare, reduce the clarity of the stimuli and produce visual stress (Pielstick, 1988, p. 116) and, on the other hand, low levels of illumination tend to be relaxing.

Rudd (1978, p. 45) stated that classroom lighting systems "must bring visual comfort to students and instructors." He explained that the emphasis has changed from the quantity of light produced to the quality of light, thus the need to reduce ceiling reflections and instead put light where it is needed. He indicated that achieving good overall seeability would "reduce eye fatigue and result in a more comfortable work and learning atmosphere" (p. 48).

Stelz (1981, cited in Pielstick, 1988, p. 116) found that the students were on-task more under a very low level of illumination (7.2 foot-candles) than in a brightly lighted classroom (72 foot-candles). He also found that visual discrimination was not impaired and disruptive behavior was unaffected by the level of illumination. These effects and the responses from the children led him to conclude that the illumination levels needed for best performance need not be as high as provided traditionally in classrooms.

However, in a study to identify fourth graders' preference for studying in brightly or dimly lit areas, Krimsky (1982, cited in Dunn, 1987, p. 46) found that "preference per se for either extreme does not affect performance; what is important is that students are permitted or encouraged to read in instructional settings that complement their lighting preferences."

Specific types of light sources

Considerable research has focused on the effects of specific types of lighting on school children. In an earlier controlled experiment (Zamkova & Krivitskaya, 1966), wherein ultraviolet suntan lamps were used along with regular fluorescent lighting, the experimentally irradiated group showed increased levels of working ability and resistance to fatigue, improved academic performance, improved stability of clear vision, and increased weight and growth over the control group.

Other studies have focused on the positive effects of full-spectrum lighting as compared to cool-white lighting. Maas, Jayson and Kleiber (1974) reported in their study, conducted at Cornell University, that students studying under full-spectrum lighting had a decrease in critical flicker fusion (the frequency of intermittent stimulations of the eye at which flicker disappears) and an increase in visual acuity. Students studying under cool-white illumination became less lively or more lethargic after hours. Mayron, Ott, Nations and Mayron (1974) found that the use of full-spectrum fluorescent lighting with lead foils for radiation shielding decreased the hyperactive behavior of students in two first-grade classrooms, as compared to the students in two control rooms with standard cool-white fluorescent lighting. Similarly, using time-lapse photography, Ott (1976) concluded that using full-spectrum fluorescent tubes with lead foils over the cathode ends to stop soft x-rays, children's behavior in the classroom showed dramatic improvement as compared to standard cool-white lighting.

Painter (1977), in a comparative study on the effects of incandescent lighting and fluorescent lighting, observed that hyperactive behavior of a class of nine children, variously described as autistic or emotionally disturbed, decreased under incandescent lighting. However, hyperactive behavior returned to normal when standard fluorescent lights were replaced. This was corroborated by Coleman, Frankel, Ritvo and Freeman (1976), who found in their study that fluorescent background illumination increased the amount of repetitive behaviors in six autistic children. As these special children are mainstreamed in regular schools, these studies have increased significance.

The above studies, especially by Krimsky, delineate the need to respond to individual's need for the type of light source, fluorescent or incandescent, and also for bright or dim conditions in a classroom. Dunn (1987, p. 47) has stated that bulbs or fluorescent tubes in one section of the room may be loosened to reduce the amount of illumination in there, and reading groups comprised of students with preferences for either bright or dim conditions may meet and work in differently lighted sections of that environment." Thus, through efficient manipulation of seating arrangements and furniture layout, individual preferences for any type of illumination condition can be accommodated.

<u>Color</u>

A well designed environment not only facilitates learning new subject matter, but reduces behavioral problems. Papadatos (1973) stated that proper use of color in a school can convert an atmosphere that is depressing and monotonous into one that is pleasing, exciting and stimulating, thus reducing absenteeism and promoting positive feelings about school.

He further explained that walls opposite windows should be painted in a light color "that would reflect the sun's rays back to the window wall, which would be painted in a cool medium tone. The front and rear wall should be treated in light tones in order to compensate for the sun's rays" (p. 92). He also asserted that treating walls with a reflecting paint may increase the light by one third without remodelling the lighting system.

Preference for warm over cool color schemes

Studies by Child, Hansen and Hornbeck (1968, cited in Sharpe, 1975, p. 18) show a general tendency among children in favor of "cool colors over warm colors, light colors over dark colors, and a steady increase in high saturation preferences from the 1st through the 4th grades.

However, from the 5th through the 12th grades, hue takes precedence over high saturation."

However, a 3-year study, conducted by Henner Ertel (cited in Birren, 1978, p. 51) to assess the impact of environmental color on children's learning capacity, showed that popular colors among the children such as blue, yellow, yellow-green and orange stimulate alertness and creativity; white and brown playrooms make children less active. Ertel also found that the color orange improves social behavior, cheers the spirit and lessens traits of hostility and irritability.

In an effort to corroborate the above research, Wohlfarth and others (1985) conducted a study on the effect of colorpsychodynamic environmental modification on academic achievement and I.Q. scores in elementary grade students of four nearly architecturally identical schools. One school had its lighting changed to full-spectrum lights; the second had its colors (including carpets and blackboards) changed according to those proposed by the previous researchers; the third had both its color and lighting changed; while the fourth served as a control with no changes in its environment. Computer data analysis of the test results found no support that bright, warm colors had any effect on academic achievement or I.Q. Although a trend toward higher academic performance and I.Q. was seen in the light and color modified school, these trends were not significant and the author contends that they could have been a result of "artifactual factors" (p. 54). Interestingly, the same study showed that the light and color modified school significantly lowered blood pressure, increased the surgency and mastery of self-esteem, and decreased sadness and aggression in students (Wohlfarth and Gates, 1985).

Birren (1969, p. 84) has stated that since the bright environment created by warm colors like soft yellow, coral, peach will have a diverting effect causing visual and emotional interest to proceed outward; the bright, warm color scheme becomes highly appropriate for elementary grades. This is supported by Mahnke and Mahnke (1987, p. 83) who found that the warm, bright color scheme complemented the extroverted tendency of elementary school children, thereby reducing tension, nervousness and anxiety. On the basis of their observations, they suggest colors like light salmon, soft warm yellow, pale yellow, orange, coral, and peach.

Studies have shown that harmony becomes a feature of artistic analysis to children at ages between 8 and 12 (Sharpe, 1975, p. 12). It has also been noted that there is a transition from color to form dominance by the age of five, and form dominance is usually established by the age of nine (p. 8). A study conducted by Joan Chase (1965, cited in Sharpe, 1975, p. 18) using the Lowenfeld Mosaic Test with children from 2 to 16 suggests that position of color in the stimulus presented for assessment is an important factor influencing the choice of color. She cites the spontaneous behavior of 7-year olds picking up blue and black tiles more frequently when placed in end positions.

Alschuler and Hattwick (cited in Birren, 1978) stated in their research that young children are more responsive to color than to form. They found that "small children release their feelings through warm and luminous colors such as red, orange, pink, yellow. Children who use cool colors, blue and green, may be more deliberate and impetuous. Use of black, brown or gray may reveal some inner troubles" (p. 117). Sharpe (1975, p. 23) found a negative correlation between red and intellectual functioning in a test given to feeble-minded grade school children.

Mahnke and Mahnke (1987) have devoted an entire chapter citing the ill effects of using a "sterile, bleak and emotionless" (p. 23) hue like white. They have noted that reaction to white is one of bored disinterest. Also, when white is accompanied by high levels of natural or artificial light, it may play havoc with human vision. On the basis of the this argument, it can be stated that white would be inappropriate to use extensively in a classroom, and make learning and seeing more difficult in areas of intense lighting.

The right choice of color

Hanlow (1979) suggested that the choice of color scheme (whether warm or cool) should be decided on the basis of the desired warmth or coolness in a room. On the strength of earlier experiments, he stated that the feeling of warmth can be added to a room by the use of a warm color scheme and focused incandescent lighting. On the other hand, a cool atmosphere can be added by the use of fluorescent lighting and sparse furnishings.

The above studies and observations by Wohlfarth et al. (1985) and others show that although colors may not be significantly affect academic achievement, their proper use can prevent behavioral problems, and enhance the learning environment.

Day (1980) has noted, for any color there is an association that goes on in the mind. "Some colors tend to stimulate, some soothe and relax, and others create fatigue, depression and irritation" (p. 5). Thus, colors should be properly used to influence and enhance the visual and learning environment.

Acoustics

Research on the impact of sound on the children's selective attention to cognitive tasks has yielded contradictory results. Weinstein and Weinstein (1979), in their short-term study on the effect of quiet and normal background noise on reading comprehension of fourth graders in an open-space school, found no significant difference in performance. However, Bonzaft and McCarthy (1975), on an examination of the reading scores of students attending an elementary school located near an elevated train, found the sores of students on the noisy side to be significantly lower. Weinstein (1979) explained that this phenomenon was the result of an "auditory screening process by which children in perpetually noisy environments filter out relevant as well as irrelevant sounds" (p. 591). These findings were corroborated by an earlier study by Cohen, Glass and Singer (1973) that examined the auditory discrimination and reading achievement scores of elementary school children living in multi-story apartment buildings near a major highway. The researchers found significant correlations between floor level and performance in these tests for children living in the apartments for 4 years or more. Weinstein (1979) stated that this failure to discriminate sounds can lead to a difficulty in associating a verbal cue with a written symbol.

On the other hand, Cohen, Evans, Krantz, and Stokols (1980) found that children in the air corridor of the Los Angeles International Airport performed as well as their counterparts from quieter schools on tests of auditory discrimination, mathematics achievement, and reading achievement. However, the children from the noisier school did not perform as well on a puzzle task and manifested greater distractibility with increased years of exposure to the noise. In addition, these children were more likely to demonstrate a lack of persistence on the puzzle task and had significantly higher blood pressure.

Internal classroom noise

As opposed to the above two studies on the effects of persistent background noise due to outside interference, Christie and Glickman (1980) studied the effects of internal classroom noise on the intellectual performance of children of different elementary grades. Their study showed that the effects of classroom noise did not vary with age. They also found that males scored higher in a noisy environment than a quiet one, while females scored higher in a quiet environment rather than a noisy one. This replicates the findings of Carter (1969) and Zimmer and Brachulis-Raymond (1978), that high levels of sound affect the reading achievement among both boys and girls, but significantly more so among girls. This finding also is consistent with Restak's (1979) finding that developmentally, girls remember more by listening earlier than boys, and they tend to be more sound-sensitive than their male counterparts.

Music and individual learning styles

Other studies have looked into the effects of music on task performance. Rosenfeld (1977) stated that music is an effective means of increasing production, reducing errors, tension and absenteeism, and combating fatigue. He found that effective use can facilitate concept and skill learning, mental imagery, reading efficiency and such creative abilities as painting. This is corroborated by Davidson and Powell (1986), in their study on the effects of easy-listening background music on the on-task performance of fifth-grade children. They defined easy-listening music as being melodious, traditional with a rich use of strings and winds, highly orchestrated and, with a non-percussive beat. Time series analyses showed a significant increase in the on-task performance for the males and for the entire class. However, in an examination of the effects on student performance of a quiet reading environment versus one which contained background rock or classical music, Mullikin and Henk (1985) reported that, although soft classical tones appeared to enhance reading comprehension for many children, there were not positive effects for all children.

Thus, individual learning styles can be attributed to auditory preference and the ability to concentrate in quiet, with sound, or in either condition. Pizzo (1981) in his study of elementary school children, found that students in an environment that matched their learning style preference (quiet versus noisy) performed better, and evidenced statistically higher attitudinal scores than their mismatched peers. They also found that a mismatched environment not only impaired reading achievement, but also detrimentally affected students' attitudes toward their own intellectual ability, physical and emotional strength, and emotional stability.

Dunn (1987) concludes that all this research shows the need to "place students away from traffic or activity patterns; use soft cotton or rubber ear plugs, or non-functioning listening sets to limit the number and types of sounds heard; use listening sets or earphones for students who need music when learning; or cover a small section of the floor with carpet where the student is seated to reduce sound distractions" (p. 46).

Acoustic refitting

Pekkarinen and Viljanen (1990) state that "the deleterious effect of background noise on speech discrimination can be minimized by acoustic refitting of the (class)room" (p. 225). They found that reverberation times were reduced by covering most of the back walls and part of the ceiling with 50mm mineral wool panels. Also, speech discrimination improved significantly after acoustic refitting of rooms. However, in settings where both ceiling tiles and absorptive flooring like carpets have been used, teachers have complained that they have trouble making themselves heard. This is due to the fact that completely covering the ceiling with acoustical tiles provides the classroom with more absorption than necessary and makes the room overly "dead." Thus, Holahan (1982) has suggested the use of soft or absorptive flooring along with a sound reflective ceiling.

Flexer, Millin and Brown (1990) have also identified sound field amplification as an effective education tool in special as well as regular classes, as it makes improved use of the critically important auditory modality. They point out that "because teacher and pupil movement, poor classroom acoustics, learning loss, and inattention interfere with a child's ability to detect such differences, any strategy that could counteract this interference would be helpful" (p 182). This is all the more important as the quality of visual and auditory contact between people is inversely proportional to the physical distance between them. Hall and Sommer (cited in Sebba, 1986) have stated that beyond a distance of 3 meters, verbal communication is impossible without raising one's voice.

Heating

According to Pielstick (1988), "the effect of temperature on pupils in the classroom may be an even more subjective matter involving comfort, which is determined by a complexity of factors, including absolute temperature, humidity, the radiant temperature of surrounding surfaces, air movement, physical activity and acclimatization to prevailing conditions" (p. 117). He also contends that according to both teachers and pupils, physical conditions in the classroom, such as temperature, tend to have an important effect on learning only when the condition becomes extreme. Although there is no evidence of effects on learning, he cites research to determine the comfort range for school-age children as about 65-70^{0}F (18-24 C). This reiterates Rosenfeld's (1977) claim that classroom temperatures should be maintained between 64-68^{0}F, as cooler temperatures are more healthful and produce less fatigue.

On the other hand, Murrain (cited in Dunn, 1987) examined the temperature preferences of seventh graders to determine whether they were related to scores on a word recognition test taken in two diverse thermal environments, extremely warm and extremely cold. Nearly four times as many students preferred a warm, rather than a cool classroom; even the students who preferred cooler classrooms attained higher scores on the test in a warm setting.

Scagliotta (1980) devised a chart to track atmospheric conditions and daily misbehavior of elementary grade children. He stated that "it soon became apparent that with each change in barometric pressure, came an obvious change in the child's behavior" (p. 611). His finding that as the barometric pressure went down, the frequency of misbehavior went up; leading him to conclude that "by using barometric pressure readings to forewarn a teacher, adequate preparation for dealing with and managing deviant behavior could be established prior to its inception" (p. 612).

Anthropometrics

The aim of any classroom planning is to house the students with great consideration given to their physical and emotional needs. A good classroom is the one that is designed and equipped to satisfy all the needs of the students as well as supporting the teacher's needs. The classroom and the shared spaces in the school cannot function properly if the spaces are too small for individuals or groups of children, or if the shelves are to high to reach and seats too small to sit in with comfort. There also is "a strong relationship between improperly designed furniture and accidental death and injury to children" (Panero, J. & Zelnik, 1979, p. 105). The following illustration (Figure 1) from Toward Better School Design by Caudill (1954) shows characteristics of the anatomy of the pupil, based on the statistics prepared by the United States Department of Agriculture. The illustration is based on "H" -- the average height in inches indicated in circles for each age and corresponding grade.

The Physical Size
of the Client

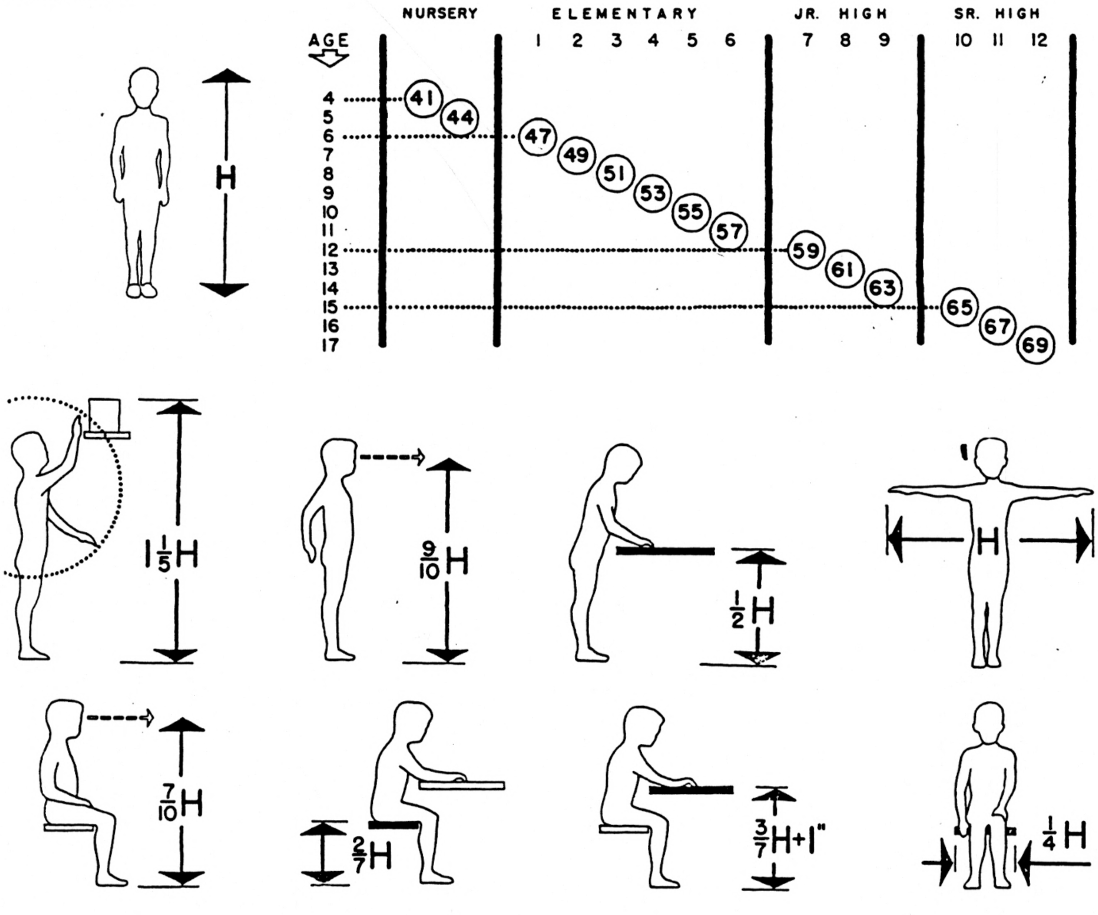


FIGURE 1

Source: Caudill, W. Toward Better School Design. N. Y.: F. W. Dodge Corporation, 1954, p. 11.

REVIEW OF RELOCATABLE SCHOOL FACILITIES

As seen by now, relocatable facilities are used as supplementary teaching stations consisting of isolated classroom units, physically separated from the main school building. Furthermore, building code requirements and fire safety regulations necessitate the absence of any connection to the main school building and between any two units. This isolation from the mainstream of a school's functional plan - the limited access to the mainstream activities and experiences -is undoubtedly the major educational disadvantage of these relocatable facilities. On the other hand, in the absence of any other feasible solution in a time-bound situation, and as a stop-gap solution to school housing on a short-term basis, these units can be invaluable.

Their importance as a stop-gap arrangement can be gauged from the fact that more than 36,000 'non-permanent facilities' were being used in U. S. schools, as reported in a Spring, 1962, National Inventory of School Facilities and Personnel (study by the U. S. Office of Education, released Feb., 1964). Although physically, most of the units have not changed in appearance since their early configurations, more recent units have seen the inclusion of better facilities and utilities.

There are four basic types of relocatable units in use: portable, mobile, divisible, and demountable. Whatever the type or appearance, on the basis of anthropometrics and the space required for each activity in an elementary classroom, an area of 35 sq. ft. per student, as proposed by W. W. Caudill (1954) is still preferred. Also, all types of relocatable facilities are usually set on cement blocks or wood piers, a perimeter block foundation, a poured concrete pier foundation, or even on a rough slab foundation. Exterior and interior finishes and materials in all relocatables are a matter of choice, design and cost. Except for demountable units, all other types have a 13'0" - 13'6" road-to-roof peak clearance -- a restriction imposed by the need to transport units on a flatbed 30"-36" above the road.

The following table (Figure 2) gives a comparative study of the size limitations of the different types of relocatable units.

	PORTABLE	MOBILE	DIVISIBLE	DEMOUNTABLE
Width Range	8'0" -28'0"	10'0"	8'0" - 10'0"	---
Max. Length	68'0" - 72'0"	65'0" - 70'0"	24'0" -36'0"	---
Int. Height	8'0" - 9'6"	8'0" - 9'6"	8'0" - 9'6"	---

Figure 2

Portable Facilities

Portable facilities (Figure 3) are moved as a whole from one site to another over short distances (the distance decreasing with an increase in the width that ranges from 8'0" to over 34'0"). The total structure (including floor) is jacked up above the footing, lifted and dollied onto a flatbed, and hauled through the streets from one location to a new site. To achieve interior floor to ceiling heights of 8'0" - 9'6", most portables are either flat roofed or designed with low peaks. As these structures have to accommodate for the stress and strain of constant moving, traditional wood framing, when used, is often over a rugged steel chassis.

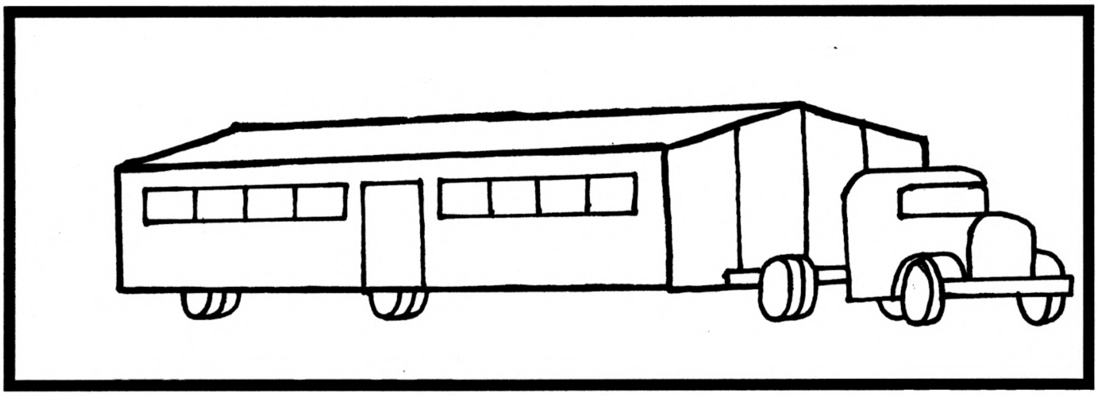


Figure 3: Portable Facilities

(Reproduced from: Educational Facilities Laboratories, 1964, p. 16)

Mobile Facilities

Mobile facilities (Figure 4) are designed along structural patterns used for mobile (trailer) homes, applying mass-production technology to a space enclosure. Due to a maximum width of 10'0", these structures can be carried across state highways, making them feasible and cost-effective. However, as the mobile units are used as a whole, without any modifications or on-site linkages with other units to create more space, the restrictive width also makes them unsatisfactory as classrooms. These units can, thus, be adapted to serve as laboratories, libraries, or special training facilities. A steel carriage is standard to the mobile structure, while pulling hitch, axle and wheels can be permanent or removable. Wood framing with sheet aluminum skin exterior or curtain wall systems are some of the finishes used for mobile units.

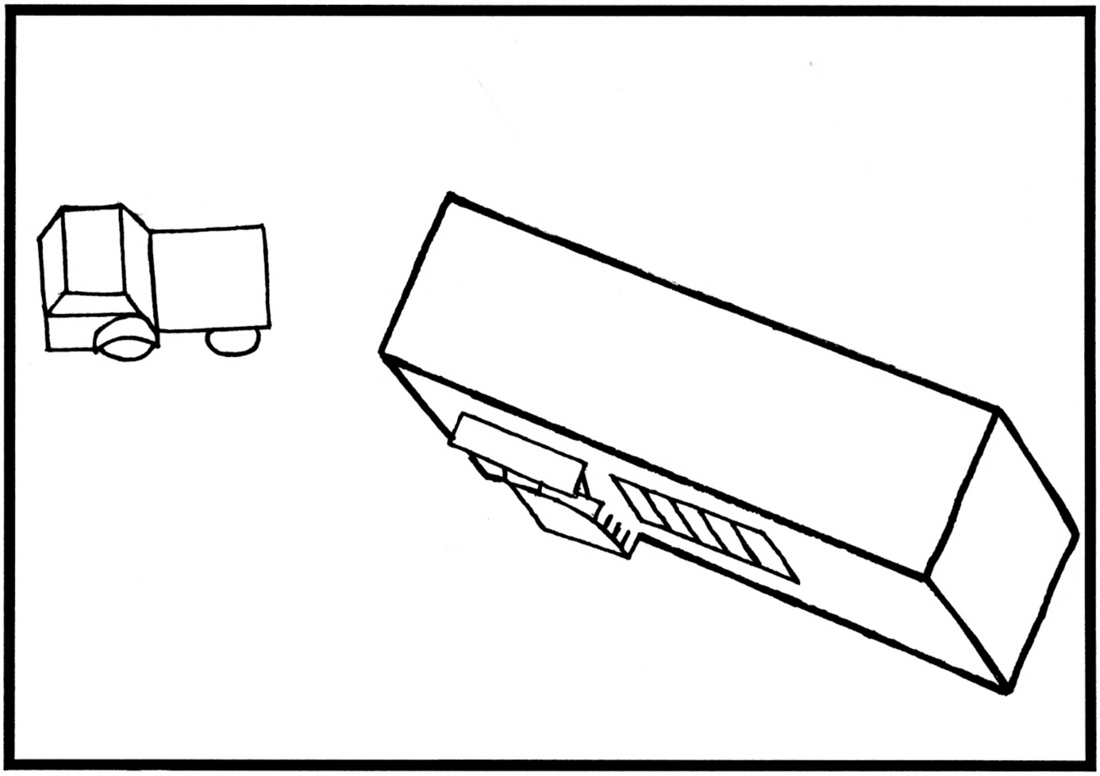


Figure 4: Mobile Facilities

(Reproduced from: Educational Facilities Laboratories, 1964, p. 17)

Divisible Facilities

Divisible facilities (Figure 5) hold the most potential due to their modularity, wherein all the components like windows, doors and entire side walls, roof, flooring, and utilities -- are combined and pre-finished for greatest ease of shipping and rapid assembly at a given site. The modules allow for greater flexibility in design and space delineation.

Divisible-mobile units, a sub-type, are mobile units that are joined together to form single or double classrooms. The size limitations and mode of transportation are, therefore, the same as that for mobile units. However, the length is in the shorter range of 24'0" - 36'0".

Steel space frame, wood frames or reinforced concrete systems are some of the structural systems that have been used.

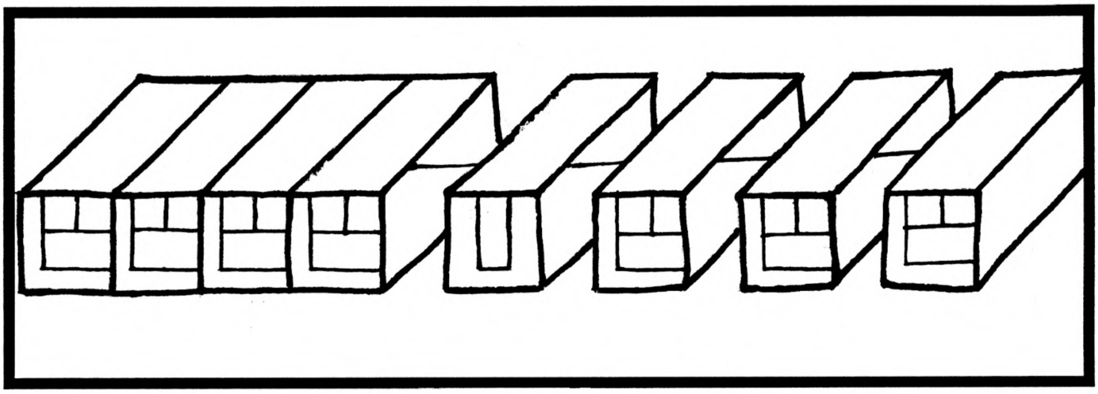


Figure 5: Divisible Facilities

(Reproduced from Educational Facilities Laboratories, 1964, p. 18)

Demountable Facilities

Unlike the earlier structures, demountable structures (Figure 6) are composed of components that are assembled at the site. The components, being recoverable and factory made (e.g., curtain wall modules), can be assembled at site and later moved in even larger sections. The floor may be planned as recoverable and moved with the structure or may be considered as expendable. Buildings of almost any size, shape, or complexity can be planned by combining these various elements. Although this allows for greater flexibility in design and space, it makes them more expensive and slower to build than the other types of relocatable facilities.

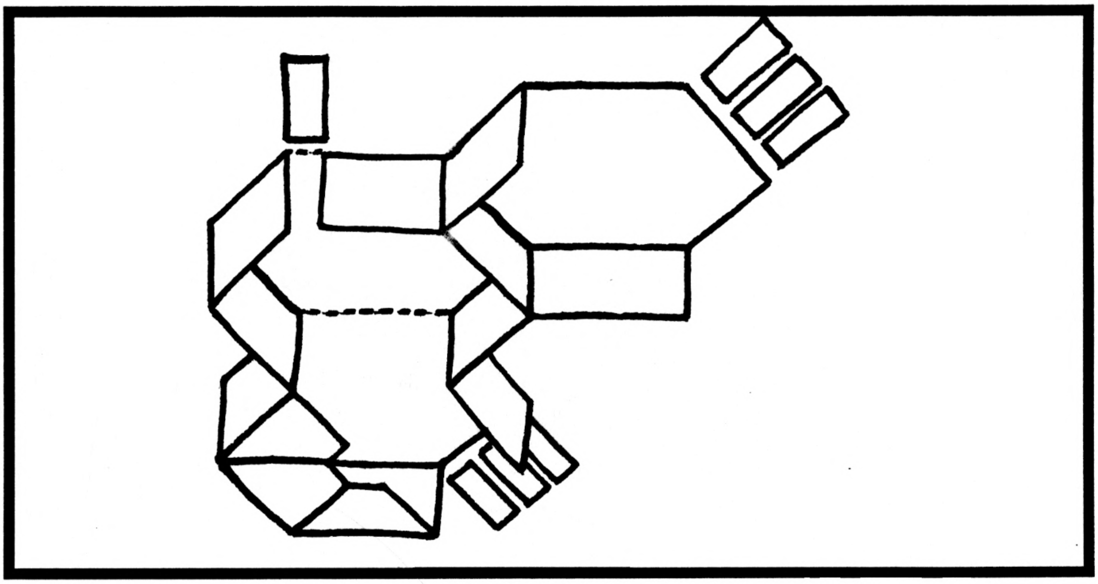


FIGURE 6: Demountable Facilities

(Reproduced from: Educational Facilities Laboratories, 1964, p. 19)

Study of Documented Relocatable Units

Due to the space and size limitations, and lack of complexity in design (except for the demountable facilities), in the 1960's, some schools and manufacturers devised innovative features that improved the use, effectiveness and appearance of relocatable classrooms. Some examples are described below.

Divisible-Mobile Units in Chicago

Some of the divisible-mobile units built on different school sites in Chicago were constructed of two sections of 10' x 45', staggered to create recessed steps and a covered entry (Figure 7). Windows were regrouped to improve utilization of interior wall space and improve exterior appearance (Figure 8).

The overall design showed: 1 teaching wall; 2 chalkboard; 3 teacher's center; 4 teacher's wardrobe; 5 student wardrobe; 6 entry; 7 resource/ project center; 8 furnace space; 9 storage; 10 tackboard/display walls; and 11 rest rooms (Figure 9).

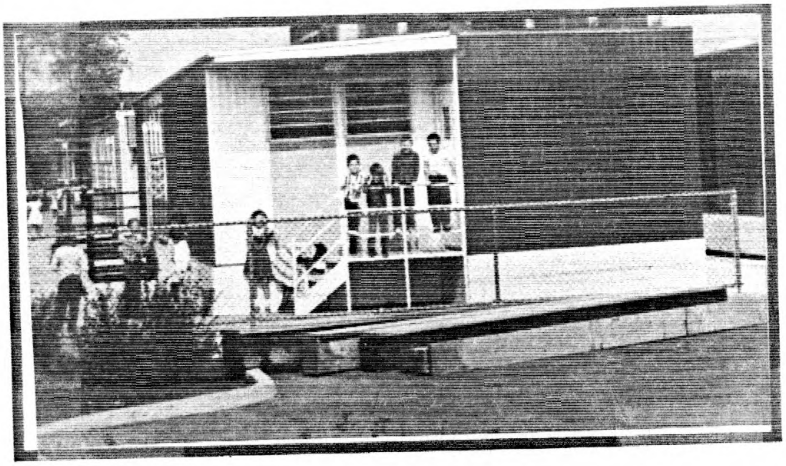


Figure 7: Staggered building sections allows for recessed steps and covered entry.

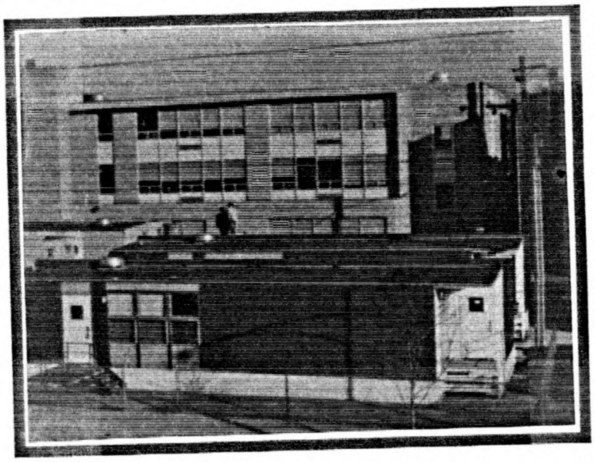


Figure 8: Exterior appearance of units improved by alignment of windows.

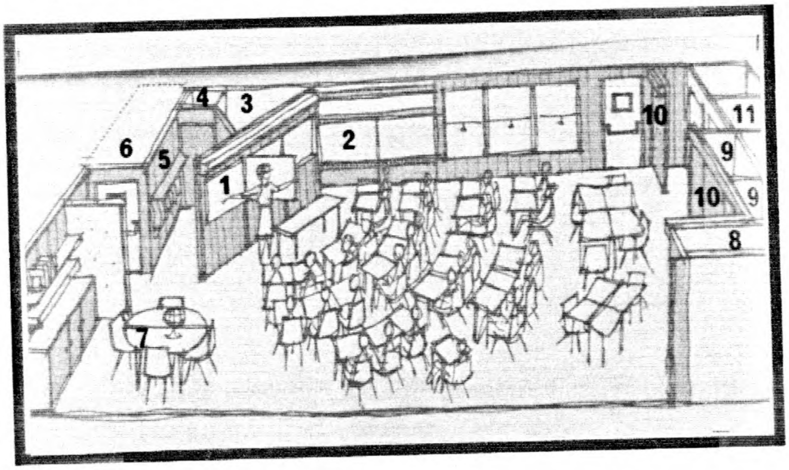


Figure 9: Sectional view of interior spaces.

(Reproduced from: Educational Facilities Laboratories, 1964, p. 26)

Special lighting was installed to improve illumination (such as over tack/chalkboards), and to create special atmosphere and improve lighting conditions necessary for task jobs (such as in resource/project area) (Figure 10).

The teaching wall featured swinging chalkboard panels, controlled chalkboard lighting, and sliding wall to close off teacher's center and provide extra writing surface (Figure 11). Chalkboard, tackboard and bookshelf were all adjustable to student's needs (Figure 12).

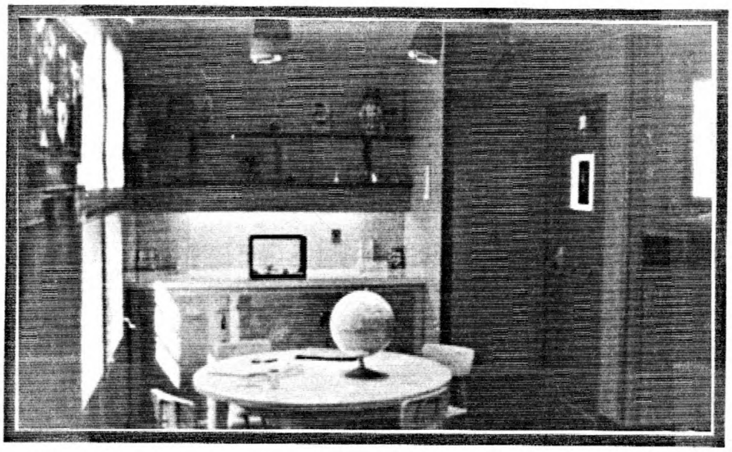


Figure 10: Lighting and furniture used to emphasize Resource Center.

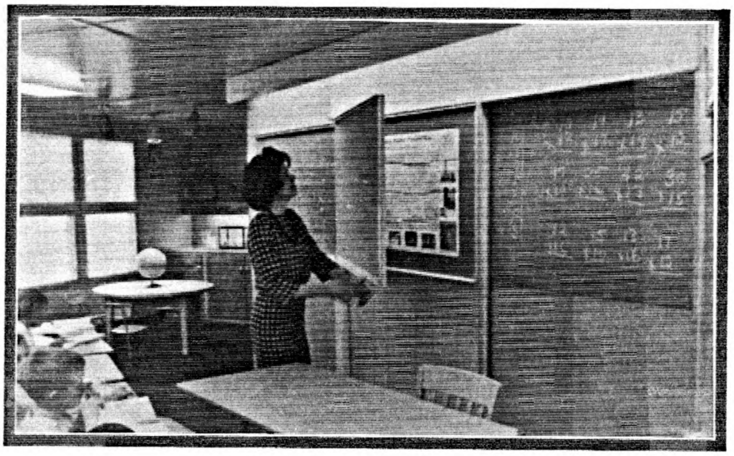


Figure 11: Multi-functional Teaching wall.

(Reproduced from: Educational Facilities Laboratories, pp. 26, 27)

Figure 12: Adjustable lighted chalkboard.

(Reproduced from: Educational Facilities Laboratories, p. 26)

Divisible units in Newark, Ohio.

In Newark, double classroom units consisting of nine modules were threaded onto double H-beam foundations to create an enclosure of 32' x 72' (Figure 13). The overall planning considerations were similar to those employed in Chicago (Figure 14). A six-inch raised platform with raised, lighted chalkboard panels, besides improving sight lines and visibility, served as a partition or divider to a semi-private teacher's center (Figure 15). The general layout showed spaces to work in groups (such as in the resource center) as well as spaces for individual study.

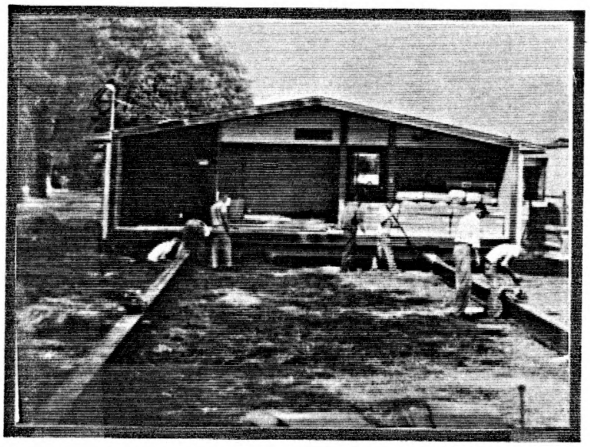


Figure 13: Placement of the divisible units on the foundation at Newark.

(Reproduced from: Educational Facilities Laboratories, 1964, p. 29)

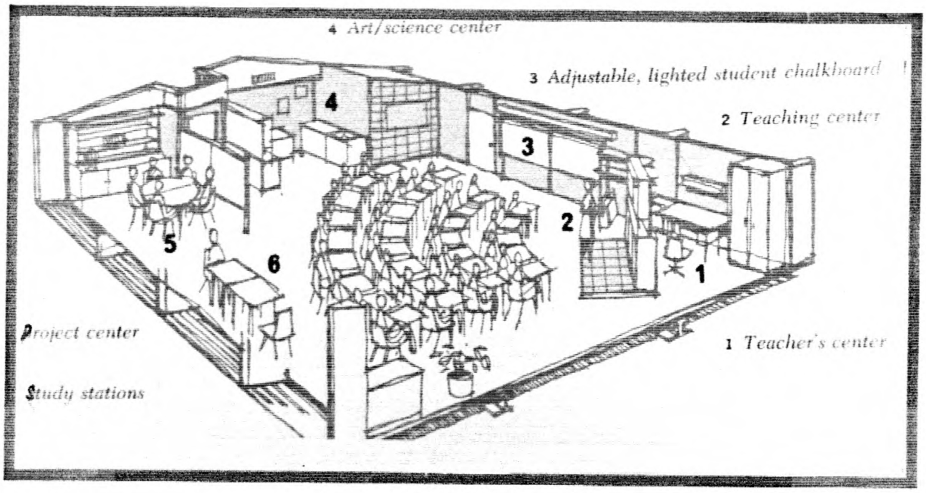


Figure 14: Sectional view showing overall planning.

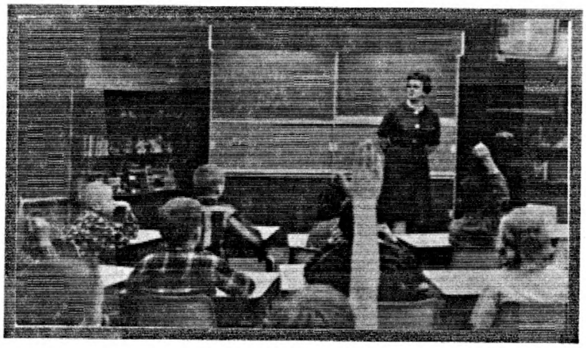


Figure 15: Teaching Center

(Reproduced from: Educational Facilities Laboratories, 1964, p. 30)

Demountable Classrooms in Minneapolis.

In Minneapolis, demountable structures with an enclosed area of 1400 sq. ft., were erected comprising of 16 common-sized triangular panels, mass produced, pre-finished, and shipped flat to the site (Figure 16). High-impact structural plastic sheathing was used on interior and exterior side walls, and tinted plastic was used to reduce glare on fixed sash (Figure 17). As in Newark, the teaching center comprised of special lighting for raised platform and chalkboard/display panels served as a room divider between the general classroom and teacher's work center. The stacked, sliding panels offered the teacher a quick choice of movable chalkboard, display panels, or rigid, translucent material for rear screen projection (Figure 18). The furniture layout showed the use of movable wardrobe cabinets, which besides being innovative and flexible storage units, were backed with tackboard or pressure adhesive chalkboards for students' use. These units efficiently divided, and hence provided privacy to, the resource/ project center (whenever used) from the general classroom (Figure 19).

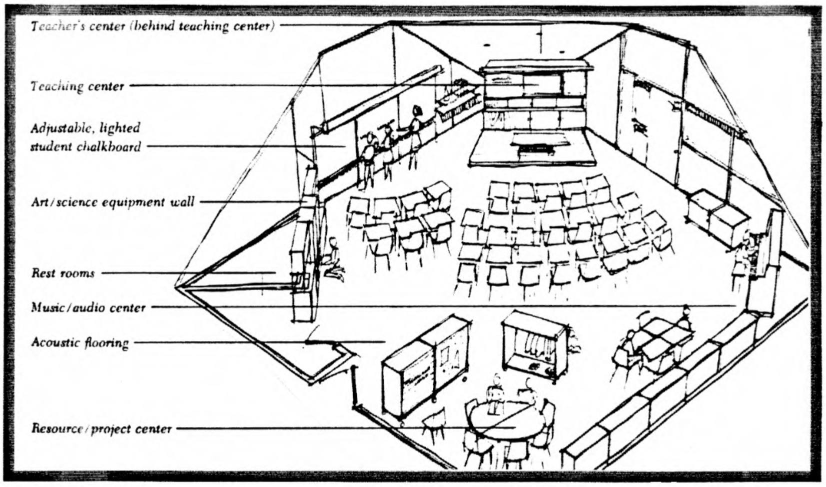


Figure 16: Sectional View showing overall planning of a demountable classroom in Minneapolis.

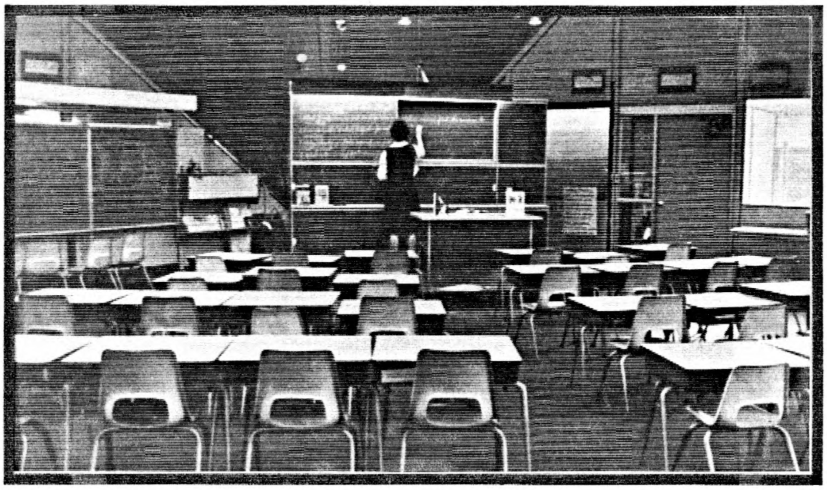


Figure 17: View of the interior layout.

(Reproduced from: Educational Facilities Laboratories, 1964, pp. 33-34)

Figure 18: Teaching Center.

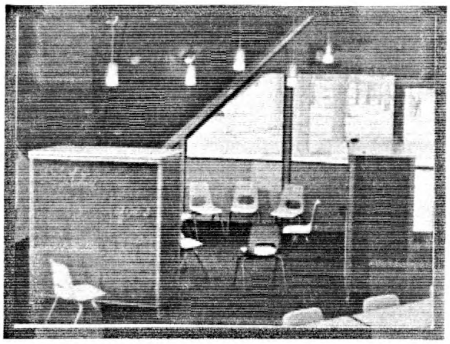


Figure 19: Resource Center.

(Reproduced from: Educational Facilities Laboratories, 1964, pp. 34, 35)

Thus, in spite of using a standardized structural system (divisible-mobile), the Chicago units were considerably changed by staggering the units to create a covered porch. The regrouping of the windows not only improved the efficiency of the interior spaces, by increasing the useable wall area, but also improved the exterior appearance. In Newark, too, the emphasis seems to have been on using more wall space for display. In Minneapolis, however, due to the nature of the construction, there are a fair amount of windows with a view to the outside. This is consistent with the research findings that the amount of windows desired in a space are predicted by knowing how important specific factors are to individuals in the space (Butler & Biner, 1989).

Due to the lack of space, a horseshoe or circular arrangement was not used in any of the above three examples, however, the crescent shape used therein could have been effective in verbal interaction in the given conditions, and is certainly better than the standardized column and row formation. The design features also showed a de-emphasis of the teacher's presence by the provision of a separate Teacher's Center in the corner. In Newark and Minneapolis, though, the use of a raised platform for the teaching center shows that detailed planning was considered for improving viewing and legibility. Special lighting as seen in critical visual areas such as chalkboards and tackboards must have enhanced the emotional environment of children, beside improving illumination. Adjustable focused lighting, as used in the resource/project area, must have emphasized the area and created special atmosphere. The use of a carpeted floor shows that consideration was given to the absorption of sound in order to improve the acoustics.

Divisible Prototypes in Pittsburgh.

In Pittsburgh, prototypes of two building types - a divisible steel structure (site erected) based on a plan of transverse sections 8' x 28'; and a demountable concrete structure in split top-and-bottom, transverse sections of the same size were designed.

Classroom units for the Phillip Murray Elementary School were constructed of the prototype with steel sections. Light gage mullions were load-bearing and accepted both exterior panels and interior partitions. Open web joists were doubled up and bolted together, as were the 8" floor channels, to allow disassembly (Figure 20). Floor framing sat atop concrete block footings. If ever the units needed to be moved, the 8'0" section would be simply jacked up, a low-boy run underneath and the section pulled away (Figure 21). The L-shaped planning with movable partitions allowed flexibility, enabling varying sizes of classrooms to be accommodated. A mechanical core was concentrated in a single unit, used as the entry as well (Figure 22).

A 4 classroom addition to Homewood Elementary School in Pittsburgh was formed of the second prototype using sections of integrated precast concrete units comprising of columns, slabs, beams and walls (Figure 23). The units were assembled as if a table rightside up were stacked atop another table upside down. The perimeter was windowless to minimize damage from vandalism; however, windows faced onto a court (Figure 24). Thus, this could have led to improvement in pleasantness of student's moods (Ahrentzen et al, 1982), and also reduced streetside distractions.

Both the designs showed that relocatability had been given careful thought without comprising with the design and space allocations. The use of movable partitions also demonstrated that flexibility and the possibility of shifting grades were considered.

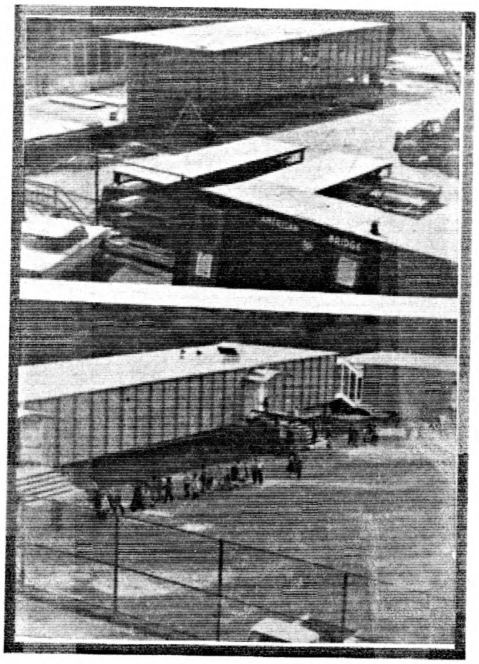


Figure 20: The components come apart

in 8' sections.

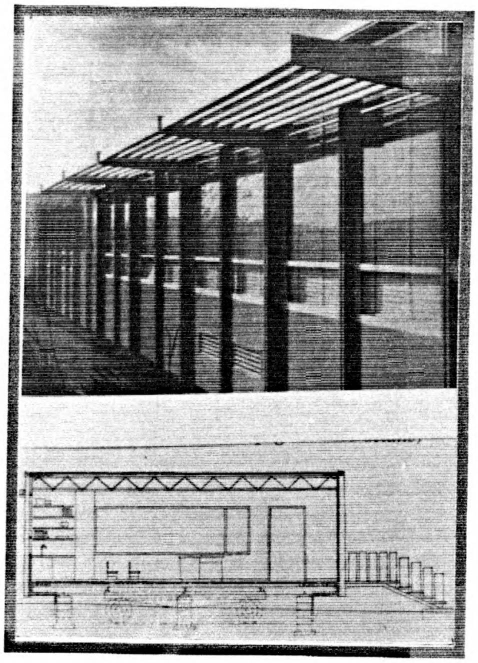


Figure 21: Steel units showed ease

in removal from site.

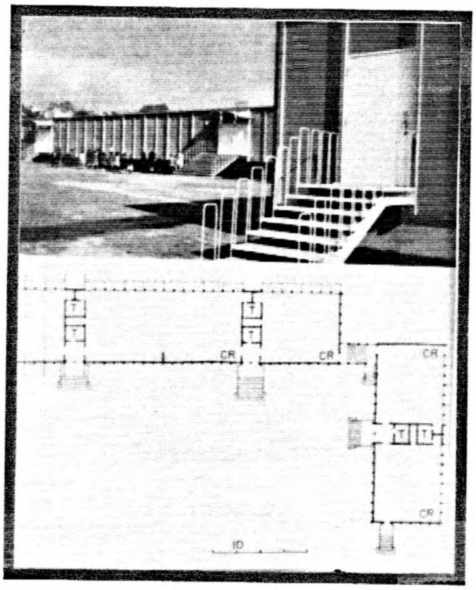


Figure 22: L-shaped plan with mechanical core and entry.

(Divisible steel structures used for the Phillip Murray Elementary School)

(Reproduced from: Architectural Record, Feb. 1963, pp. 177, 182)

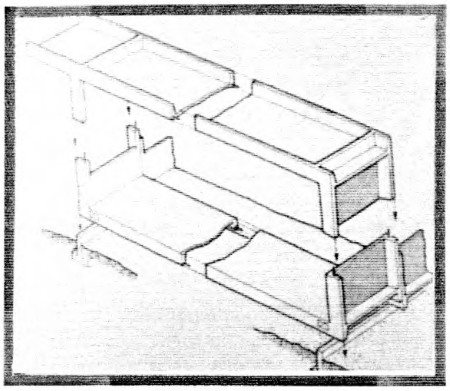


Figure 23: Demountable unit with its component parts in Pittsburgh.

Figure 24: External appearance

of the above units, with(out) windows.

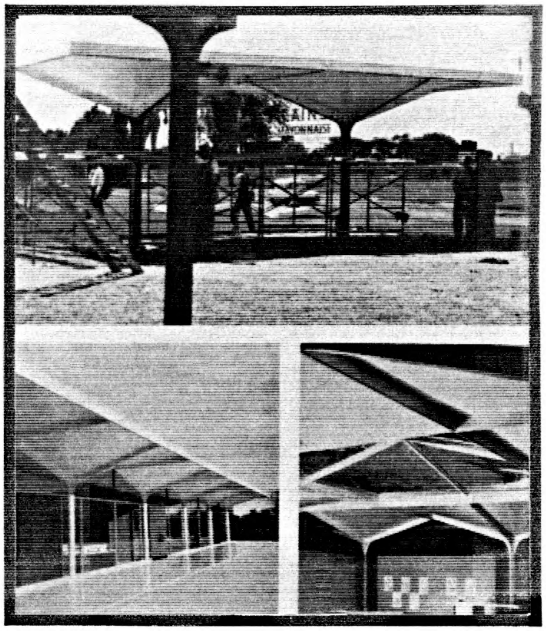


Figure 25: Prototype M.I.T. unit with

potential interior/exterior designs.

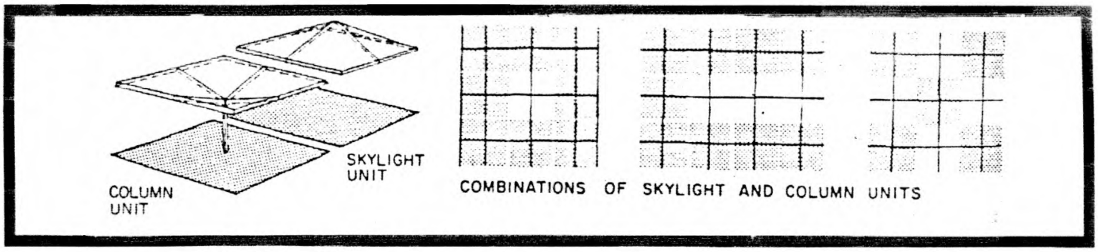


Figure 26: Combinations of skylight and column units developed by M.I.T.

(Reproduced from: Architectural Record, Feb. 1963, pp. 178, 183, 184)

Demonstration demountable classroom developed by M.I.T.

The Departments of Architecture and Civil Engineering at M. I. T., under the sponsorship of Educational Facilities Laboratories, Inc., developed a demonstration demountable school room system. The umbrella-like roof panels were of plastic-plywood sandwich construction, mounted on steel pipe columns. The columns served additionally as drains and as a means of connecting wall components through 4 vertical fins (Figure 25).

Skylit units of translucent plastic were dropped in between column units. On three of the four walls, aluminum-faced, plastic core sandwich panels were fitted between columns, underneath a horizontal strip of gray glass (Figure 26).

These units show that relocatable classrooms need not be of the standardized shape and appearance. Use of the skylight units increased the illumination and also gave a special and dynamic interior, demonstrating that with careful detailing light can be used effectively. Expansive use of glass also showed that view to the outside was considered important by the designers to the pleasantness of the students' moods.

CASE STUDY OF RELOCATABLE UNIT AT WOODROW WILSON ELEMENTARY SCHOOL, MANHATTAN, KS

Woodrow Wilson Elementary School in Manhattan represents a typical school in Kansas, that has responded to the issue of increasing enrollment by installing a relocatable unit to serve as two classrooms. This particular unit was a result of a bid let in September 1989 by the School Board for the provision of foundations, steps and utilities for relocatable units to be located at Woodrow Wilson, Ogden and Lee (two units) Elementary schools and Manhattan High School of the unified school district 383 in Manhattan, Kansas. The drawings had to be consistent with the given guidelines and requirements as stated in the School Standards (See Appendix A). The architects (Bowman, Blaske and Associates) provided a relocatable unit of two divisible-mobile sections to form two classrooms, a toilet for each of the sexes and storage areas (Figure 27 shows the plan for Woodrow Wilson).

The unit is constructed by joining two sections of approximately 14'0" x 60'0" to create two classrooms of sizes 22'6" x 27'0" (approximately); with the intermediate area providing a space for the utilities and storage. The unit is provided, on the side facing the playground, with one separate entry for each classroom on the extreme ends, and one entry each with a common porch towards the center of the unit (See Figure 28).

The unit does not have any innovative design characteristics, yet, according to the teachers, it seems to have provided a workable solution to the problem of additional classroom space. Although the classrooms presently serve third graders, for one year they were being used by sixth graders, indicating the flexibility in the design.

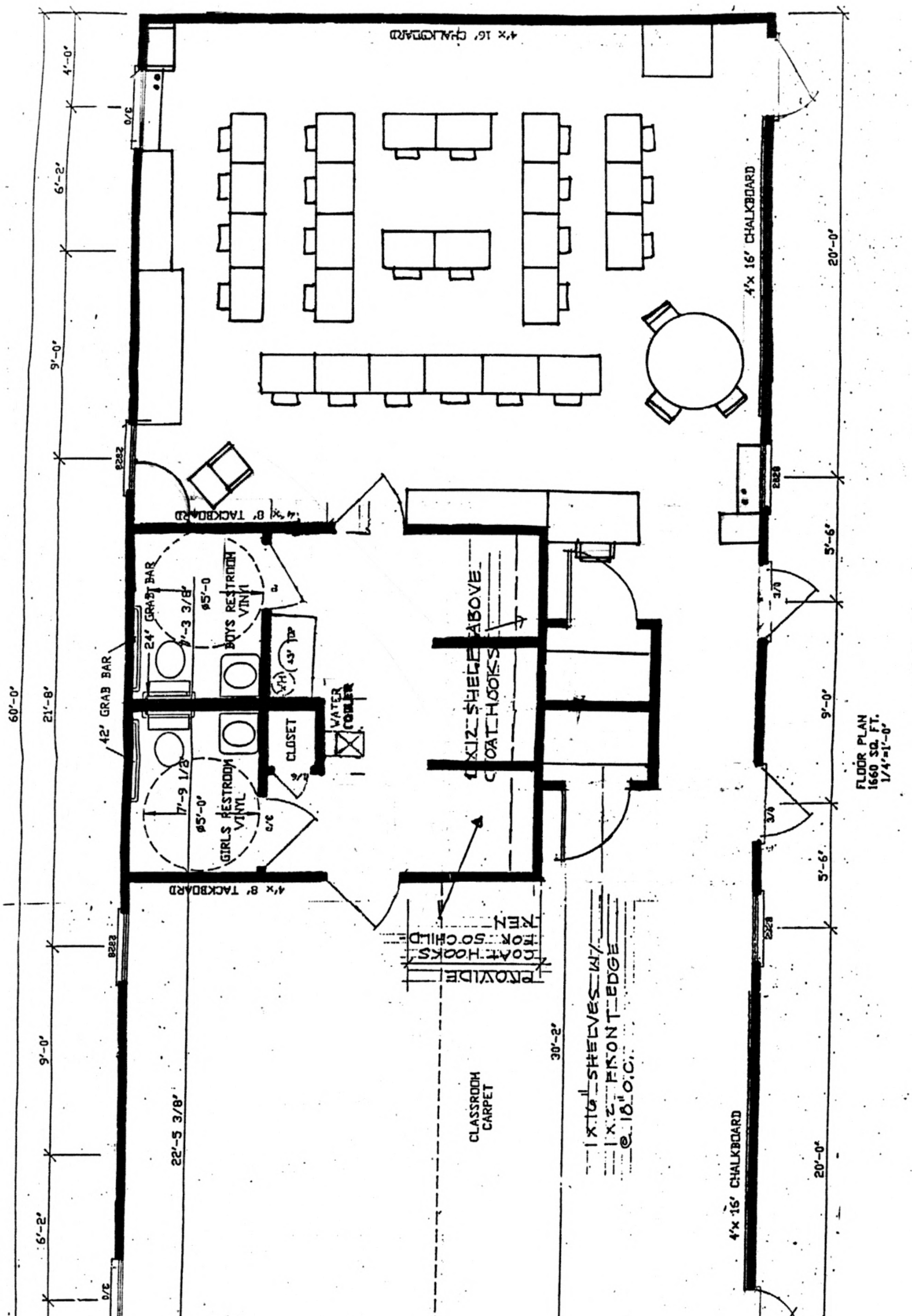


Figure 27: Plan of the relocatable classroom with interior layout of one of the classrooms

(Source: Bowman, Blaske & Associates, Architects, Manhattan, KS.)

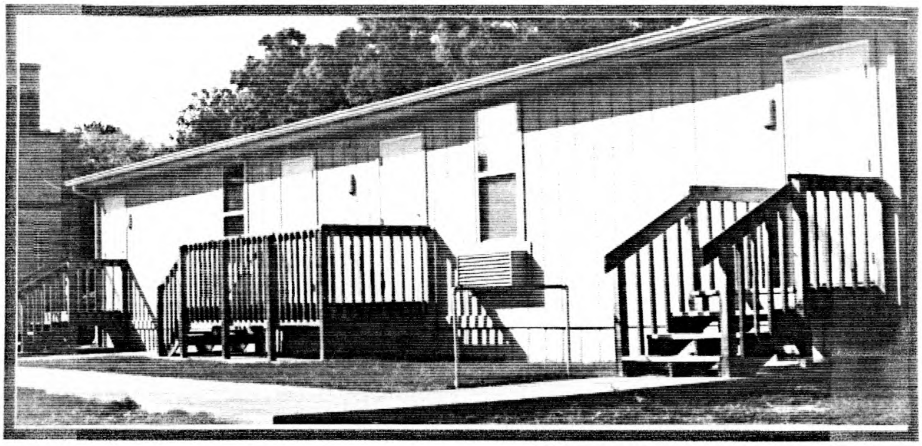


Figure 28: Entrances to the relocatable classrooms.

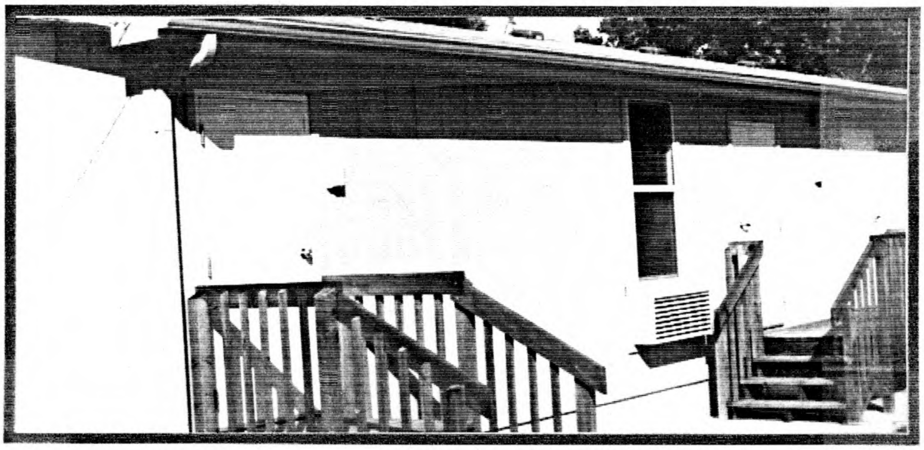


Figure 29: Entry exposed to the elements and with no handicap accessibility.

Figure 30: No connection to the main school building.

None of the entrance porches is covered, and the common complaint of the teachers was that this exposure leads to the accumulation of snow on the steps during the winter months, making it a safety hazard (See Figure 29). Also, at the time of the construction, the School Standards did not require any handicapped access, and no provision was made for a ramp. According to the teachers, this has proved to be an irritating problem for parents with disabilities. This problem has not been remedied as yet due to the absence of any handicapped child in these particular classrooms (Figure 29). Interestingly, however, the toilets do have handicapped accessibility.

There also is no connection to the main school building in the form of a covered walkway, giving the unit a separate and distinct identity (See Figure 30). The psychological impact to the children within these classrooms of such an isolation remains unexplored. However, the teachers preferred teaching in the relocatable classroom, against a regular classroom, as it provided no interference or distractions from other classrooms, was acoustically better for teaching, and did not have the common problem of choked corridors at break-times and at end of class periods. The only problem of this isolation, they felt, was the apparent lack of knowledge of activities in the main school building. Due to the absence of speakers connected to a central audio system, the classrooms have no clue of fire drills or any other emergencies, unless informed by telephone. This problem, however, can be avoided by the installation of speakers.

The seating arrangement does not have any special form, but shows the presence of a horseshoe in combination with a few chairs in the central portion facing the main chalkboard (See Figure 31). Although the design appears to be a direct response to "fit" the available space, on the basis of the available research, it can be said to be conducive to verbal interaction.

Maximum usage of space also can be seen in the presence of bookshelves, and storage cabinets with overhead projector - all backed up against the wall (See Figure 32). Despite this lack of space, the teacher has managed to retrieve a small corner to place a rocking chair for relaxation (See Figure 33).

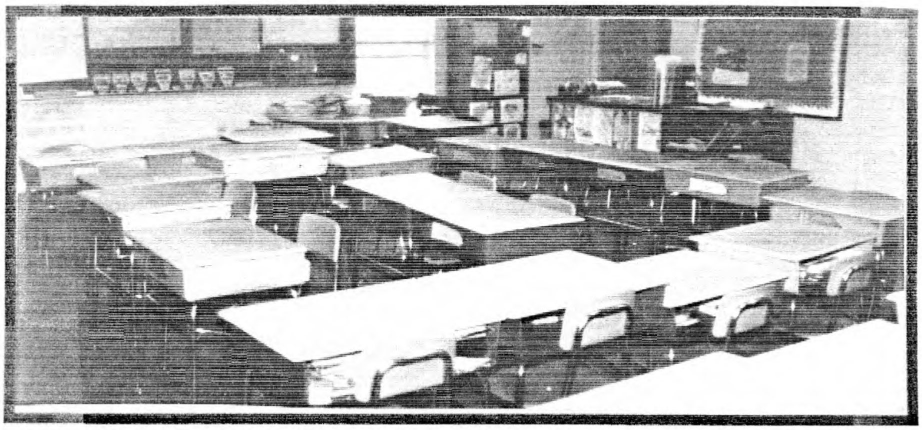


Figure 31: General arrangement of the classroom.

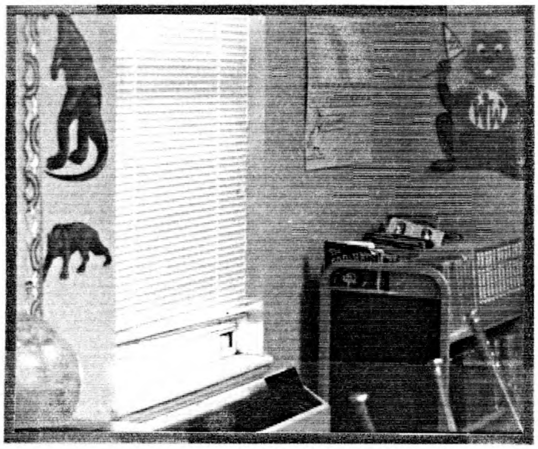


Figure 32: Backed-up storage.

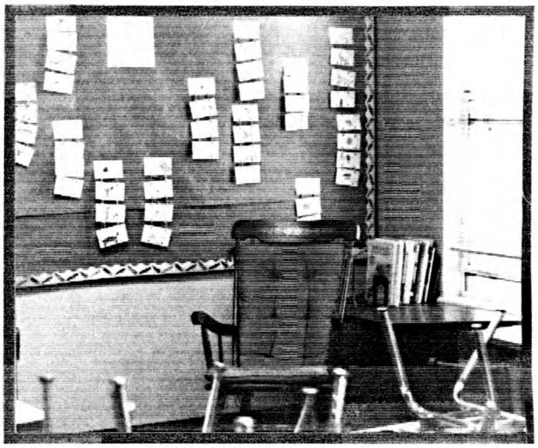


Figure 33: Teacher's corner.

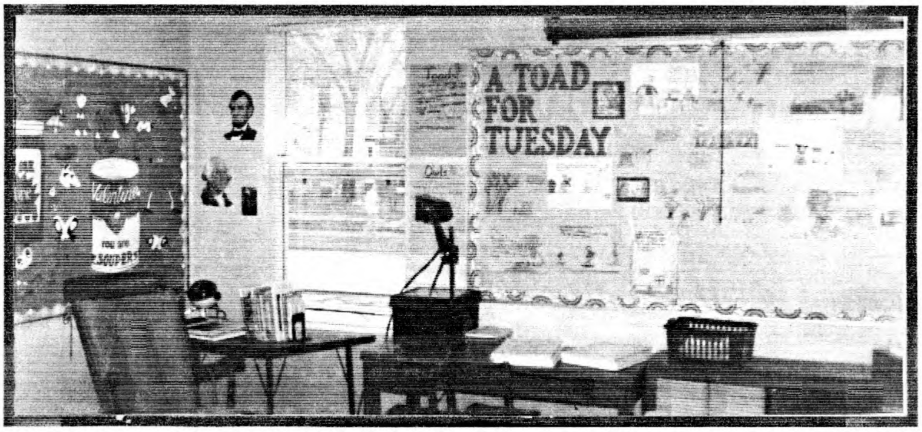


Figure 34: Display boards.

All the walls are used as either display areas or tack/chalkboards. Although the classroom has neutral beige colored walls, the display boards are in shades of yellow and blue with children's creative work displayed on them. The colors do not appear to have been chosen with any particular regard to the psychological impact (to the children), but as an effective background to highlight displayed work (See Figure 34).

The windows to each of the classroom are not meant to provide any view, but were designed to meet the minimum requirements as stated in the School Standards, the justification being that the extra wall space can be put to better use as display area. Below two of the windows on opposite walls are placed the heating/air-conditioning units that allow easy control of the temperature, and hence the comfort levels that can affect children's behavior in the classroom (See Figure 35).

The teachers have a work table and chair near the central entrances, in full view of the class (See Figure 36). There is no special semi/ private Teacher's Center as seen in the documented case studies of the preceding pages. There is a closet behind this area for the storage of reports, grades, etc. (See Figure 37).

There is a project/resource center consisting of a round table and chairs within the main classroom area of one of the classrooms (See Figure 38). Lack of space prevented the inclusion of this area in the other classroom despite the need for a space for projects and private reading/study. In fact, lack of enough space for storage and other activities was the common complaint of the teachers of both the classrooms. The storage facilities are centrally located within the unit for the common use of both the teachers and the students within the classrooms. There is open storage for coats, space for audio-visual trolley, and shelves for the storage of files, books, paper and other miscellaneous items (Figure 39). In the central space, there also is a sink for art and science projects, and a water cooler for drinking. In spite of the fact that it is meant to be used by adults and children, no provision was made for different size coolers or, at least, a combination type with two different levels. The difficulty caused to children and handicapped people can be

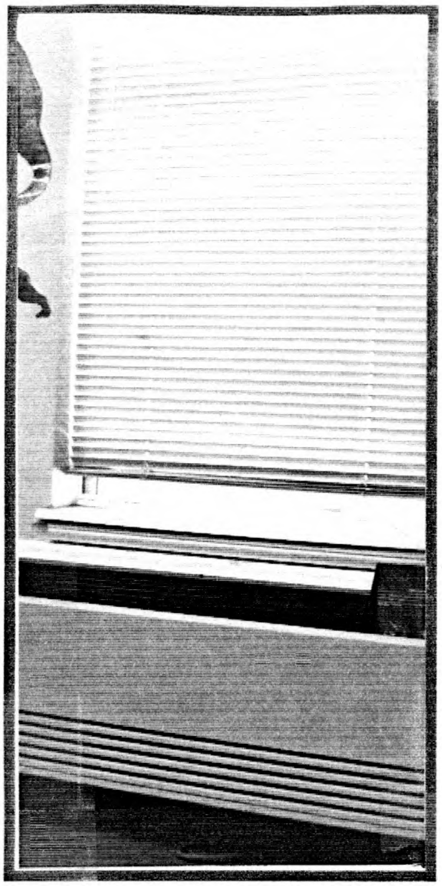


Figure 35: Window with unit ventilator.

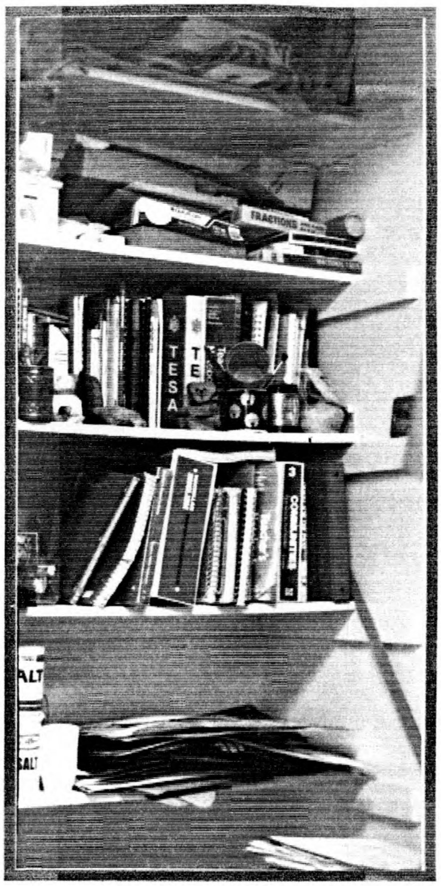


Figure 36: Teacher's closet.

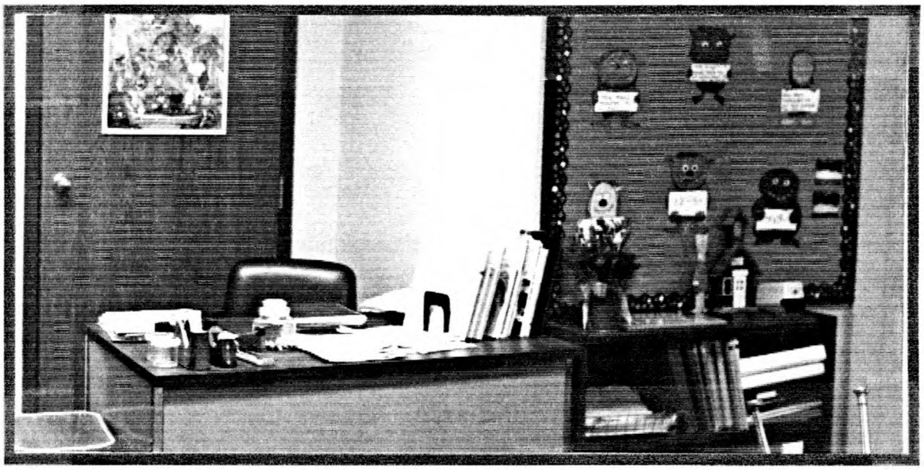


Figure 37: Teacher's Center.

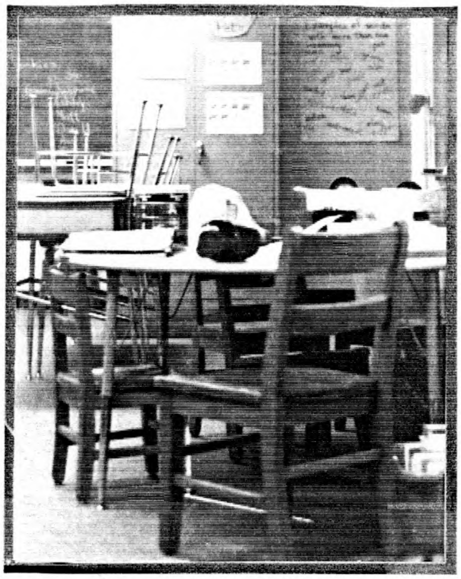


Figure 38: Resource Center.

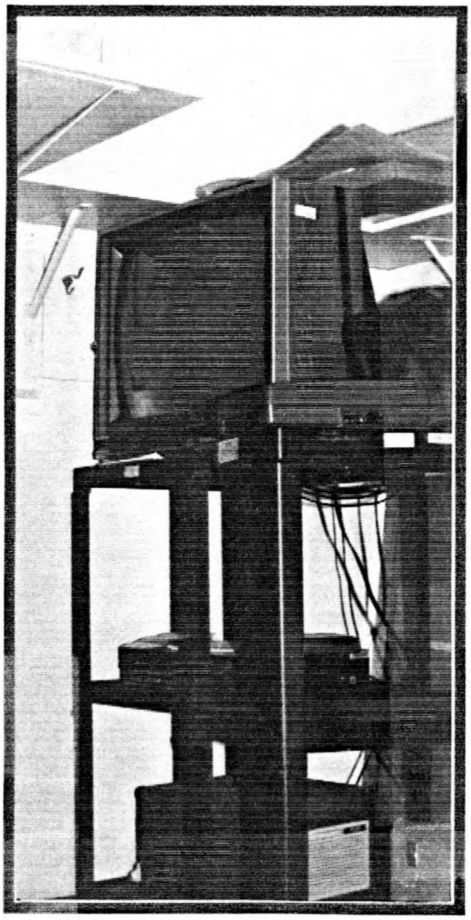


Figure 39: Storage Area.

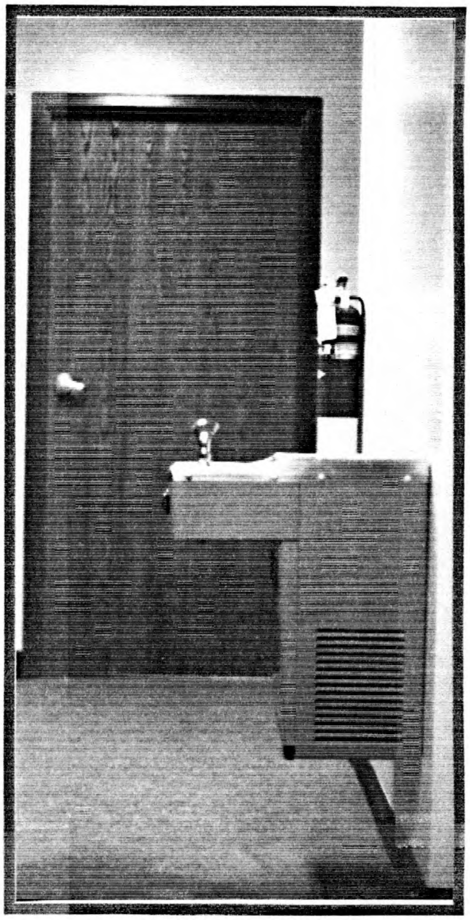


Figure 40: Drinking water cooler.

gauged from this inconvenient design (See Figure 40). There are two toilets in this central area, one each for each sex, for the use by both adults and children (See Figure 41). Due to the impracticality of providing separate toilets for children and teachers, the sizes do not meet the anthropometric sizes of children. In support of this lack of provision can be stated the argument that children should be able to adapt and interrelate their activities with the teacher's, which can allow them to become independent and resourceful (Osmon, 1973).

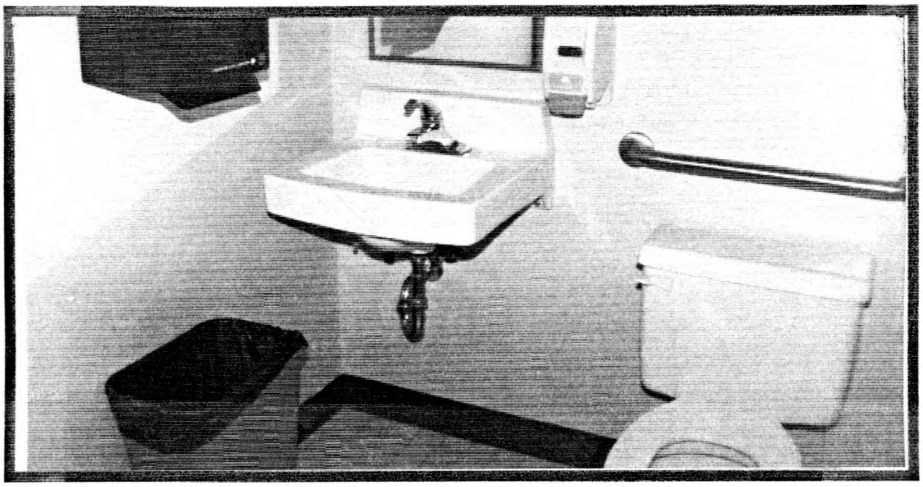
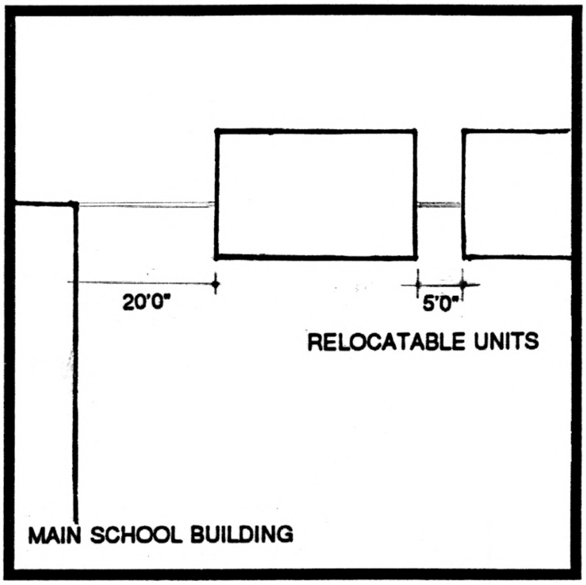


Figure 41: Toilet with handicapped accessibility.

Overall, the general planning features and furniture sizes show sensitivity to the children's sizes. The interior furniture layout also shows the teacher's innovativeness and her understanding of the effects of classroom arrangement on the verbal interaction and behavior of children. However, the lack of space prevented any mobile partitions or display boards from being used to separate the Teacher's Center or the Resource Center. There was no special lighting in any area other than the fluorescent lighting used to give 70 foot candles of light intensity at desk level, as mandated by the School Standards. The effect of focused lighting needs to be explored in the resource area and over the display areas. Despite the proximity of the two classrooms and the toilets, noise was not a problem in either of the classrooms. The control of heating through the unit ventilators also shows that temperature can be controlled easily within each classroom, avoiding any behavioral problems due to lack of comfort levels.

GUIDELINE 1:

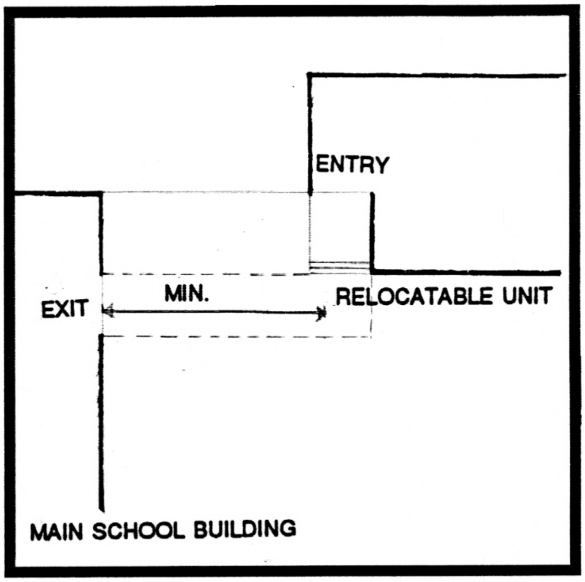
The minimum distance between the school building and the relocatable unit should be 20', and the clearance between any two units should be at least 5'.



RATIONALE:

The School Standards (1988) for relocatable classrooms state that the clearance between existing school buildings and relocatable classroom units shall be at least 20'0", and that the clearance between relocatable units shall be at least 5'0", provided the total square footage of units so located does not exceed 9,100 sq. ft.

Relocatable units, due to their 'temporariness' and in order to comply with fire safety regulations, are purposely located away from the main school building, without any connection whatsoever with the main building. This regulation does not allow much variation in the location of the units; however, they should not be too far out on the school grounds, which could make them seem isolated and remote.



GUIDELINE 2:

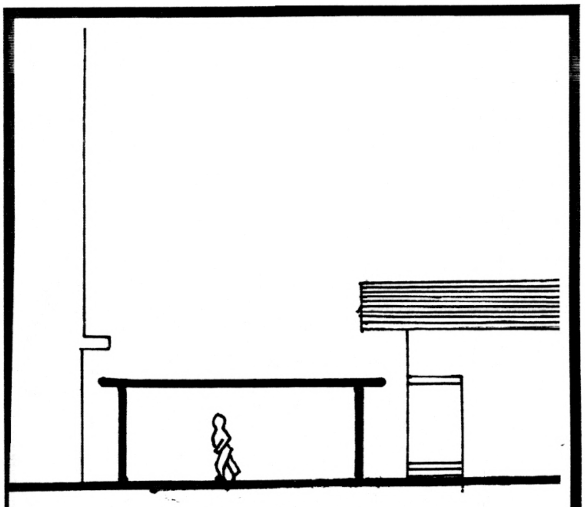
The entry to the units should be located at close proximity to the exits of the main building.

RATIONALE:

This guideline allows for easy access, gives a psychological feeling of proximity and provides minimum distance to be traversed during winter, especially when it snows or rains. It also is necessary to consider the orientation of the school, such that the relocatable unit does not face north, or fall in the "sun shadow" area leading to a micro-climate wherein it takes more time for the snow to melt.

GUIDELINE 3:

The use of a covered walkway (semi-permanent structure) that satisfies the school standards (of being detached) but gives the feeling of connection and transition is recommended.

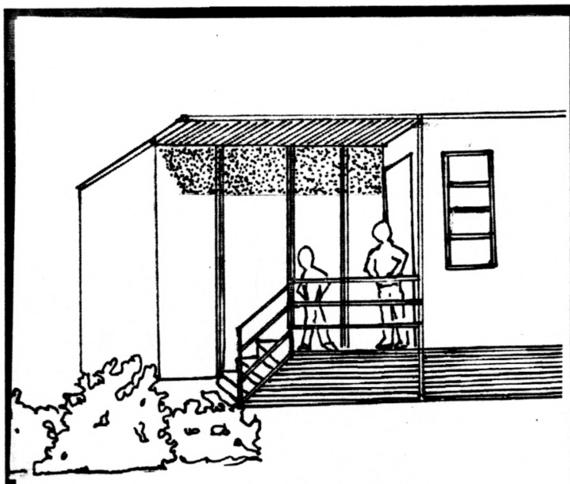

COVERED WALKWAY

RATIONALE:

This strategy provides a symbolic gesture by reducing the perception of detachment and separation from the main building. It also protects the children and the teachers from the natural elements.

GUIDELINE 4:

The external access to a classroom unit should be provided with a covered porch. Provision of anti-slip, sturdy material for the access is recommended. Concrete, steel or 2" lumber are good choices.



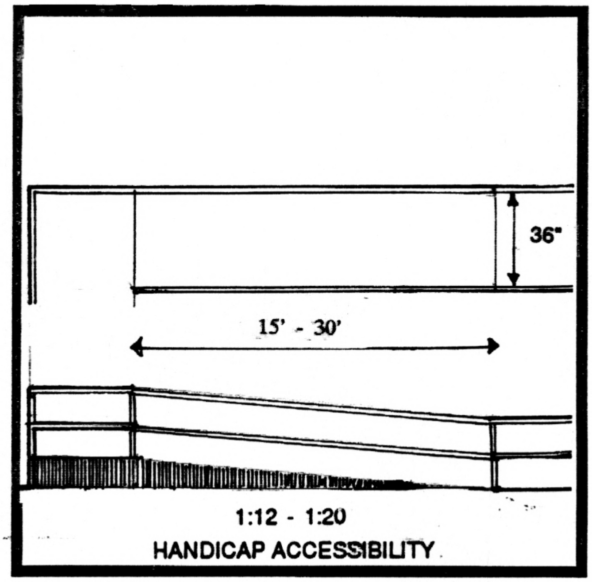
COVERED ENTRY PROVIDED BY STAGGERED ALIGNMENT OF BUILDING SECTIONS

RATIONALE:

The guideline is based on the School Standards (1988) and the case studies. The porch will serve the users as a transition place - a place to pause - before being exposed to the outside elements. Accumulation of snow on the porch and steps can prove hazardous and the access should be well protected.

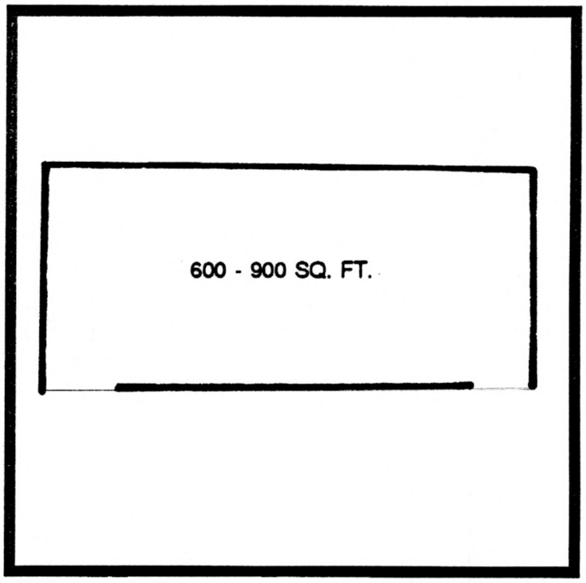
GUIDELINE 5:

It is required that facilities be made accessible and usable by persons with physical disabilities. Provisions to meet this requirement typically are met by at least one ramp to the unit.



RATIONALE:

The absence of a ramp can prove to be very uninviting and irksome for a handicapped child or parent. Beside complying with the Americans with Disabilities Act (1990), the standards state that handicap accessibility is mandatory as the lack of the latter can make the relocatable unit less usable and uninviting for the persons with physical disabilities. Daily entry into the unit for the child or even a visit by the parent can mean a lot of manoeuvering in order to access it.

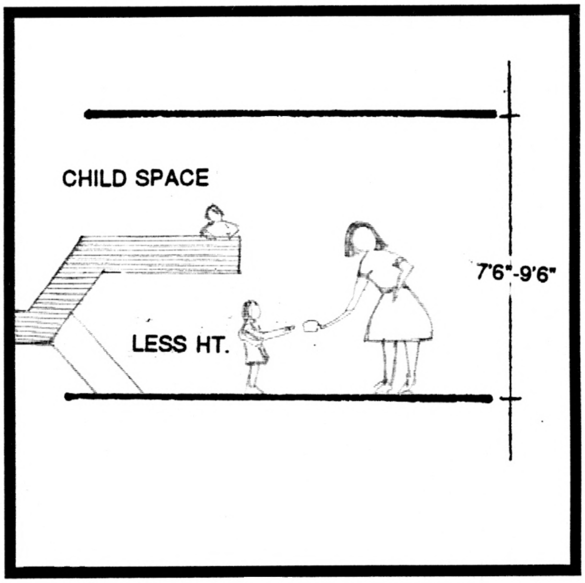


GUIDELINE 6:

Classrooms should have approximately 600-900 sq. ft. of floor space in relocatable units.

RATIONALE:

According to the study of the anthropometrics and the space required for each activity in an elementary classroom, the recommended area of 35 sq. ft. per pupil as proposed by W. W. Caudill (1954) is preferred. Although the School Standards (1988) recommend 600 sq. ft. as the minimum area, on the basis of the study of the relocatable units, the above area has been recommended for a class of 25 pupils.

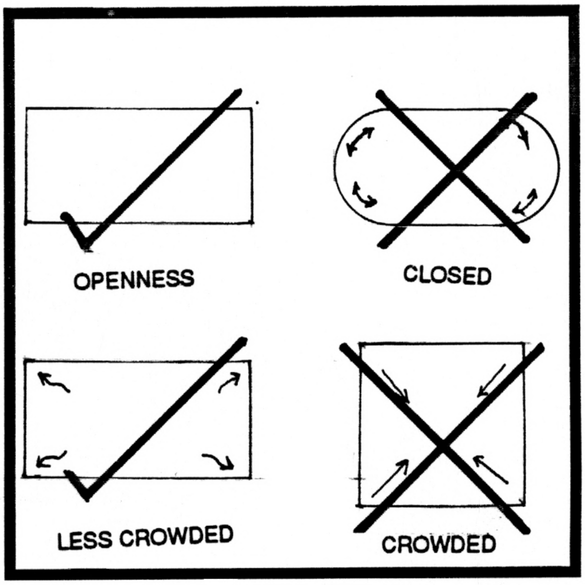


GUIDELINE 7:

Interior floor-to-ceiling height should be 7'6" - 9'6".

RATIONALE:

It is often misconstrued that a low-ceilinged space (with an allowance for enough height for the teachers) will create an intimate environment. However, an adult placed within such a space would appear excessively large to a child due to the adults' nearness to the ceiling and would result in a feeling of dominance (of size) by the teachers (Osmon, 1973, pp.20-21). The maximum 13' - 13'6" road-to-roof peak height - a restriction imposed by the logistics of transporting these units, necessitates a maximum interior ceiling height of 9'6". As the School Standards (1988) mandate a minimum of 7'6" ceiling height, intimate environments can be created within by designing alcoves or internal classroom structures, such as a loft, that creates lower ceilings in limited areas.



GUIDELINE 8:

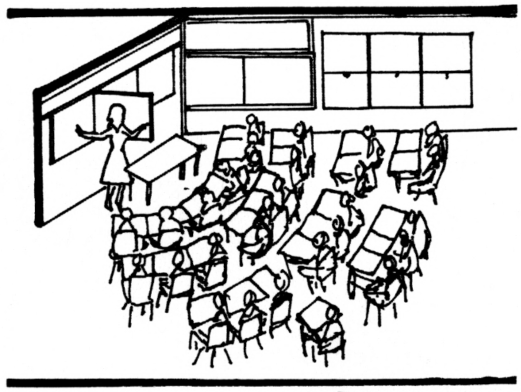
Rooms with high social or spatial densities should have well-defined corners and curved walls/partitions should be avoided. Classrooms should be rectangular in shape and not square.

RATIONALE:

Studies conducted by Rotton (1987) indicate that rooms with well-defined corners elicit less crowding than curved walls. Desor (1972) noticed in his findings that rectangular rooms seem to elicit less crowding than square rooms of the same size.

GUIDELINE 9:

The design of the classroom should facilitate main activities in the center of a room rather than in a corner or along a wall, especially in high social or spatial densities.



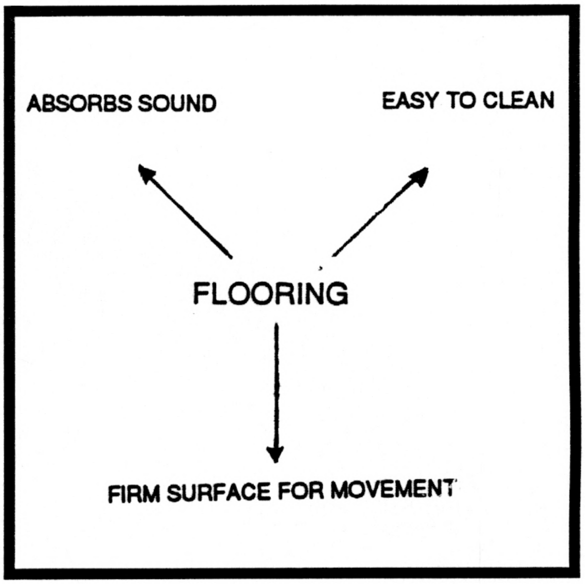
TEACHING AS THE FOCAL POINT OF A CLASSROOM

RATIONALE:

This form of placement elicits a perceived feeling of less crowding (Dabbs, Fuller, Carr, 1973).

GUIDELINE 10:

The flooring should be easy to clean after any wet spills, absorb sound and provide a firm surface for easy removal of furniture.



RATIONALE:

Instant removal of any wet spills (e.g. soiled feet from wet playground) will prevent germ retention. Thus, the floor should be easy to clean. It should also provide for easy movement and rearrangement of furniture and storage units to suit various activities. Special types of carpets and vinyl tiles, that have been found to deal effectively with this problem in health care facilities, could be considered. Also refer to Guideline 31.

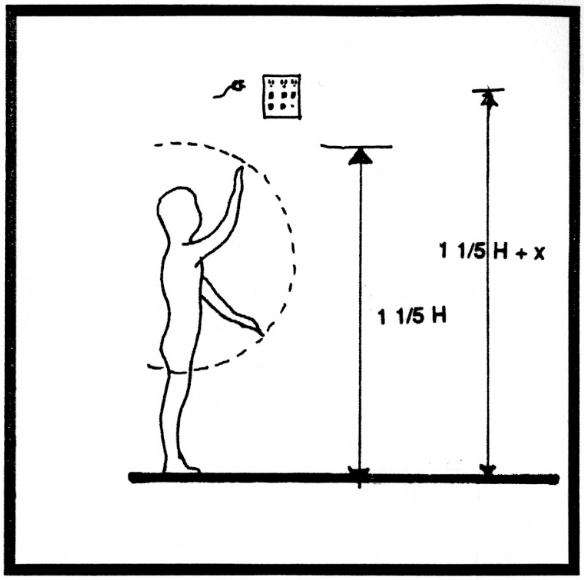

'MULTI-LEVEL' FLOORING

GUIDELINE 11:

Creation of raised and lowered areas (if any) should not be extensive, but if used to differentiate different activity areas, a ramp should be provided.

RATIONALE:

Extensive use of level change eliminates flexibility and the flat, open area needed for group activities. In addition, the Americans with Disabilities Act (1990) requires that all areas be handicap accessible and use of level changes mandates the provision of a ramp as well. Thus, a ramp eliminates places to stumble, allows for easy movement of furniture and most importantly, provides handicap accessibility, especially in a tight area like that in a relocatable classroom.

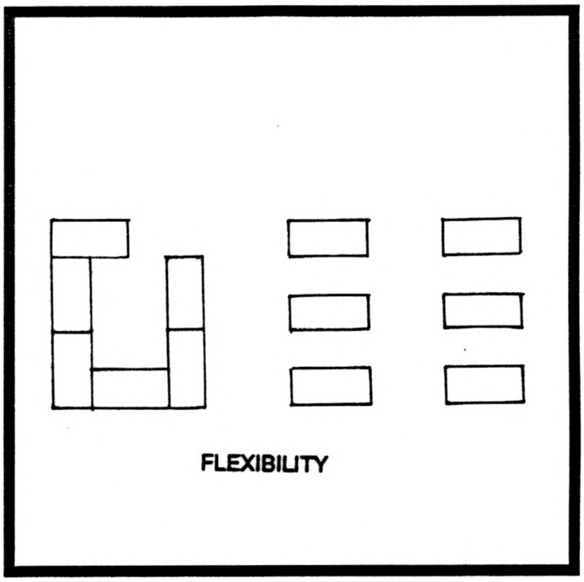


GUIDELINE 12:

Units should have convenient electrical outlets, placed at approximately 10' on centers along the wall perimeter. They should be shock proof and, as far as possible, not be easily accessible to children.

RATIONALE:

The School Standards (1988) mandate a minimum of 10 convenience outlets, placed at least 10' on centers along the wall perimeter and located at least 15" above the floor. Given the flexible nature of an elementary classroom and the high use of audio-visual equipment, electrical outlets should be placed conveniently. However, safety should also be considered and hence, should be shock proof and not be easily accessible to the children.

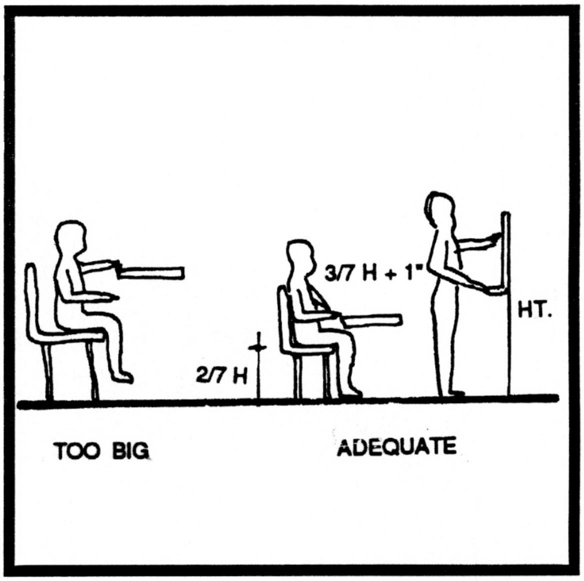


GUIDELINE 13:

The furniture should be easy to move and manage. The furniture should encourage efficient grouping and versatile use.

RATIONALE:

Given the high versatility of activities in a classroom that may involve rearrangement of furniture, it should allow for maximum flexibility. The changing demand for storage and student seating arrangement, prompted by the changing size of the class or the changing grade in the unit or the varying class schedule and requirements, makes the use and movement of furniture a crucial decision. Although there is no conclusive research on the influence of circular, square, horseshoe, as against polygonal arrangements of desks and chairs; there is a popular conviction that these arrangements are more conducive to verbal interaction. This is based on studies in other environments wherein greater interaction has been found between people when the space is rearranged such that they face each other (Bell et al, 1990).

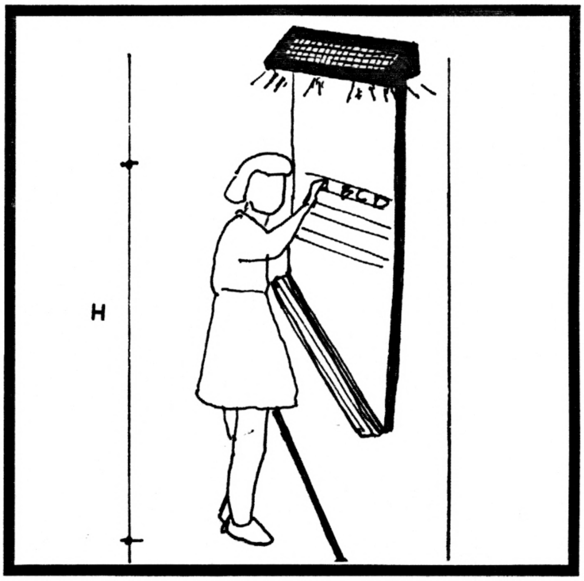


GUIDELINE 14:

The sizes of the furniture should meet the anthropometric sizes of students of a particular grade.

RATIONALE:

The classroom and the shared spaces in the school cannot function properly if the spaces are too small for individuals or groups of children, or if the shelves are too high to reach and seats too small to sit in with comfort. There also is "a strong relationship between improperly designed furniture and accidental death and injury to children" (Panero, J. & Zelnik, 1979, p. 105).



GUIDELINE 15:

a) *Chalkboards, tackboards and bookshelves should be adjustable to students' height specifications.*

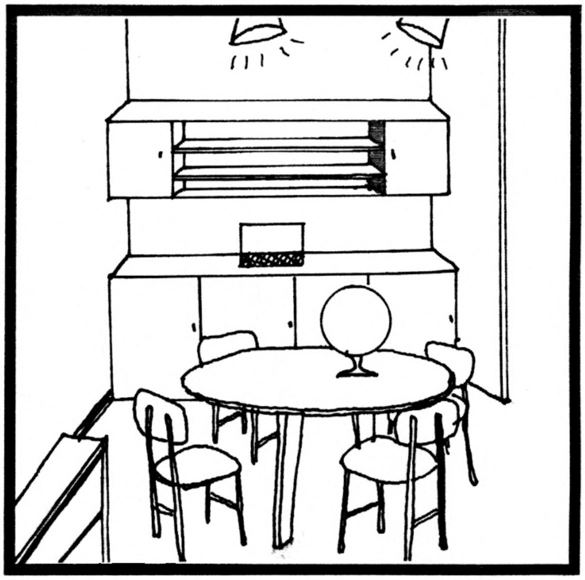
b) *All the tackboards, chalkboards, display areas should have special (focused) lighting.*

RATIONALE:

a) *Existing research on relocatable units shows that furniture that can be better adjusted will allow more flexibility and meet the anthropometric sizes of students of different grades without changing the existing furniture.*

b) *This is to ensure better visibility and highlight any areas, if necessary.*

RESOURCE/PROJECT CENTER



GUIDELINE 16:

a) *Each classroom should be provided with a semi-private Resource/Project Center and should be equipped with a table and 5-6 chairs for group work, shelves, display boards and storage cabinets.*

b) *Special lighting should be provided in the Resource Center.*

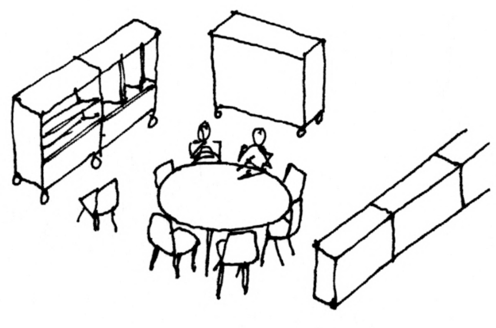
RATIONALE:

a) *The semi-privacy ensures group work without disturbing the rest of the class. As project work requires group co-operation, planning of the seating should be socio-petal. A round table could be used as it allows flexibility in the number of students working at a given time as compared to a polygon.*

b) *The special task work or activity requires highlighting or focusing for better visibility. The area may be de-emphasized when not in use.*

GUIDELINE 17:

The Center should be partitioned, if at all, by shelves, movable storage cabinets or sliding displayboards / tackboards or by change in level of flooring or/and ceiling.



FLEXIBLE PARTITIONING

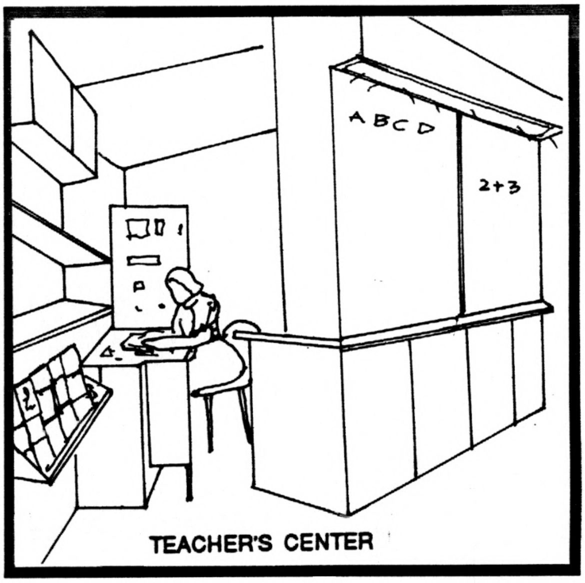
RATIONALE:

A relocatable classroom seems always short of much-needed space, and the case studies and literature review have shown that every available space is put to use. The above arrangement will make the classroom more efficient and serve the dual purpose of partitioning and as a storage unit or a displayboard. The cabinets can be shifted to increase the area for class participation in a group project or for a demonstration/display. The change in height creates a more dynamic atmosphere and differentiates the activity areas.

GUIDELINE 18:

a) Each classroom should have a semi-private Teacher's Center and should be furnished with a desk, a chair, bookshelves and cabinets for storage.

b) The Center should be partitioned, if at all, by shelves, storage cabinets or sliding chalkboards or tackboards.



TEACHER'S CENTER

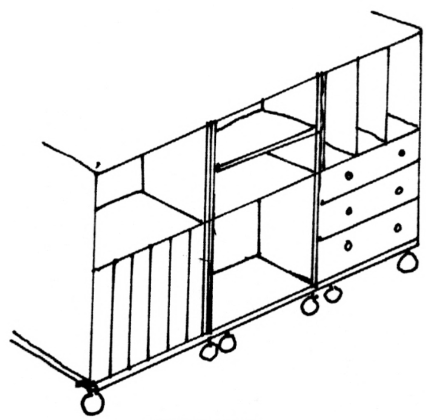
RATIONALE:

a) The Center should be a working space for the teacher wherein he/she can work without any interruption. However, the place should be located in such a way that the teacher can observe students, if needed.

b) A relocatable classroom seems always short of space and the case studies and literature review has shown that every available space is put to use. The above arrangement will make the classroom more efficient as it not only separates the Center from the main teaching area, but also provides extra storage space or display area (as the case may be).

GUIDELINE 19:

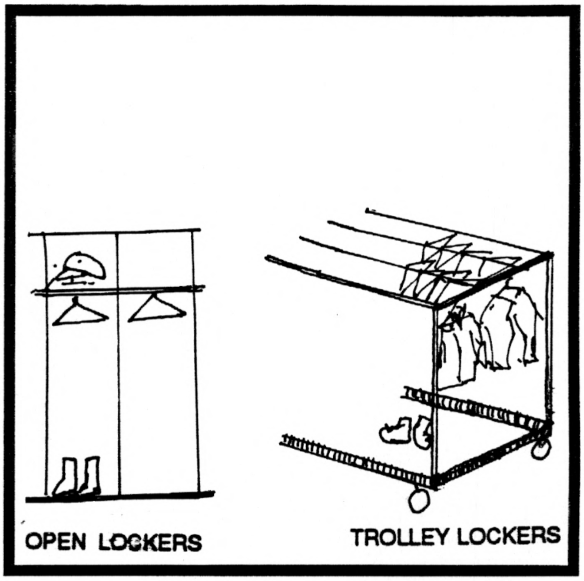
Provision should be made for the general storage of books, papers, audio-visual equipment/carts, extra chairs/tables etc. in the form of a separate storage room or space with shelves and/or cabinets.



STORAGE

RATIONALE:

As the units are detached from the main school building, there is a need to provide more storage area for convenience and easy availability of material. Every available space can be efficiently utilized, as seen in the preceding rationales, in the use of low storage units to partition activity areas. A separate storage space can be created to adequately store audio-visual equipment, with a provision of shelves to store books and other accessories.

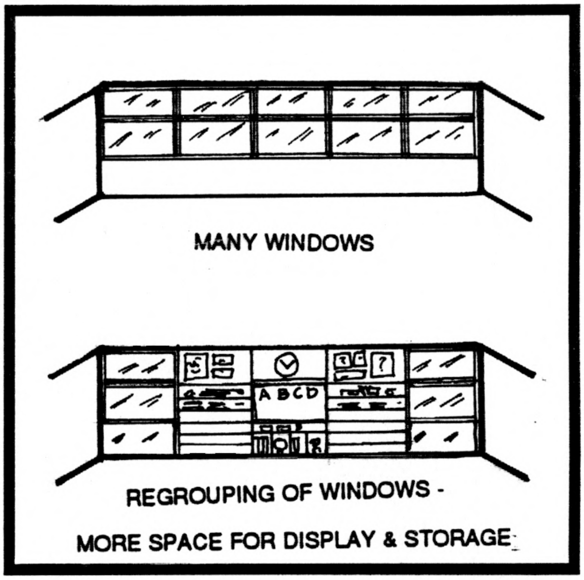


GUIDELINE 20:

Individual open lockers with coat hooks, a shelf above for small items and an area below for boots, or trolley lockers should be provided near the entrance.

RATIONALE:

Kansas climate necessitates the use of coats, gloves, etc. which need storage on entry inside the unit. As relocatable units are separate entities and the children have to travel to/from the main school building on any given day, this can involve constant use and removal of outer clothing during winter. Doors in these storage spaces or cloakrooms are considered a "safety hazard and as disruptive elements that get in the way when the children are trying to put on or take off clothes" (Stanton, Rudolph, 1965, cited in Osmon, 1973, p. 54). Trolley lockers, first developed for the Eveline Lowe Primary School, London (cited in Osmon, 1973, p. 54), besides providing ventilation for wet clothes can be stored against a wall when not in use but are accessible from both sides when pulled away from the wall.



GUIDELINE 21:

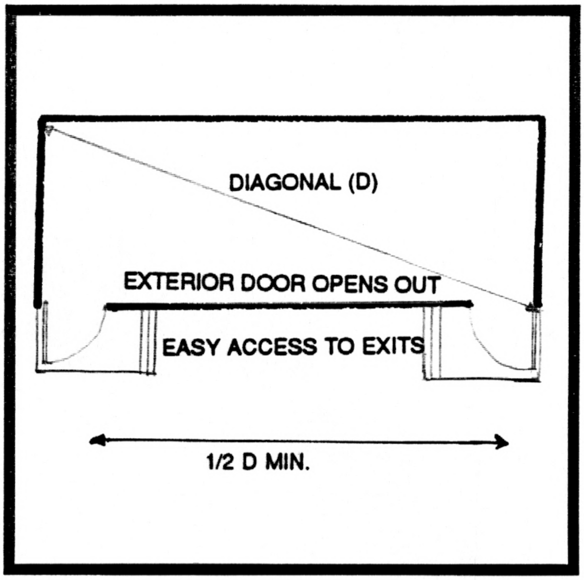
Besides meeting the school standards, especially if used for cross-ventilation, windows should be used as desirable for the activities and on the basis of the specific needs of the class.

RATIONALE:

Recent studies have shown that windowless classrooms reduce the pleasantness of students' moods (Ahrentzen et al, 1982). Also, growing literature documents the positive effects of windows on affective behavior of children. At the same time, regrouping of windows, as done in some units in Chicago, was found to improve utilization of interior walls. Thus, even if the classrooms are to be air-conditioned and artificially illuminated, windows should provide an "eye" and "view" to the outdoors. However, the amount of windows desired in a space should be subject to the specific needs of individuals using the space (Butler & Biner, 1989). At the same time, the specific requirements, as stated in the School Standards (1988, see Appendix A), also should be considered.

GUIDELINE 22:

a) Each classroom should be equipped with an external doorway leading out to a porch. There should be at least two exterior exits to a unit, located on opposite sides, or if located on the same side, they should be separated by not less than 1/2 of the diagonal distance of the unit.

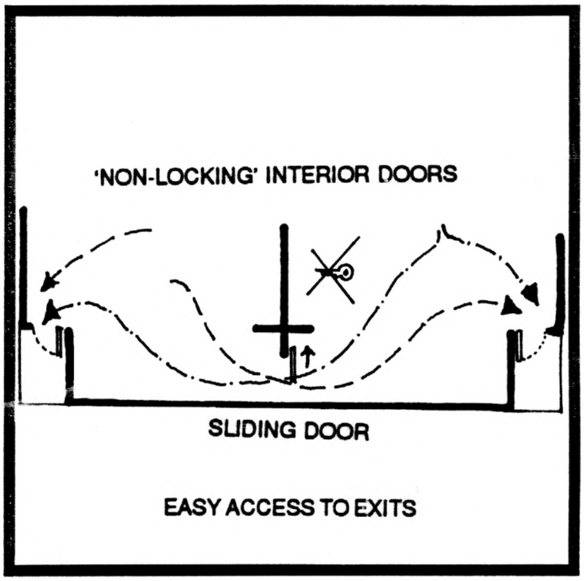


b) All exterior doors should swing in the direction of exit and should be easy to open from the inside at all times, even when locked from the exterior.

RATIONALE:

This guideline is based on the School Standards (1988) and the ease of evacuation in case of a fire or any other natural calamity. Furthermore, the School Standards (1988) also mandate the use of panic type hardware on exit doors that serve a combined area with an occupancy load of 50 or more.

GUIDELINE 23:



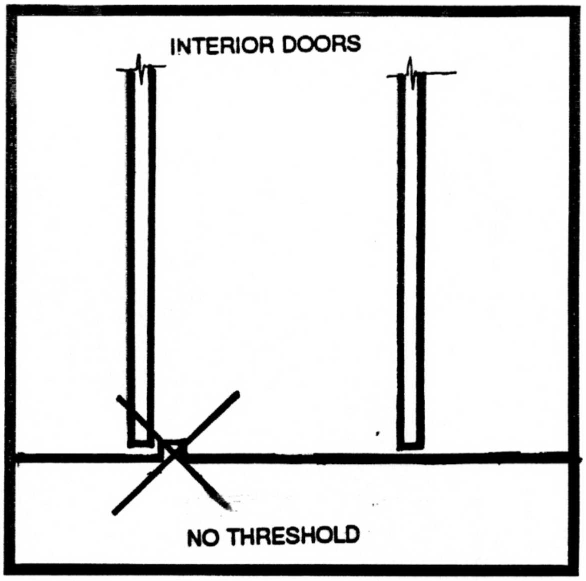
a) If the relocatable unit is divided into two or more separate classrooms, non-locking doors should be provided connecting all classroom spaces in such a manner that either exterior door can be reached from any classroom space at any time.

b) A sliding door is recommended as the connecting door between two classrooms to allow for maximum storage space at the sides.

RATIONALE:

Besides being mandated by the School Standards (1988), the ease of evacuation in case of a fire or any other natural or human calamity, especially as this involves children, necessitates this recommendation.

Guideline 23b is based on the recommendation of a teacher using a mobile classroom. The connecting door between this classroom and the adjacent one swings out in her classroom and has made the area next to the door unusable for any temporary placement of such furniture as the audio-visual equipment.



GUIDELINE 24:

Thresholds should be avoided for all interior doors.

RATIONALE:

Beside complying with the Americans with Disabilities Act (1990), this guideline also is based on the Time Saver Standards (1990, p. 231) and case studies. It is noticed that thresholds should be avoided due to their handicap inaccessibility, and also to ease movement of trolleys with audio-visual equipment, etc.

GUIDELINE 25:

Adequate toilet facilities with visual and acoustic privacy shall be provided in the form of one water closet and one lavatory for each sex.

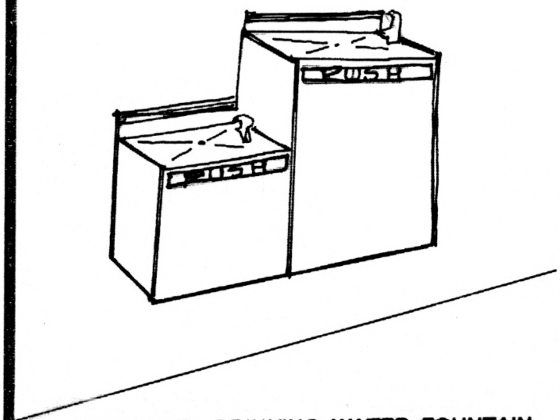
RATIONALE:

The guideline is based on the School Standards (1988) for relocatable classrooms, the case study and documented studies in Chicago and elsewhere (See pp. 38 - 57). The presence of toilets within the unit will make the latter self-sufficient in services and save the users from traversing through the outside to use the facilities in the main building. However, as the activities within a relocatable unit are in close proximity to each other, care should be taken to provide visual and acoustic privacy.

TOILETS & DRINKING WATER FOUNTAINS

GUIDELINE 26:

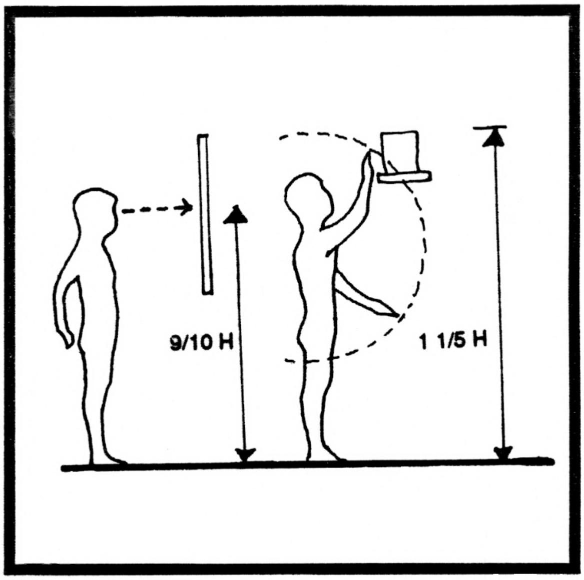
Drinking water in the form of drinking water fountain(s) of a combination type with two different levels should be provided in each unit.



TWO-LEVEL DRINKING WATER FOUNTAIN

RATIONALE:

Beside meeting the anthropometric sizes of the students of different grades and that of the teachers, this guideline complies with the requirements of the Americans with Disabilities Act (1990).

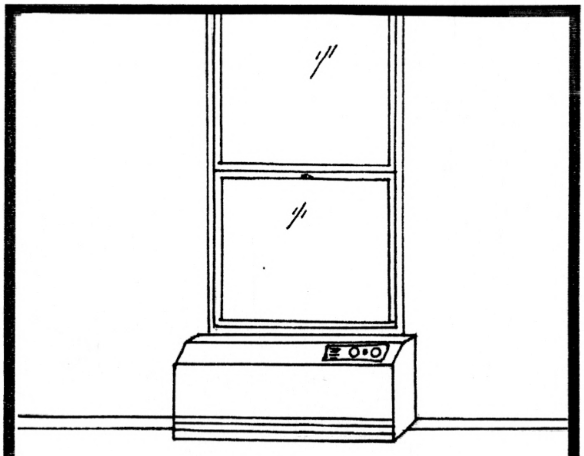


GUIDELINE 27:

Mirrors, toilet papers, towels should be within easy reach of the students.

RATIONALE:

Beside meeting the anthropometric sizes of the students of different grades and that of the teachers, this guideline complies with the requirements of the Americans with Disabilities Act (1990). This guarantees better safety and ease of use.



UNIT VENTILATORS

GUIDELINE 28:

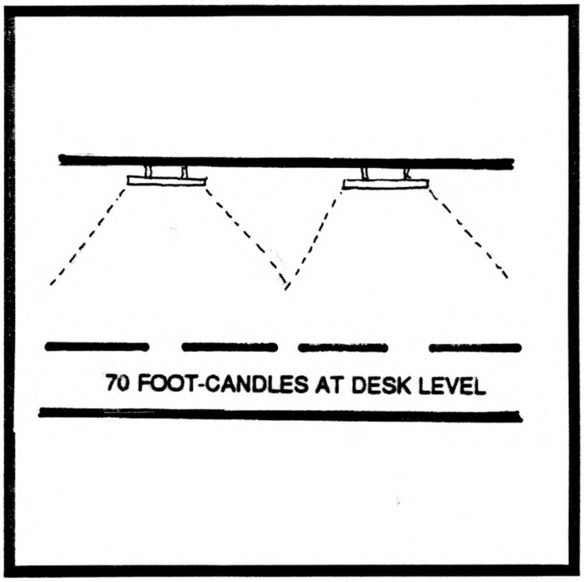
Unit ventilators are recommended in relocatable classrooms.

RATIONALE:

The case study has shown that it is easier to control the heating in the classroom with the use of unit ventilators that can be attached to the windows, and hence using minimum space. Easy control of the temperature is all the more crucial as research has shown that temperature affects children differently and needs effective regulation (Dunn, 1987; Pielstick, 1988; Rosenfeld, 1977; Scagliotta, 1980). The School Standards (1988) state that relocatable units should have not more than 50 B.T.U. heat output per square foot of floor space and this also should be kept in mind while designing the capacity of these units.

GUIDELINE 29:

All classrooms should have a minimum of 70 foot-candles of light intensity at desk height level, evenly distributed throughout the area. However, the amount and type of illumination should allow for flexibility, ranging from 7.2 foot-candles to 72 foot-candles (as the need may be).



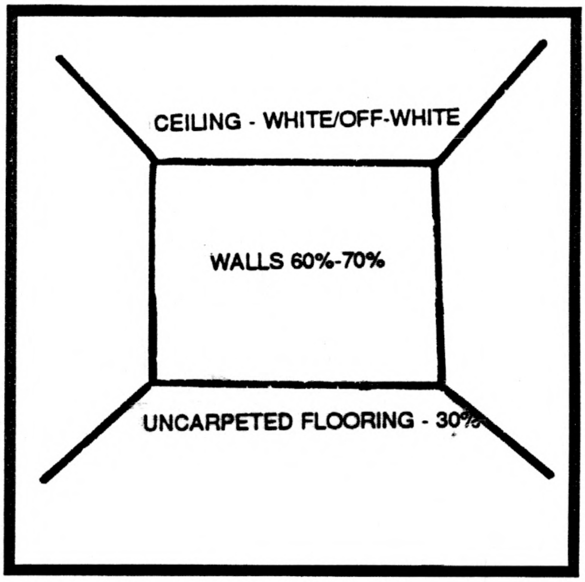
RATIONALE:

The School Standards (1988) specify a minimum of 70 foot-candles at desk height level. Also, the American Standards Guide for School Lighting (1962), formulated by the American Institute of Architects, the Illuminating Engineering Society and the National Council on Schoolhouse Construction, recommends 30 foot-candles as the minimum for ordinary classrooms. More conflicting results on the type and amount of illumination in classrooms (Coleman, Frankel, Ritvo & Freeman, 1976; Maas, Jayson & Kleiber, 1974; Mayron, Ott, Nations & Mayron, 1974; Painter, 1977; Rudd, 1978; Stelz, 1981; Zamkova & Krivitskaya, 1966), and the increasing awareness that individual preferences for the type and amount of illumination should be accommodated within a classroom, there should be an allowance for efficient manipulation of the lighting source and furniture layout (Dunn, 1987). Task activities like quiet reading or group projects can show a variance of the given standards and lighting can, thus, be best used to differentiate and suit the given activity, creating a dynamic environment.

GUIDELINE 30:

***a)** Rooms should show the use of warm, bright colors. Walls should have a reflection value of 60% to 70% and ceilings should be white or off-white. Uncarpeted areas should have a reflection value of at least 30%.*

***b)** Harmony, position and form of colored objects also should be considered.*



RATIONALE:

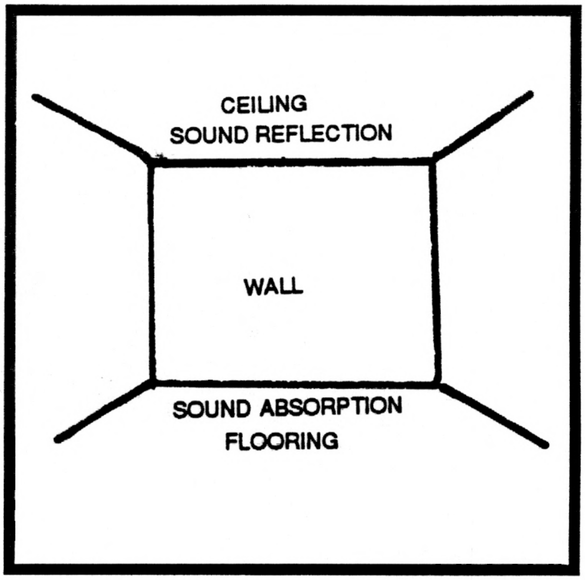
A majority of the studies have shown that a bright, warm environment has positive effects on students' behavior and health (Birren, 1969, Ertel, 1955; Mahnke and Mahnke, 1987; Wohlfarth and others, 1985). At the same time, the color schemes for the walls, ceilings and floors must be within the reflection values as mandated by the School Standards (1988). Since white does not facilitate human vision and learning, it should be avoided for the walls. However, it is essential to use white for the ceiling, as, since it is a given School Standard, and increases the reflection and intensity of light in a room.

Sharpe (1975) has reviewed research showing that it is not just color, but the combination of harmony, position and form of colored elements that has an influence on children. Hence, it is essential to integrate the above mentioned components.

GUIDELINE 31:

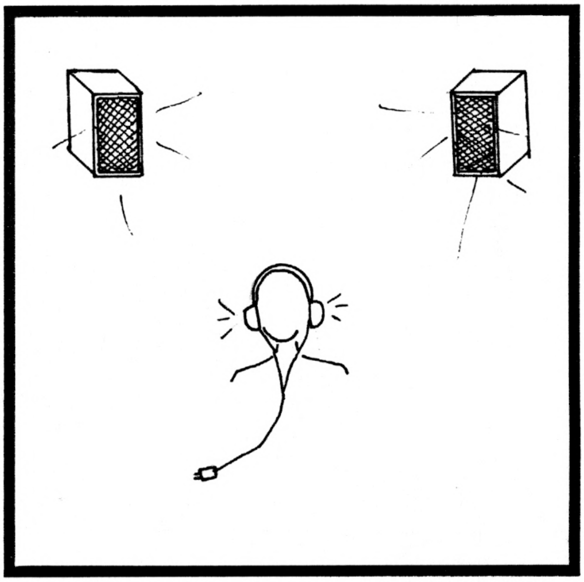
a) *Hard, non-absorptive surfaces such as plaster, concrete, glass, wood panels are recommended for walls, whereas a soft flooring such as carpet is recommended.*

b) *The ceiling should be sound reflective when the flooring provides sound absorption.*



RATIONALE:

The wall surfaces may be useful in reflecting sound and directing it to different parts of a classroom where it will reinforce the sound coming directly from the source. A soft floor covering will muffle or eliminate disruptive sounds of dropping pencils and books, clicking heels or footsteps, scraping furniture, etc. The psychological effects of carpeting in the schools also help to establish disciplinary controls over both the sound output of the students and general behavior. However, in settings where both acoustical ceiling tiles and carpets have been used, the room may become overly "dead." Thus, soft or absorptive flooring along with a sound reflective ceiling should be used (Holahan, 1982, p. 149).



GUIDELINE 32:

***a)** Sound field amplification is recommended as an effective education tool.*

***b)** Provision should be made for both non-functioning listening sets and listening sets or earphones, as needed.*

RATIONALE:

Sound field amplification has been found to counteract any deleterious sound interference caused by bad acoustics, movement, inattention or learning loss in children (Flexer, Millin & Brown, 1990). Another approach of reducing outside distractions, especially during quiet study and to suit individual learning preferences for quiet areas, is the use of non-functioning listening sets or ear plugs (Dunn, 1987). Since background music has positive effects on the learning of a few children (Mullikin & Henk, 1985; Rosenfeld, 1977; Pizzo, 1981), listening sets or earphones should be provided to students who need music during quiet reading or learning (Dunn, 1987).

DESIGN PROJECT TO TEST PRELIMINARY DESIGN GUIDELINES

A group of eleven third year interior architecture students at Kansas State University were given a one week project to design prototypical relocatable elementary classroom units on the basis of the preliminary set of design guidelines. The intention of this project was to test the applicability, scope, practicality, generality and clarity of the guidelines. This was a new experience for the students, as it involved designing on the basis of a given set of guidelines in order to improve the quality of interior spaces in a relocatable unit, transforming it into an exciting and dynamic environment.

A brief introduction to the problem and a relocatable facility, along with the problem statement, scope and objectives was provided to the students (See Appendix B). Anthropometric data and a case study of Woodrow Wilson Elementary School, in addition to the graphic and written design guidelines, assisted the students in this exercise. At the end of the project, a questionnaire (See Appendix B) was provided to draw general comments on the assignment. The students also were encouraged to note any comments, suggestions, or doubts on their given set of design guidelines, which were collected later to study the general feedback. The final step of this exercise was an open jury attended by members of the thesis committee and the studio instructor.

The following provides an overview on the general feedback of this project on the basis of the review of the audio/video tapes of the jury, the questionnaire, and comments on the guidelines, which helped to refine the design guidelines presented in the preceding chapter.

There was a feeling among the students that the connection to the main school was very important, but was often neglected in existing facilities. Despite the strict standards and regulations prohibiting any permanent attachment, a free-standing covered walkway from the main school building to the relocatable unit was found essential. It also was felt that the orientation and planning of the relocatable units should be in a manner that would create a psychological sense of belonging. A common courtyard could be created that would serve not only the children in the relocatable units, but also the entire school. This could reorient the play activities of the school, emphasizing the connection of the relocatable unit with the school. Thus, it was judged that it was not sufficient to just design the relocatable unit in isolation but consider the site planning as well.

The general feedback from the students was that the design guidelines were quite clear, allowing flexibility in design. However, the space allocation i.e. 600 -900 sq. ft. of area was felt to be too small for an elementary classroom, given the range of activities occurring. With rapidly changing ideas, teaching methods, and the increased use of computers and other technology, it was suggested that a relocatable unit should be allowed to grow, using a modular approach, making it more efficient. Thus, the upper limit of the given area should be used as a minimum rather than as a maximum specification. Similarly, it was felt that the ceiling height was too restrictive and did not offer much scope for the variation of ceiling levels (if at all) within a relocatable unit. There was a suggestion that a modular unit be provided with folded elements on the roof that had the option of being opened up, with minimum effort, on-site, to create more height. As the additional height is erected on site, it also complies with the logistics of transportation.

There was some confusion about the guideline related to the Teacher's Center. These students had not experienced this type of design response in their own educational settings, but rather used to a desk-chair (for the teacher) within the classroom area. A few students felt that the Center took away much-needed space from other activities. Others felt that this Center should be private, locked from the classroom to avoid any distractions and tampering with grade sheets, assignments, and other files. A Teacher's Center, recommended in the guidelines as an option, could be modelled around those in the documented studies in Chicago, Newark, or Minneapolis.

Students considered color an issue of primary significance in an elementary classroom. Although studies on color have shown conflicting results, on the basis of major and recent empirical findings, most students responded with bright, warm color schemes as appropriate for elementary classrooms. Due to the restriction imposed on the use of only black-and-white media for the presentation drawings, color concepts could not be fully documented in the student projects. Two of the projects that are representative of the responses of the student's projects are listed below.

One of the students extruded the central two sections to form a lobby with the services and cloak room - all common to both the classrooms (See Figure 42). The roof of the central portion of the structure was similarly extended out to create clear-story windows (See Figure 43). This additional height was to be erected on-site with the use of modular components. His design showed a flexible open space planning that could allow two classrooms to be combined to form one large classroom. This was done through the use of partitions that could be folded and moved on a 4' x 4' grid. The arrangement of desks and chairs also was informal, in the form of small groups, allowing participation and interaction among the students. The teacher's center, beside being placed in the corner of each classroom, was separated by partitions to ensure privacy.

Another student joined the divisible units to form an L-shaped design that provided a courtyard for the children (See Figure 44). It was, however, felt that the orientation of the relocatable units should have been reversed in order to make the courtyard a common meeting ground for the displaced children, and the children from the main school building. Overall, the design showed sensitivity to detail. The chalkboards and tackboards were adjustable to the students' height requirements, and had overhead storage cabinets. The resource center was provided with extra counter space and a sink for art and science projects. The toilet and storage facilities were centrally located to provide easy access to the children from both classrooms, and the entry. Provision was made for four cubicles within this area that could accommodate coat hooks with shelves above for open storage (See Figure 45).

Due to the nature of the combination of the four divisible sections, the planning appeared rigid and unable to allow modifications to meet changing demands. The careful detailing of the interior spaces and furniture, however, downplayed this limitation.

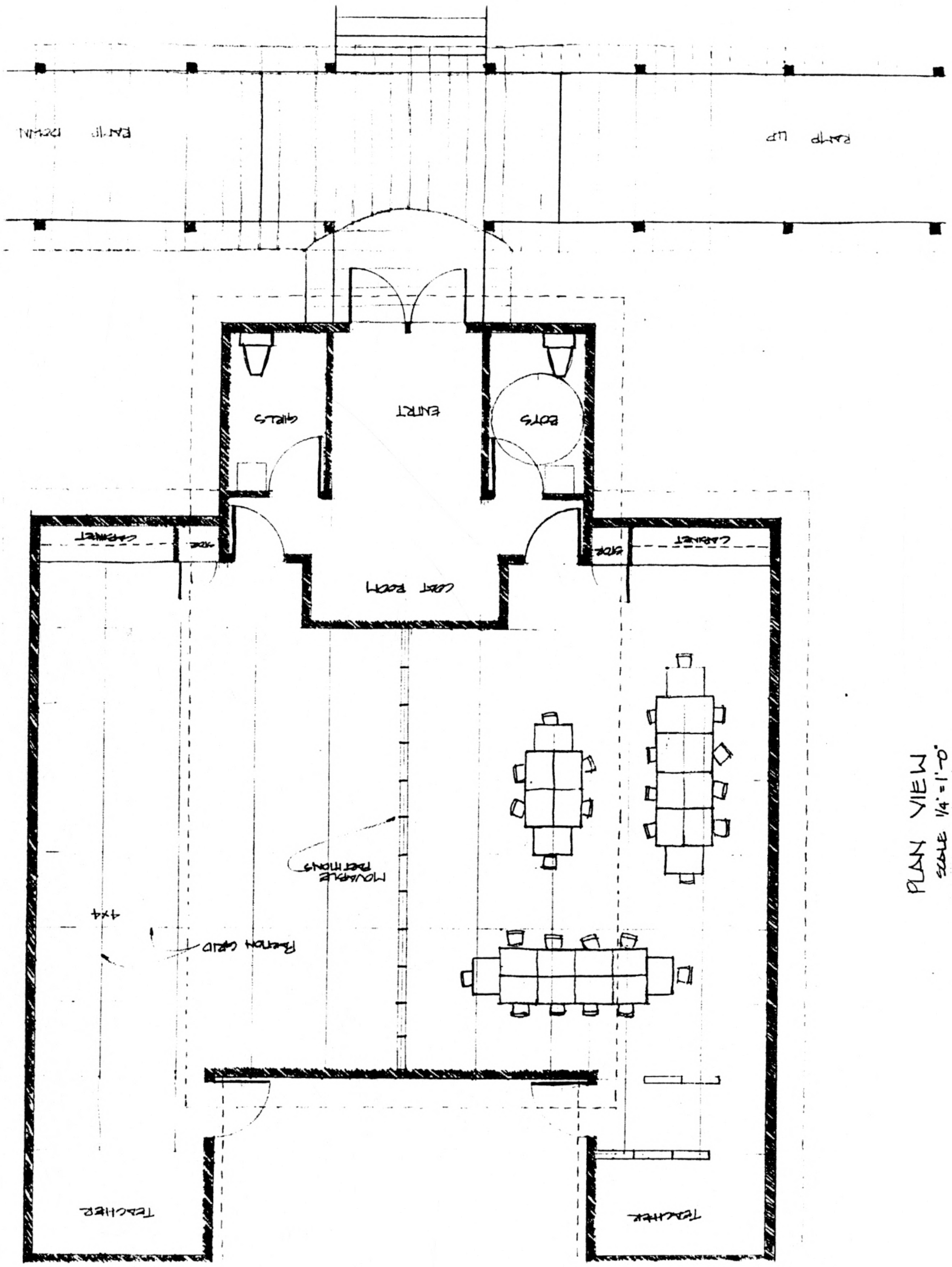


Figure 42: Plan showing the configuration of the units and the interior layout

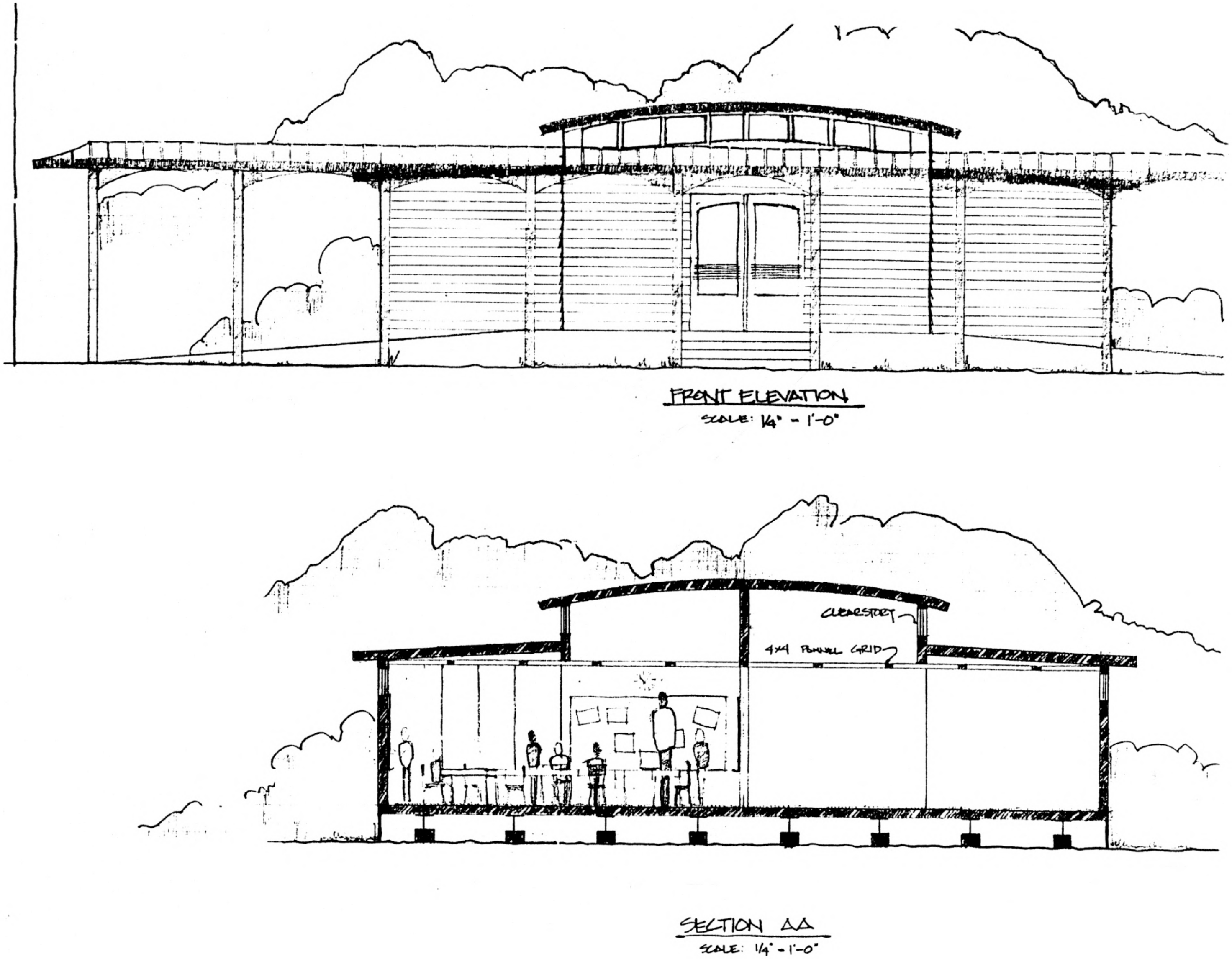


Figure 43: Elevation and Section of the same unit

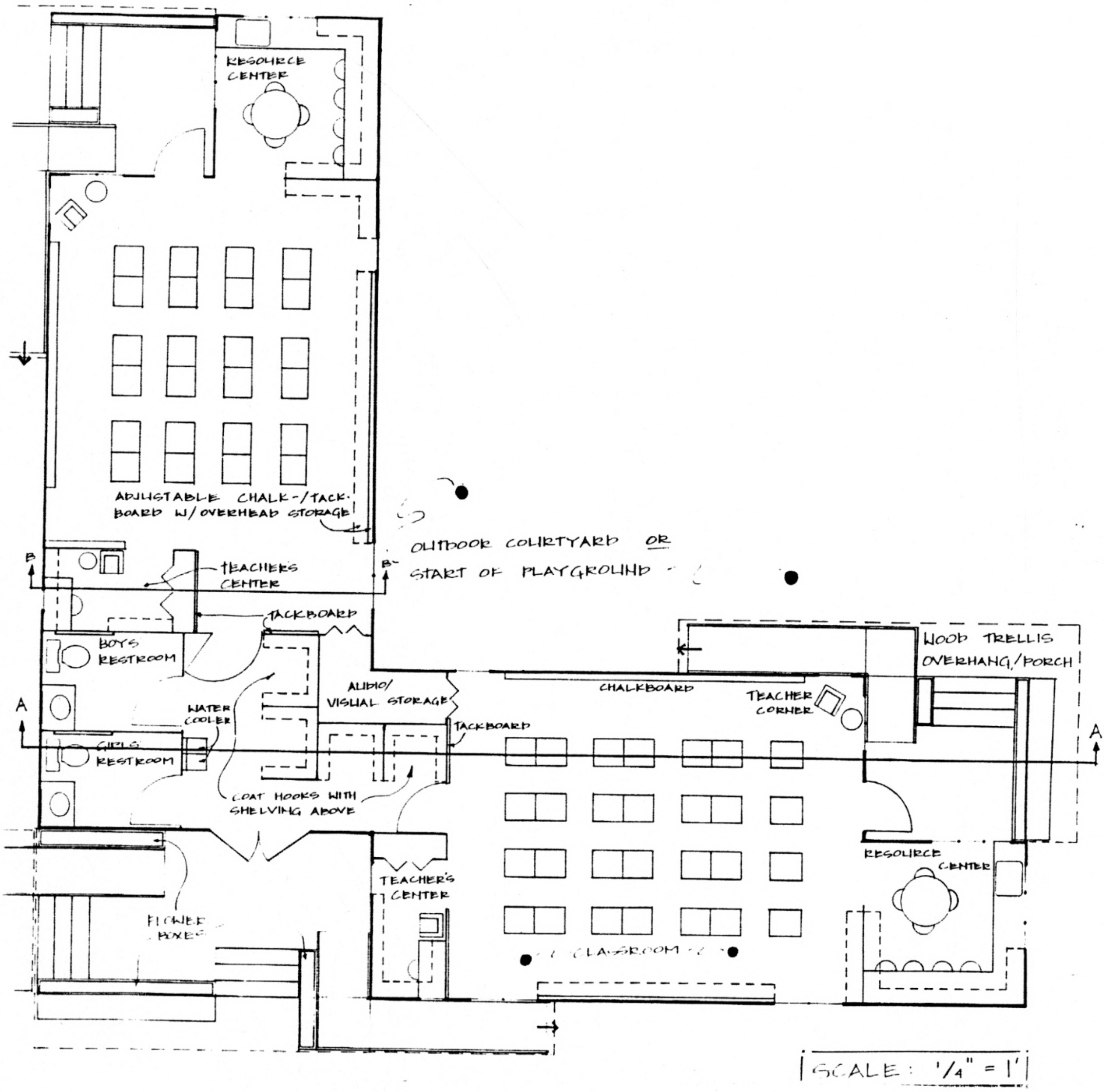


Figure 44: Interior planning of a L-shaped design

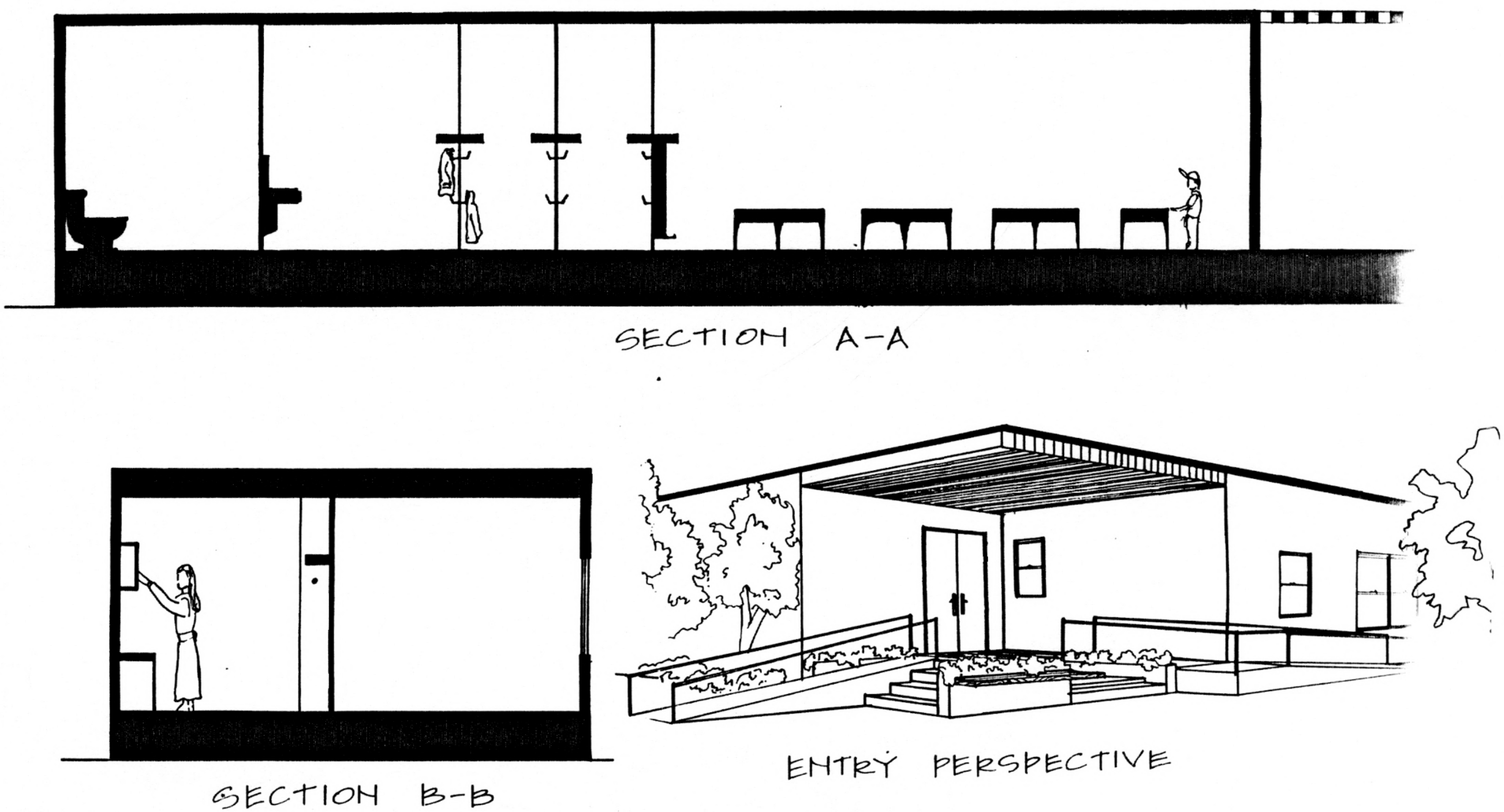


Figure 45: Sections and entry view of the unit with the L-shaped design

CONCLUSIONS

Relocatable facilities have been in use in schools for many years to accommodate increasing numbers of children in a short time and with low cost. Due to their "temporariness", little thought typically has been given to their specific connection to the main school building. These units often become permanent fixtures on the school grounds; yet, there is little research on the impact of these classrooms on the well-being and academic performance of the children who learn there. The interest in relocatable classrooms was greatest in the 1960's, when there was a sudden growth in these structures all over the country. However, after this initial surge in attention, there has been no mention in recent literature, and the design of relocatable classrooms seems to have changed little over the past three decades.

Summary of the Review of Environment-Behavior Literature

This thesis has endeavored to review the empirically-based literature relevant to relocatable classrooms and to assist architects and administrators in the design of future relocatable classrooms of elementary schools by developing design guidelines based on this review. In order to achieve the final guidelines, the initial steps of the thesis involved a survey of general environment-behavior literature related to education of children and specific literature on relocatable classrooms. The literature review showed that the 'learning environment' is not isolated to issues such as size acoustics, lighting and heating, but includes other environmental variables such as seating position, classroom design, crowding and density, personal space, presence or absence of windows, noise and color. The effects of these environmental characteristics influence and shape children's learning, preferences and behavior; thus the physical environment may serve as one means for advancing developmental and educational processes.

The review of the research literature on environment-behavior relations showed that, although many environmental variables have been investigated, results have been contradictory. A number of studies have not been able to link the effects of the environment directly to academic achievement. However, many of the environmental variables such as classroom design, furniture arrangement and seating position appear to have an impact on other non-achievement factors such as student's general behavior and on their attitudes toward the class and other students. High levels of density have resulted in dissatisfaction, decreased social interaction, and increased aggression. "Relatively minor design modifications introduced into already functioning classrooms have been shown to produce changes in students' spatial behavior, increased interaction with materials, decreased interruptions, and more substantive questioning" (Weinstein, 1979, pp. 598-599). These findings are relevant to the proposed guidelines as more positive attitudes and behaviors may eventually result in improved achievement.

Some research has focused on the need to accommodate individual preferences of students. It has been argued that the needs of every child are different, and the ability or inability to meet these demands can enhance or inhibit learning and overall development. Since classroom management can respond to some needs through minor changes to satisfy the individual learning styles of children, the guidelines were developed to allow for adaptation to different needs and requirements.

Although there is much research on environment-behavior relations appropriate to school environments, there is a lack of sufficient data on the relationship between the physical environment and the behavior of children. For instance, there is a need for further research on the arrangement of classroom furniture that enhances verbal interaction. Considering the discrepancies in the research findings, there also is a need to have new, empirically-based studies addressing specific environmental variables, such as color, that can be used in the design of elementary classroom environments. Similarly, new research on other issues related to classroom environments needs to be updated in order to revise these guidelines to suit the changing needs and demands.

Case Studies

The study of the documented case studies showed some innovative features introduced to improve use and appearance. The interior design of the divisible units in Chicago and Newark, and the demountable unit in Minneapolis showed that the use of display boards or storage units, not only differentiated separate functional spaces, but also saved on much-needed space. The prototype developed by M.I.T. demonstrated the use of new technology to create an environment, where natural light was effectively allowed to filter through skylight components. However, many classrooms, such as the relocatable unit used as a case study, do not show any new approaches to design. All the interior modifications and arrangements have been a result of specific ideas and experiences of the teacher.

After a careful study of these divergent strands of inquiry and evaluation of existing or documented designs, the information was used to generate design guidelines that reflect changing needs and demands of present educational approaches. These guidelines were then grouped on the basis of general planning considerations, the activities and specific environmental variables such as heating, lighting, color and acoustics. Some of the guidelines such as those on toilets and furniture size requirements might appear basic and obvious, but have been specifically stated due to the possibility of being overlooked in the actual design of these classrooms. Topics such as siting of and access to the relocatable classrooms, and the connection of these classrooms to the main school building also were included. Since these topics were not covered in the environment-behavior research, the effect of this sense of detachment or isolation remains unexplored, and there is a need for research in this area.

The Need to Update School Standards

Furthermore, the School Standards issued by the School Facilities Office (1988) were very restrictive for the design of relocatable classrooms. Due to the fire safety regulations and the "temporariness" of the relocatable units, it was stated in the Standards that there should be no connection to the existing school buildings. The exposure to the natural elements and the psychological feeling of detachment created by such a stringent requirement does not seem to have been carefully considered. The minimum limit of 9'6" imposed on the internal floor-to-ceiling height also does not allow for much scope in creating dynamic environments. These Standards limit the spaces that might be created by architectural features such as lofts and alcoves with lower ceiling heights for exclusive child use. The Standards on lighting and windows, similarly, need to be updated on the basis of recent literature. Studies have shown that illumination levels needed for best performance need not be as high as specified (Stelz, 1981, cited in Pielstick, 1988, p. 116). Additionally, research has shown that the amount of illumination and the presence or absence of windows are dependent on the individuals using that space (Dunn, 1987; Butler & Biner, 1989). This suggests that the School Standards should be flexible in order to respond individually to a specific situation.

The format used for each of the guidelines included a statement with an adjoining figure, and a rationale that formed a basis for the guideline. These preliminary guidelines were tested with a group of eleven interior architecture students to study their usefulness and applicability. On the basis of the students' design solutions and general comments and observations about the guidelines, the guidelines were refined and clarified. Some of the guidelines such as height and space requirements were made less restrictive, and an allowance was made for flexibility. These design guidelines should enable architects to design facilities that are sensitive to the needs of elementary school children. It also is hoped that this thesis will lead to a new impetus in environment-behavior research that can be used for further enhancement and improvement of schools.

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APPENDIX A

(Source: School Facilities Office, 1988)

CHAPTER 4

RELOCATABLE SCHOOL BUILDING STANDARDS

Code or Reference	Narrative	Subject
	A Relocatable School building is a unit of construction consisting of one or more rooms which is movable or relocatable. Concrete floors, concrete foundation stem walls, party walls or connection to other buildings are not permitted. The term mobile, movable, temporary, portable or relocatable shall be considered synonymous.	
	Kansas Statutes 31-150 provides that all relocatable school buildings shall be constructed in conformance with the 1985 Life Safety Code (NFPA 101), the 1985 edition of the Uniform Plumbing Code and shall include reasonable provisions for making buildings and facilities accessible, and usable by the physically handicapped, as approved by the State Board of Education.	CODE
	The relocation of relocatable school building shall not be construed to be new construction or reconstruction under the provisions of K.S.A. 31-150, however, requirements for provisions of accessibility of the handicapped shall apply as noted in K.S.A. 58-1301 *et seq.*	
	Plans and specifications for the acquisition or construction of new relocatable school buildings shall have the seal of an architect or engineer licensed to practice in the state of Kansas, and shall be submitted to the State Department of Education for approval. A site plan shall accompany the submittal which indicates property lines, existing buildings, walks, roads, utilities and drainage features.	
	The minimum drawings required to be submitted for the review and approval to move and reinstall a relocatable classroom building are a scaled site (indicating the location of existing school buildings, parking, surfaced areas, etc.), a scaled floor plan, a structural plan sealed by a licensed architect or engineer from Kansas indicating how the unit will be supported and tied down, and details concerning ramps and handicapped accessible elements.	
	The following standards are submitted for assisting school administrators in planning, purchasing and locating relocatable school buildings. These standards are paraphrased from the Life Safety Code, Uniform Building Code, Uniform Plumbing Code, Uniform Mechanical Code, National Electrical Code, K.S.A. 75-1220, Guidelines for Manufactured Housing Installations (I.C.B.O.) and American National Standards Institute A-119.1.	RECOMMENDED FEATURES
	The clearance between existing school buildings and relocatable school buildings shall be at least 20 feet.	CLEARANCE
	Clearance between relocatable units shall be at least 5 feet, provided the total square footage of units so located does not exceed 9,100 sq. ft.	
	Classrooms should have not less than 600 square feet of floor space in relocatable units.	CONSTRUCTION
	Interior ceiling heights shall be not less than 7' 6".	
	Framing members should be not less than 2"x 4" dimension lumber spaced on 16" centers or other equivalent construction.	
	Roof should be constructed in a manner to support a live load of 30 pounds per square foot.	
	Floors should be constructed in a manner to support a live load of 40 pounds per square foot.	
	Vertical walls and bracing should be constructed in a manner to support a horizontal wind load of not less than 20 pounds per square foot.	
	All interior wall and ceiling finish, for areas other than exits, shall have a flame spread rating of not more than 75 as rated by an approved independent testing laboratory.	

Subject	Narrative	Code or Reference
	All exit corridors and vestibules shall have wall and ceiling finishes with a flame spread rating of not more than 25 as rated by an approved independent testing laboratory.	
	Floors and roofs should have non-combustible insulation installed which will produce a finished resistance rating of 19. A vapor barrier shall be provided on the room side of the insulation.	
	Walls should have non-combustable insulation installed which will produce a finished resistance of 11. A vapor barrier shall be provided on the room side of the insulation.	
	Relocatable units that are not air-conditioned should have cross ventilation of not less than 24 square feet of free window area on each of two opposite sides. On units separated into more than one classroom or assembly area, each classroom or assembly area should meet this requirement. Rooms which do not have exit doors to outside shall have at least one window per classroom or assembly area not less than 30" wide and 36" high with a sill not more than 42" above the floor.	
	Units shall be anchored firmly to the foundation's piers in a manner to resist movement in the vertical direction and both the longitudinal and transverse direction (perminent foundation stem walls are not permitted). Anchor details shall be shown on the drawings and should be approximately equal to one 5/8" bolt embedded not less than 12" in solid concrete or mortar for each 60 squre feet of floor area. Footings for piers should be not less than 30" below grade.	
	Units shall have a clear crawl space height of at least 12" and that portion containing plumbing or utility connections shall have a minimum of 18" of accessible height. Crawl space may be enclosed with removable skirting.	
EXITS	Each unit shall have not fewer than two exterior exits. Exits should be located on opposite sides of the unit, or if located on the same side or adjacent sides, they shall be separated by not less than 1/2 of the diagonal distance of the unit.	
	All exterior doors and interior doors serving an occupant load of 50 or more shall swing in the direction of exit and shall be equipped with hardward that can be opened from the inside at all times, even when locked from the exterior.	
	If the relocatable unit is divided into two or more separate classrooms, non-locking doors shall be provided connecting all classroom spaces in such manner that either exterior door can be reached from any interior space at any time.	
	Exit doors which serve a combined area with an occupant load of 50 or more shall be equipped with panic type hardware.	
PORCHES	All exterior doorways to relocatable units shall be equipped with a porch or landing of not less than five feet in length and five feet in width with appropriate steps or ramp.	
	Porches over 7" in height and all steps or ramps shall have sturdy handrails. Porches, steps and ramps shall be of steel, concrete or 2" dimension lumber. The frames and handrails shall be firmly fastened to a concrete or masonry base.	
HEATING	Relocatable units should have not less than 50 B.T.U. heat output per square foot of floor space.	
	Furnaces using oil or gas fuel shall be of a forced air (blower) type, shall have an adequate source of combustion air from outside the unit equal to one square inch of free air per 1,000 B.T.U. input.	
	The furnace and clearances shall conform to A.G.A. requirements and be equipped with a 100 percent safety shut-off device. It shall be complete with appropriate ducts, grills and remote temperature thermostat.	

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If heating equipment is enclosed by permanent partitions, the enclosure shall be of one-hour fire-resistive occupancy separation construction and all interior doors to the furnace room shall be of one-hour fire-resistive labeled door and frame and shall be equipped with automatic closers.

PLUMBING

Materials and installation shall comply with the 1985 Uniform Plumbing Code as published by the International Association of Plumbing and Mechanical Officials.

Drinking water shall be provided in each unit.

Adequate toilet facilities shall be provided by the inclusion of one water closet and one lavatory for each sex in each unit, or, if the unit will be served by existing facilities, those facilities shall meet the requirements of the code for the calculated occupancy of the total complex. Additionally, no person should be expected to travel a distance exceeding 150 feet, from door to door, to reach restroom facilities. The use of existing toilet facilities shall be permitted only if student class assignments are for one hour or less in the relocatable unit.

ELECTRICAL

All materials and installations shall comply with the 1984 edition of the National Electrical Code (NFPA-70). Aluminum wire should not be used for internal circuit wiring.

Each unit should be equipped with a three or four wire service panel which shall be of the circuit-breaker type. Two 20 amp lighting circuits per unit should be provided. A single unit without air conditioning should have not less than a 60 amp service. Other installations should have not less than a 100 amp service.

Units should have not less than 10 convenience outlets. Outlets should be placed not greater than 10 feet on centers along the wall perimeter and shall be located at least 15 inches above the floor.

The electrical system and metal members of the structure shall be grounded in compliance with the National Electrical Code.

LIGHTING

All relocatable units should have fixed fluorescent lighting to supply a minimum of 70 foot candles of light intensity at desk height evenly distributed throughout the classroom level.

Ceilings should be white or off-white. Floors should have a reflection value of not less than 30 percent (unless carpeted). Walls should be of a light and appropriate color and have a reflection value of 60 percent to 70 percent.