Sheltering Education: Open System Prototyping in the School Construction Systems Development (SCSD)

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In the decade following World War II, the United States population grew by almost 20%[1], and the housing industry responded with prolific and rapidly-constructed homebuilding programs to accommodate the Baby Boom. Lagging just a few years behind the explosive growth in housing production, but no less critical, was the need to construct new schools to educate the burgeoning student population. Local boards of education found themselves in need of new facilities that could be built quickly without sacrificing construction quality and functional needs. In response to the problem, the Educational Facilities Laboratory (EFL) assembled a group of young designers directed by architect Ezra Ehrenkrantz to study the feasibility of flexible, component–based systems for prefabricating secondary schools.

The idea of a systems approach to school production was compelling, but certainly not revolutionary. More than a decade earlier, England's Hertfordshire schools pioneered prefabricated construction methods for primary schools in response to its own escalating school-aged population. Ehrenkrantz led an examination of Hertfordshire's school construction program in hopes that it might provide a model for the EFL's School Construction Systems Development (SCSD).[2]

THE HERTFORDSHIRE PROGRAM

The Hertfordshire experiment resulted, in part, from a severe shift in British politics at the War's end: Clement Atlee's Labour Party gained majority control of the government.[3] Their resounding victory at the polls ushered in an excited era of social democracy and "a national determination to create a post war social order which would be humane, equitable, planned and, above all, new – the Welfare State allied to a modernist architecture would help to ensure there would be no return to the grim, depression days of the 1930's."[4] Essential to this new social order were heightened government provisions for public education and the implementation of 1944's Education Act that provided free secondary education and raised the school-leaving age to 15 years.[5] Also in Hertfordshire, a town located slightly north of London, construction of several New Towns--planned developments designed to combat suburban sprawl--intensified the need for new schools.[6]

In 1945, The Hertfordshire County Council (H.C.C.) responded to its impending educational facilities crisis by devising a construction program that would rely heavily on factory-built, prefabricated components rather than traditional materials, which were in short supply.[7] County Architect C.H. Aslin and his deputy, Stirrat Johnson-Marshall designed a process based on Hertfordshire's immediate need of school facilities, and future estimates of at least 50 primary schools within seven years.[8] The H.C.C. set lofty goals, most notable that these new schools be built more rapidly and economically than if done by traditional means.

England's successful response to the school shortage problem came, in large part, as a result of the Ministry of Education's central control of funding and planning. Each year, the H.C.C. planned an entire program of construction rather than treating each new school in an autonomous, "one-off" fashion.[9] The H.C.C.'s procedure proved to be quite advanced technically because it created a new building method that combined "the skills of the architect, the Building Research Station, the builder and the manufacturer, in a team in which each member [could] make his contributions at the inception of a project and not at different stages in the process of building."[10] Each year, the program would specify a new kit-of-parts and standard detail drawings that delineated acceptable structures, cladding, finishes and equipment. In this closed system, county-approved architects hired to design individual buildings were expected to work through their designs quickly because the construction details were already provided.[11] Ideally, this left the designer more time to consider often neglected areas of research and decoration.[12]

Several advantages to Hertfordshire's program became apparent: the community gets high quality schools at a quick pace, the architect's work load is diminished, manufacturers benefit from guaranteed advanced orders, and contractors show higher profits because of accelerated, repetitious construction methods. Ostensibly, architects became more aware of industrial processes that produced building components.[13]

The H.C.C. was not merely concerned with implementing technological advances in building components. According to its officials, the highly standardized process of mass production would also create an aesthetically pleasing environment for its young inhabitants. Most of Hertfordshire's schools can therefore be viewed as reactionary alternatives to the monumental and institutional schools of the pre-war era. The schools were characterized by the additive nature of their organizational elements, and they achieved an organic quality because of their flowing space--often delineated with glass walls--that offered views to adjacent rooms and the exterior. A modernist aesthetic was achieved through modular repetition and technologically advanced building materials (Fig. 1). With numerous schools being built in England, "modernism, marginalized in the 1930's, became the official architecture of the Welfare State."[14]

The Hertfordshire program succeeded in creating individuality within each school despite its reliance on standardized components. Architects working on H.C.C. projects were encouraged to create their own design language based on the given set of materials: light steel columns and open lattice beams, flat pre-cast concrete slab roofs, and multiple bay window arrangements.[15]

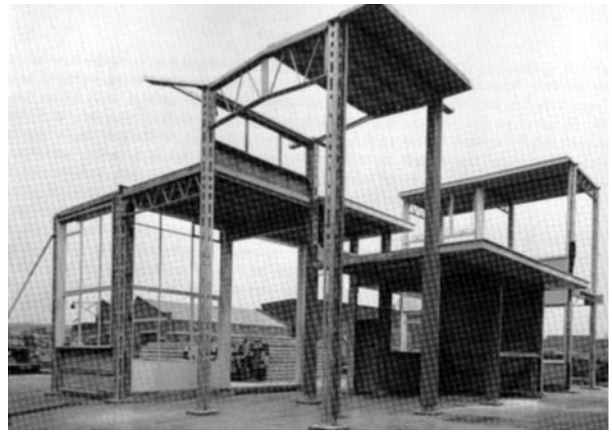

Fig. 1. Hertfordshire structural prototype
Andrew Saint, *Towards a Social Architecture, The Role of School Building in Post-War England*. New Haven and London: Yale University Press. 1987: 66

EHRENKRANTZ AND SCSD

Ezra Ehrenkrantz believed that "a close examination of the British experience seems to be a prerequisite to the scientific quest for a solution to the school shortage problem in [the United States]."[16] Ehrenkrantz's study of the Hertfordshire model took place on two separate occasions: once while a Fulbright Fellow in Britain's Building Research Station in the mid-1950's, and again on assignment from the SCSD in 1961. The result of his enquiry was a report, co-authored with James Laurits, entitled *School Construction Systems Development Report Number Two: British Prefabricated School Construction.* Ehrenkrantz and Laurits' work detailed the structure of the Hertfordshire Program and the Consortium of Local Authorities Special Programme (CLASP), a second-generation English prefabrication system.[17]

Ehrenkrantz understood that the British model could be emulated in the United States, but it had to be altered to suit a less centralized educational structure. England's Ministry of Education provided the necessary guidance and funding to orchestrate large yearly building programs, while the U.S. Department of Education basically left school construction plans to local boards of education. As a consequence of the decentralized system, American school construction projects were typically bid (publically and competitively) one at a time and constructed by traditional means. There existed no incentive or time for designers to explore alternate means of design, building methods, and construction processes. Realizing that new design, construction, and bidding procedures would be the only means of building schools for a rapidly expanding population, the Educational Facilities Laboratory (EFL) created SCSD. Because of its location on the Stanford University Campus in Palo Alto, the EFL would focus SCSD's pilot program on a consortium of California school districts.[18]

In August of 1962, SCSD put forth its mission statement in *School Construction Systems Development Report Number 1: Project Outline.* Three clear objectives were stated:

- to create a system of standard parts with which architects can design individual schools;
- to reduce the cost of school construction by obtaining volume production of standard parts;
- to reduce the time needed for the construction of a school.[19]

SCSD planned a series of procedures that would ensure their objectives' efficacy and SCSD outlined their tasks as follows:

- Build consortium of 13 separate school districts
- Develop building performance specifications based on a systems approach to design
- Identify components and interested manufacturers
- Bid the components
- Refine the systems
- Build prototype
- Release component information to design architects[20]

BUILDING A CONSORTIUM

SCSD gathered 13 different California school districts into one consortium for two main purposes. First, the collection of school districts would coalesce to determine a set of school building use specifications. Secondly, the consortium would provide a collective building program large enough to interest manufacturers in the research and development of components for the projects. Another advantage would be the consortium's leverage in the bidding process: theoretically, the more schools using the components, the lower the components' unit price.[21] The First California Commission on School Construction Systems, as the consortium was known, defined a need for two year's worth of school building projects with an estimated $25 – 30 million budget. Originally, 22 schools were planned, but only 13 were eventually built.[22]

As a consortium-based project, SCSD's procedural approach relied on communitarian ideals. Before moving the project forward, it was important for Ehrenkrantz and his staff to understand current sociological trends and theories in the teaching profession. The consortium worked to define its teaching methods in spatial terms that would aid the designers' efforts. Some popular aspects of 1960's pedagogy were open plan schools, team teaching, and individualized instruction. Most importantly, current educational practices required variable spatial arrangements. After developing a case study of a fictitious 1800-student high school, SCSD concluded that designing flexible arrangements would be the key to accommodating new teaching methods. Ehrenkrantz promoted a plan for flexibility through component standardization.[23]

The consortium cannot be seen merely as SCSD's effort to better understand its client's needs. The consortium's primary purposes were to simplify the school district organizational structure and provide greater leverage in the bidding process.

PERFORMANCE SPECIFICATIONS AND THE OPEN SYSTEMS APPROACH

One of the most revolutionary aspects of the SCSD was its implementation of performance specifications. SCSD believed that the performance of the entire building system was more important than the performance of an individual product, and the performance specifications were written to encourage experimentation by construction industry manufacturers. Also, SCSD reasoned that the design architects would more readily accept a component designed by manufacturers rather than by another set of architects.[24]

The performance specification put the responsibility on manufacturers to coordinate their products with other manufacturers so that there would be no integration problems during construction. This "integration concept in the specifications"[25] was designed to release the architect and engineer from typical product coordination duties and liabilities. SCSD also prepared a set of diagrams to assist manufacturers in developing components. The diagrams delineated conceptual ideas rather than intended solutions, leaving most of the design work to the manufacturers.

Without the performance specifications, Ehrenkrantz's dream of a systems approach to school building would have been impossible. The systems approach is not defined as a simple kit-of-parts to be coordinated with each other as necessary. Rather, it is "a process which is based on viewing a problem as a set of interrelated, interdependent parts, which 'work together for the overall objectives of the whole.'"[26] SCSD represented the first such systems approach to be carried out in the United States.[27] Regarding the outcome of the this method Ehrenkrantz stated that "we have hopefully no preconceptions regarding what we are to build, but rather we work with a process which, if used skillfully, would assure a high level of performance with respect to our client's desires and his pocketbook."[28] The benefits of a systems approach were mostly quality and speed of construction, but it did not guarantee a less expensive product. Success was predicated on market demand that justifies the requisite research and development.[29] SCSD, in a sense, created an artificial market made possible by the Ford Foundation's direct funding of EFL.

To ensure that all SCSD schools could achieve an individual identity (like the Hertfordshire schools), Ehrenkrantz's group decided to permit the flexibility of an open, "incomplete building system."[30] To this end, SCSD omitted exterior cladding from its system, leaving design architects with a certain degree of creative freedom in designing the missing components.

SCSD was an organized and well-funded program that benefited from the systems approach, but obstacles to its success included building codes, union rules, industry-wide fragmentation, and communication problems between owners, designers, manufacturers, and contractors.[31] Although the systems approach conflates responsibility and liability in design and performance, it ultimately increases the responsibility of bidders. "The permutations of this approach" wrote Michael Hacker, "are alarming."[32]

COMPONENTS AND MANUFACTURERS

SCSD defined a set of components, or sub-systems that would constitute a common set of construction elements for its schools. Ehrenkrantz systematized only half of his components because of union concerns that on-site jobs would be lost and to allow the project's architects to maintain significant authorship.[33]
The SCSD focused on developing four main subsystems with an assortment of manufacturers (Fig. 2). Among the sub-systems included were: 1.) structure, 2.) heating/ventilation/air-conditioning, 3.) ceiling-lighting, and 4.) interior partitions.

The SCSD focused much of its attention on the roof structure where Inland Steel produced an "ingenious… lightweight folding truss which [could] be delivered by flatcar."[34] Square-sectioned, lightweight steel columns held these trusses aloft.[35]

Integral to the roof structure was a full HVAC system (a new amenity in many schools) which could be zoned and relocated according to user needs. Along with the mechanical systems, a ceiling system with integrated modular lighting fixtures became an important element in the SCSD design palette.
One last component in the SCSD system was a series of interior partitions. Three types were implemented in the final bid process: demountable, panel-style folding partitions, and accordion-style moveable partitions.[36]

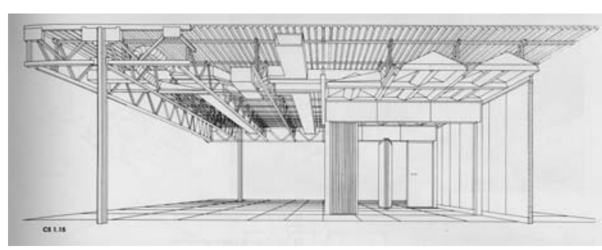

Fig. 2 Composite drawing of SCSD system
Ehrenkrantz, Ezra *Architectural Systems*. USA: McGraw-Hill, 1989: 141

BIDDING

Bidding projects in California proved to be complex. Where England used a closed system of working directly with select component manufacturers, schools in California were required to be bid by an open invitation process, allowing all manufacturers and contractors equal access to the jobs. Without a consortium of districts guaranteeing a large amount of work, manufacturers likely would not have joined SCSD's experiment.

SCSD eschewed conventional bidding practices in favor of a complex, three-stage process that began in 1963. In September, an overwhelming number of industry leaders attended the pre-bid conferences, and SCSD felt that the interest from the construction industry validated what had, up to then, been a speculative venture. The second step in the bid process asked potential bidders to submit, in two months time, an Evaluation Submission as a proposal of intended methods to meet the performance standards. This submission did not require pricing information, but it helped SCSD to analyze the nature of its component choices.

Final bids were presented to SCSD in December 1963. The manufacturers bid on 1,400,000 sq. ft. of floor area rather than one complete school project. The terms of the bids also called for installed prices for buildings that were to be completed up to four years hence. More than 50 manufacturers bid to become a part of the SCSD component system, but only five were awarded contracts. The members of SCSD spent a month before awarding the contracts meticulously reviewing all submissions to ensure that the products bid were without flaw. Based on SCSD's calculations, their bids amounted to an 18% savings over comparable products for use in conventional construction methods.

SCSD avoided traditional awarding of contracts based on a lowest dollar cost scale for each product. Instead, they awarded contracts based on cost/benefit analysis that considered both the cost and a component's ability to be integrated into the entire system.[37]

SYSTEM REFINEMENT

With SCSD acting as a coordinator, five manufacturers began working together in January 1964 to ensure that the sub-systems would be compatible. Each manufacturer also began to prepare systems for a prototype scheduled for later in the year.

Inland Steel produced a lightweight steel structural system of cruciform columns and warren trusses. Innovations in the roof structure included a steel roof deck that spanned between trusses acting as a compressive top chord. The tubular steel webs and bottom chords of the roof structure folded flat to ease transport and site placement. The columns offered less innovation, but the shape made connection points possible in four directions, thereby accentuating the modular grid.[38]

Lennox Industries designed roof-mounted air handling equipment that could deliver conditioned air to the interior spaces through a combination of fixed and flexible ductwork. Lennox coordinated its discreet strip diffusers to fit within Inland steel's ceiling-light system.

The ceiling-light system offered several design solutions within a fairly rigid 5' x 5' grid system. Inland Steel's system accomplished all of the following functions: source of illumination, finished ceiling, sound absorption, fire protection for the steel structure, support for partitions, and air delivery / return. The five-foot square grids could accept either a flat in-fill surface or a coffered attachment that acted as a light reflector.

The interior partitions were the most vibrant component in the SCSD system. Ehrenkrantz's goal was to create an aesthetically neutral system so that architects would not be averse to using it. The three partition companies, however, were able to provide a range of finishes, including enamel-finished steel panels in 28 colors. Additionally, glazed panels or more pragmatic chalkboard and tack surfaces could be ordered.[39]

THE PROTOTYPE

As part of the process of testing the new component system, SCSD constructed a 3600 sq. ft. prototype on the Stanford University campus

Fig. 3. Completed prototype on Stanford University campus. King, Johnathan "An Industrialized School System for California." *Canadian Architect* 12 (1967): 37.

(figs. 3-4). The prototype showed "the systems in as pure a form as possible, and to minimize extraneous architectural expression."[40] The prototype, however, foreshadowed the defining architectural feature of all future SCSD schools: a thickened horizontal roof that hovers above and overpowers the exterior facades. For two years, it served as a useful tool for experimenting with SCSD components.

THE SCHOOLS

SCSD schools benefited from high quality components and construction, but the aesthetic successes (always a secondary issue for SCSD) were few. Five of the initial schools received citations at the 1966 A.I.A. – A.A.S.A. convention, but most interiors of SCSD schools shared similar expressive characteristics.[41] The school districts were free to choose architects to design their individual buildings, and two firms, Leefe & Ehrenkrantz Architects and William Blurock & Associates designed the most notable schools.
Unfortunately, the components limited architects' ability to create a set of schools, each with varied and distinct characteristics, like the English Hertfordshire schools. Standard, repetitious components created "dead-pan styling down"[42] in most interiors. SCSD intentionally designed their system to achieve this effect in hopes that design architects would not feel constrained by aesthetic elements mandated by other architects.[43] The ceiling is the most distinctive element in any SCSD school interior. Whether used as coffered or luminous surfaces, the ceilings in SCSD schools seem to float continuously above the dividing partitions. The open floor plans, divided by 3" wide paneled

Fig. 4. Prototype construction with aerial component delivery. King, Johnathan "An Industrialized School System for California." *Canadian Architect* 12 (1967): 38.

partitions, help to ensure the ceiling's dominance. Furniture, variously colored partitions, and finishes (including carpets and tiles) help to alleviate the monotony inherent to the component– based schools. Proponents of this sparsely-styled interior design approach note that the school's spaces became articulated by the inhabitants, but this only emphasizes the system's banal qualities.[44]

Architects were given more freedom to choose materials for the exterior. SCSD schools were confined to single-story construction, but their low, horizontal facades were clad with materials such as stucco, painted concrete block, split-faced concrete masonry, and glass and steel storefront systems.[45]

Like the Hertfordshire schools, SCSD models lacked the formality and grand gestures of traditional pre-war schools, but were capable of accommodating varied plan arrangements. A comparison of three high schools--El Dorado in the Placentia Unified District (fig. 5), Sonora High of the Fullerton Union District, and Fountain Valley High in the Huntington Beach Union District--reveals that the SCSD system provided flexibility in plan organization. El Dorado High School is organized into a campus configuration that isolates different subject areas. Courtyard spaces intend-

Fig. 5. El Dorado High School in the Placentia Unified District. King, Johnathan "An Industrialized School System for California." *Canadian Architect* 12 (1967): 40.

ed for social interaction separate the individual buildings. Within each unit, mutable spatial configurations provide areas for group and independent study. Sonora High School presents a more contained, centrally-oriented plan organization with classroom spaces located on the perimeter of the building. Fountain Valley High School arranges linear academic buildings around a central courtyard.[46]

CONCLUSIONS AND PROJECTIONS

SCSD set out to produce flexible schools through a mass-produced, open systems approach to design that would reduce the time and cost needed to design and build high quality schools in the United States. The schools challenged procedural standards, but never achieved the aesthetic merit of England's Hertfordshire schools. SCSD's rigid component system proved to be detrimental in aesthetic terms, and architects found that the systemized kit-of-parts lacked enough flexibility to design attractive buildings. Ehrenkrantz noted that there were "problems with specific architects or consultants [designing SCSD schools] who, instead of working with the system, tried to use the system to do specific things for which it was not designed."[47] William Blurock, who designed several SCSD schools, found the component system's appearance "disappointingly conventional."[48]

A more important SCSD goal was to design flexible plans that could adapt to new methods of teaching, most notably team teaching and individualized instruction, but the hope of flexibility eventually overwhelmed the system. Ehrenkrantz's partner "discovered that too much flexibility is almost as bad as not enough, for when everything moves, the student can have no anchor, no feeling of a home base."[49]

SCSD's chief innovations were located in procedural practices rather than aesthetic discoveries. The systems approach to design offered a radical departure from traditional construction, research and development, and bidding practices.[50] SCSD's implementation of a component-based system, however, proved to be marginally effective in terms of cost and delivery time.

While the program fell short of producing a new, aesthetically rich architecture, it succeeded in altering the status quo in regards to architectural design and construction methodologies, and integrated many contributors from the manufacturing sector. Additionally, SCSD spawned an interest throughout American design in the capabilities of industry and rapid-paced building construction technologies. SCSD was only meant to stand as a pilot program, and it came to an end in 1967, but many of the components developed through the program would become a part of school designs nationwide.

SCSD provides many compelling lessons of how current prototyping, prefabrication, modular, and digital fabrication methodologies can be implemented in public building projects, particularly schools. An array of contemporary architects, such as Marmol Radziner, Resolution: 4 Architecture, and Rocio Romero, are preoccupied with updating prefabricated housing using the latest technology and a renewed sensitivity to materiality and residential individuality, but few are extending research and experiments into the public realm of school design and construction.[51]

The public bid process required by most school districts and contractor control of means and methods both present a formidable challenge to implementing systematic prototyping for public educational facilities. The SCSD example, however, provides significant support for an argument that integrated design teams (architects, engineers, contractors, manufacturers, and other specialists) equipped with sophisticated digital design and fabrication technology could engage current social, ecological, economic and pedagogical issues through prototyping and prefabrication processes.

Enrollment in many American school districts continues to increase, and contemporary pedagogical philosophies suggest that smaller numbers of students in classrooms create a more effective learning environment. School planners manage financial constraints and fluctuating enrollments, and often resolve spatial/pedagogical needs with rapidly-deployed, commercially available mobile classroom units that frequently remain in use beyond their "temporary" intentions.[52] These units represent a significant opportunity for architects to design a more sustainable, technology-integrated alternative to the classroom "trailers" that have become status quo on many primary and secondary school campuses. Because the mobile units are viewed as commodities available for purchase, school districts can often acquire them outside of the typical procedural and bidding frameworks that limit design, fabrication, construction, and installation innovation.

As public school districts confront population increases and decreases in funding resources, public/private partnerships have emerged as viable, though sometimes controversial, solutions. In these arrangements, teams of developers, contractors, and designers collaborate to build a school that meets the district's specified requirements, and is leased back to the district. The typical design-bid-build process is circumvented and perhaps this suggests an innovative milieu for design similar to the collaborative environment engendered in the SCSD experiment.

SCSD's ideology offers a robust case study for architects engaged in designing buildings for rapid deployment. Its legacy is best preserved in public-project prototyping efforts that endeavor to provide commentary and solutions to socio-economic and political issues, and extend beyond self-referential aesthetic or technical exercises.

ENDNOTES

1. U.S. Census Bureau, "Table 2. Population, Housing Units, Area Measurements, and Density: 1790 to 1990",

http://www.census.gov/population/censusdata/table-2.pdf

Between 1950 and 1960, the U.S. population grew from 151,325,798 to 179,323,175. Housing units grew by 26.4% during that same time frame.

2. School Construction Systems Development, report no. 2: British Prefabricated School Construction. Palo Alto, CA: School Planning Laboratory, Stanford University, 1963.

3. Thorpe, Andrew *A History of the British Labour Party.* London: Macmillan Press LTD, 1997: 110.

4. Elwall, Robert *Building a Better Tomorrow.* Great Britain: Wiley-Academy, 2000: 9.

5. Thorpe, Andrew *A History of the British Labour Party.* London: Macmillan Press LTD, 1997: 124.

6. Davies, Richard Llewelyn and Weeks, John R. "The Hertfordshire Achievement." *The Architectural Review* (1952): 367.

7. Ehrenkrantz, Ezra and Kay, John D. "Flexibility through standardization," *Progressive Architecture* 38 (1957): 105

8. Davies, Richard Llewelyn and Weeks, John R. "The Hertfordshire Achievement." *The Architectural Review* (1952): 367.

9. Ehrenkrantz, Ezra and Kay, John D. "Flexibility through standardization," *Progressive Architecture* 38 (1957): 107.

10. Elwall, Robert *Building a Better Tomorrow.* Great Britain: Wiley-Academy, 2000: 17

11. Ehrenkrantz, Ezra "Towards a Social Architecture: The Role of School Buildings in Post-war England (book review)," *AA Files* 15 (Summer 1957): 110.

12. Ehrenkrantz, Ezra and Kay, John D. "Flexibility through standardization," *Progressive Architecture* 38 (1957): 107.

13. Ibid., 111

14. Elwall, Robert *Building a Better Tomorrow.* Great Britain: Wiley-Academy, 2000: 9.

15. Davies, Richard Llewelyn and Weeks, John R. "The Hertfordshire Achievement." *The Architectural Review* (1952): 368-369.

16. Ehrenkrantz, Ezra and Kay, John D. "Flexibility through standardization," *Progressive Architecture* 38 (1957): 105.

17. School Construction Systems Development, report no. 2: British Prefabricated School Construction. Palo Alto, CA: School Planning Laboratory, Stanford University, 1963.

18. "SCSD project, USA: School Construction Systems Development," *Architectural Design* 35 (1965) 324-339.

19. School Construction Systems Development, report no. 1, Project Outline: British Prefabricated School Construction. Palo Alto, CA: School Planning Laboratory, Stanford University, 1962: 4.

20. "SCSD project, USA: School Construction Systems Development," *Architectural Design* 35 (1965) 324-339.

21. Ibid., 324-339.

22. Hacker, Michael "R and D Takes a Sea Change." *The Architects' Journal* 22 (1967): 1288.

23. "SCSD project, USA: School Construction Systems Development," *Architectural Design* 35 (1965) 324-339.

24. Ibid., 324-339.

25. Ibid., 325.

26. Ehrenkrantz, Ezra "The system to systems," *American Institute of Architects* 53 (1970): 57.

27. Griffin, C.W., Jr. *Systems, An Approach to School Construction*. New York: EFL, 1971: 14.

28. Ehrenkrantz, Ezra "SCSD School Construction Systems Development." *Architectural Design* 41 (1971): 680.

29. Griffin, C.W., Jr. *Systems, An Approach to School Construction*. New York: EFL, 1971: 8.

30. King, Jonathan "An Industrialized School System for California." *Canadian Architect* 12 (1967): 34.

31. Griffin, C.W., Jr. *Systems, An Approach to School Construction*. New York: EFL, 1971: 10.

32. Hacker, Michael "R and D Takes a Sea Change." *The Architects' Journal* 22 (1967): 1289.

33. Ibid., 1290.

34. Temko, Allen "Building the Great Society: The Challenge to the Construction Industry." *Arts and Architecture* 84 (1967): 9.

35. "SCSD project, USA: School Construction Systems Development," *Architectural Design* 35 (1965) 324-339.

36. Ibid., 324-339.

37. Griffin, C.W., Jr. *Systems, An Approach to School Construction*. New York: EFL, 1971: 1—14.

38. "SCSD project, USA: School Construction Systems Development," *Architectural Design* 35 (1965) 324-339.

39. Ibid., 324-339.

40. Ibid., 334.

41. Ehrenkrantz, Ezra *Architectural Systems.* USA: McGraw-Hill, 1989: 135.

42. Hacker, Michael "R and D Takes a Sea Change." *The Architects' Journal* 22 (1967): 1290.

43. "SCSD project, USA: School Construction Systems Development," *Architectural Design* 35 (1965) 324-339.

44. Hacker, Michael "R and D Takes a Sea Change." *The Architects' Journal* 22 (1967): 1290.

45. Ibid., 1290.

46. King, Jonathan "An Industrialized School System for California." *Canadian Architect* 12 (1967): 37-41.

47. Ehrenkrantz, Ezra *Architectural Systems.* USA: McGraw-Hill, 1989: 135.

48. Ehrenkrantz, Ezra "Modular materials and design flexibility," *Arts and Architecture* 84, n.4 (1967): 20.

49. Gores, Harold "The Education Boom…It's up to the Designers to Meet the Demand." *Interiors* CXXVI (1976): 112.

50. Griffin, C.W., Jr. *Systems, An Approach to School Construction*. New York: EFL, 1971: 11.

51. Anderson Anderson Architecture, SHOP, and Kieran Timberlake Associates are notable exceptions. The have recently examined prefabrication methods for large-scale buildings

52. Over 220,000 units were in use in the U.S. by 2003 according to Michael Roman: Roman, Michael I. *Relocatable Classrooms Come of Age*, Modular Building Institute, January 2003