A Computer-Facilitated Approach for Development, Visualization and Testing of Functional Programming Information

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ABSTRACT

Functional programming processes for complex architectural projects have traditionally been hampered by the static nature of available tools and technologies. Connection with user groups have likewise been disadvantaged through the employment of sender-oriented communications models that limit feedback and interaction. In addition, diminishing project budgets place increasing pressure on clients and consultants to develop more effective and efficient methods for the design and construction of buildings. This paper discusses a case-study involving the design of a highly complex medical laboratory wherein information technologies were used to facilitate the development, visualization and testing of functional programming information. The objectives for the project involved creating an environment where users and clients actively participate in consideration of programming directions and implications in a manner that would not only increase confidence that the program would meet user requirements now and in the future, but also would reduce redundant and or inefficient space within the overall building programme. In the approach used the distinction between programming and design is diminished to improve communication of desires and design responses. The findings of the study indicate that the computer-facilitated approach met the objectives of the project and that the methods developed hold promise for application across a broader range of project types.

INTRODUCTION

Bad buildings are a result of designers failing to accurately predict the relationships between building activities (now and in the future) and the environmental supports that such activities require. Functional programming is an activity that occurs at the very outset of a design project to identify the goals and objectives of the client and so that these can be reflected in an appropriate design response. Therefore, from the outset of any project much of the quality of decision-making will heavily depend on the ability of the client to communicate their needs and the ability of the designer to translate these needs into conceptual alternatives.
In large complex building projects, particularly where highly technical or specialized activities are to take place, the need for client participation and input is particularly critical to design decision-making. More often than not in such cases the principle "Client" of the building, the one paying the bills, is not the one who will be actually working in it. The Client's requirements, often related to the efficiency and economy of the building construction, will inevitably differ from those perceived by the actual users of the building including visitors, workers, and those responsible for maintaining and cleaning it. As a result, designers and consultants are faced with the challenge of addressing the need for a functional programming process that accurately identifies the needs of both the users and the client without being overly time-consuming or costly.

Functional programming processes involving user-groups that are highly participatory, interactive, and creative are usually not undertaken. Traditional functional programming communication models are sender-oriented, basically starting with a list of facts and assumptions that are verified by the user and/or client. The traditional view of architectural programming is one that separates the analytical evaluation of functional requirements from the creative act of synthesizing built forms (Speckelmeyer 1982). The reasoning behind this being that programming and design need to be pulled apart so that physical solutions do not interfere with the objectivity of the analysis (Sanoff, 1977). Indeed, consultants that undertake functional programming increasingly are coming from outside the profession of architecture. However, one could argue that models that adhere to such a separation can create unnecessary barriers in communication of desires of the user and the translation of these desires into design responses.

This paper discusses an approach used in the design of a highly complex medical facility in which advanced information technologies are used to facilitate the development, visualization and testing of functional programming information. In many ways the approach used reduces the gap between analytical programming and creative schematic design. In this approach the technology is used to interactively and dynamically organize and manage verbal and visual input from all stakeholders in the development of concepts during facilitated internal meetings and on-site user focus group sessions.

The primary objectives of the project were to: (1) increase the understanding of architectural programming direction and implications by all participants; (2) improve efficacy in the delivery of functional programming services (and ultimately design services); (3) to increase confidence in the ability of the program to meet user needs; and, (4) to reduce redundant and/or inefficient space within the overall building program. The following sections of this paper describe the case-study in which the computer-facilitated programming approach was used. The findings of the case-study are also discussed in light of future promise for application across a broader range of project types.
BACKGROUND OF CASE STUDY

Architectural programming is recognized by both the AIA and the RIBA as an important first step in the planning of a facility. It involves the careful collection and analysis of information that forms a basis for design response. According to Pena, this activity is called "problem-seeking" (Pena 1987). One of the key challenges of architectural programming is the organization and management of the collected information so that the performance requirements can be clearly communicated (Duek 1993). In response to this there are a number of different models for organization and analyzing programming information including those of Duek, Pena, Palmer, White, and Markus (described in Duek 1993). In all cases cited the success of the programming process relies heavily on client participation and decision-making. There have been a few efforts to explore the use of technology in the facilitation of client participation in planning such as described in (Kubota and Kubota 1994). In light of the evidence that more emphasis is being placed by clients on economic, technical, organizational and management issues in the pre-design phase there is a question whether traditional tools and training can adequately respond (Moshini 1995).

It was the failure of traditional architectural programming techniques in the development of a new complex laboratory building that prompted the client to seek the assistance of TSB Healthcare Planning (a healthcare & technical consulting firm) and the CADLAB at the University of Manitoba. Prior to TSB and CADLAB involvement, there had been an extensive functional program developed in conjunction with laboratory user groups by an external consultant. This functional program was then used to develop an architectural program that established spatial requirements for each activity zone. The architectural program was created with some involvement of the user groups for calculating net areas — however, the users were excluded in any "gross-up" activities. Instead, the consultant relied on conventionally accepted rules-of-thumb as well as input from the laboratory administrators. The result was a program that responded to the basic functions of the laboratory but did not adequately reflect current and future trends in the laboratory workplace and management. The foremost of these overlooked issues being integration of a new Laboratory Information System (LIS) planned for the facility. Alternate concepts in workplace management that were also not considered include job-sharing and consolidations, as well as other operational issues relating to current and emergent automated laboratory equipment (i.e. the "Core Laboratory" concept). Furthermore, relying on conventional rules-of-thumb resulted in the calculation of a total square footage for the new laboratory that was substantially higher than allowed for in the budget.

In this particular instance, traditional programming practices failed for two reasons: (1) the user group was removed from the process when actual sizes were being assigned to task areas, and (2) the consultant lacked either the mandate or the knowledge to push ahead with introducing new concepts in laboratory management and technology. In order to revise the architectural program it was felt that a new approach was needed that could benefit from knowledge from both users as well as experts in the field of laboratory design to determine the functional priorities for the complex task areas.
PROJECT OBJECTIVES & APPROACH

The client group of the laboratory were relatively straightforward in their request: Without going over the amount of space allocated by the project's budget, develop a new architectural program with input from key client and user groups that accurately reflects the economic and technological realities of today's laboratory, along with accommodation for the future. The objectives of the research team therefore became:

1. incorporate relevant information collected in a previous functional programming exercise;
2. introduce and incorporate new knowledge (in this case about laboratory management and design);
3. create an environment where user/client groups could actively participate in the review process; and,
4. provide a means of collecting, storing and representing conceptual representations of user requirements that can be evaluated both qualitatively (i.e. adjacencies, circulation patterns, etc.) and quantitatively (i.e. spatial allocations).

The research team began by reviewing the functional and architectural programs to identify areas of concern. The programs also provided an understanding of the particular parameters that shaped the Laboratory's existing testing processes. Preliminary discussions were held with the Laboratory administration to review historical assumptions and to determine the appropriate approach to meeting the objectives of the study. This included consideration of a strategic plan based on future directions of the role of the laboratory (its clients and services), changing standards and regulations for hospital laboratories as well as evolving regional and provincial goals.

Based on this initial review five user groups were identified that represented the key aspects of the Laboratory. At the first group meeting users were shown an overall Laboratory organizational flow chart so that they could see how the work flow, materials, information, waste, and so on would be handled, as well as introduce the new definition of departments in the Laboratory (all based on a strategic business/management plan). In addition to the core user group representatives from the laboratory's architectural consultants, Laboratory administration, hospital administration, and client group also sat in on all meetings of the user groups. Staff were asked to participate as fully as possible in each meeting and to act as a conduit for other members of their department to ensure that as many opinions as possible were received during this evaluation process.

The role of TSB Healthcare Planning in the study was to provide the expertise relating to current and future trends in laboratory management and design. In this role TSB was responsible for educating the user groups and clients about emerging technology and trends in the healthcare business and help them to re-evaluate their corporate
structure and business practices. Acting as both facilitator and consultant, TSB bridged the gap between the hospital administrators, the laboratory user groups and government facility planners.

The role of the CADLAB was to provide an interactive environment for involving the user groups in the evaluation process as well as a means for information management. Towards this end an approach was adopted that incorporates advanced information technologies for facilitating the development, visualization, and testing of functional programming information. Computer-based communication systems, incorporating Computer-Aided Design [CAD] and multimedia software with Liquid Crystal Display [LCD] projectors, were used by the project team for both internal meetings and for on-site user focus group sessions.

A COMPUTER-FACILITATED APPROACH

The approach used in this study can be broken into four key areas:

1. Generating the core database of objects.
2. Soliciting preliminary layouts from the user groups.
3. Interactively refining layouts with user group input.
4. Based on approved layouts, generating reports from the object-oriented graphic database.

The core of this approach was the development of a “kit-of-parts”, a collection of object-oriented CAD drawing files. Starting with both the functional program and the initial architectural program, a complete set of objects (e.g. microscopes, analyzers, etc.) that were specified in the documents were drawn in a CAD program. A set of database fields containing non-graphical information was then linked to each object (see Figure 1).

One of the significant advantages to using object-oriented CAD software (Graphsoft’s MiniCAD+ 4.0), was the ability to record multiple types of information about each object. The name of each object (i.e. “microscope”) and its departmental and sub-department location were tagged to all of the objects. Notes regarding building services requirements (such as voltage, water and waste requirements) were added as required. An additional record of data was attached to each object containing the object’s relationships and proximity to other pieces of equipment or areas. For example, one such record contained a note that stated a “Cytostat” needs to be close to the receiving desk of the Histopathology Department. It is important, however, to emphasize that the vast majority of relational-type information was only discovered and added to the database during the user group sessions.

Once the “kit-of-parts” was created, the process of developing space layouts with the user groups began. Initial meetings focused on developing an understanding of the
current space limitations, along with more direct interpretations of the information that was presented in the functional program (i.e. what is meant by a wet workstation in microbiology? in cytology?). It was also at this stage when the more radical concepts of a laboratory-wide information system and corporate restructuring were introduced. At this time, the CAD system\(^2\) was introduced to the user groups. The system included a laptop computer, an overhead colour liquid crystal display panel and a portable tabloid size printer. As the discussions progressed the user groups saw their work environments take shape on the projection screen (see Figure 2).

In the first meetings most of the graphic information was exchanged via the chalkboard, not the computer screen. The reason for this was simple: at this point in the process the users had a tremendous amount of information to share, and the chalk gave them quick results - they could sketch rough layouts quickly and make changes just as fast. At this stage, the CAD tool was merely used to record and interpret the user groups input. Once this base data was recorded, the process of creating "to-scale" plan view representations of the work areas began. This initiated a process of negotiating space requirements with scale diagrams that were dynamically updated as user group members made suggestions and decisions.

Once initial sets of diagrams for each of the work areas were developed, the iterative process of refinement began. The user group members were each provided with 11" x 17" printouts of the schematic layouts to take back to their own departments. Posted in public areas, comments were solicited by users group members from the rest of the laboratory staff in their area (see Figure 3). During successive meetings, members of the user group and the facilitator would direct changes to be made to the projected drawings. It was at this stage, where there were many changes to be recorded, that it became apparent that in addition to the facilitator, it was important to have an additional person manipulating the CAD system at all times. In this manner, the facilitator would not be
distracted or bothered by minor technical issues; additionally, the CAD technician could continually update and refine the schematics as the conversation ensued. At the end of each session, another set of tabloid sized prints were produced for distribution through the existing workplace. In this scenario, the group was interacting not only with the projected images, but also the prints and sketches on a blackboard.

A critical procedure between successive user group meetings was to generate reports from the drawing databases to track the development of a space budget. As each object in the drawings had attached information, it was possible to ensure that all key requirements of the functional program were met. By defining objects within the drawings such as walls, corridors and service spaces, reports outlining the net and gross area requirements could be produced as well. This was of particular interest for this project, as no standard grossing factors could be applied\(^3\). In addition to the organizational issues, the central hospital plan called for an external power and heat plant that also impacted on what would be considered to be "normal" grossing factors for service and mechanical spaces.

RESULTS & OBSERVATIONS

This project proved to be very successful given that the primary objective was to rationalize a functional program so that it provided ample work space without being extravagant. Compared to the original architectural program, which was overturned by the government planning authorities for simply being too generous in its space
allocation, a final savings of approximately 40% was achieved in gross square footage through this highly participatory and interactive process.

As each of the user groups took ownership of their particular areas the proposed conceptual layouts moved a step beyond what is normally considered programming and ventured further into what is normally considered to be schematic design. Gross space was much more clearly identified as each user group developed a layout to meet their individual needs (which proved to be particularly valuable in factoring gross space within the proposed open design concept).

The transition from programming activities towards design is an increasingly sensitive domain that deserves some discussion if approaches such as the one used in this study become more widely used. The contention and threat in this area is related to conventional architectural professional scope and liability. In a traditional programming exercise diagrams would generally only be indications of spatial proximities. In this technology-mediated process user groups essentially “designed” down to the detail of their own work benches or, at the very least, laid out explicitly how they expect to work in the future facility. However, it is immediately apparent that the layouts produced by the user groups represent an ideal — there are no considerations for such practicalities as structural grids, economic routing of water/sewage and air handling. These are issues normally reserved for the architect and various other environmental design consultants. A concern is that in providing the user with such
explicit diagrams, the architect may feel coerced into a layout without the ability to develop independent schemes based on the data alone, as is typically the case. Arguably, it is to the designer's advantage that the users' intentions are much clearer; there can be little misinterpretation using the highly visual computer-based approach as compared with more conventional and static text-centered methods. Furthermore, open concept designs, as was proposed in this laboratory project, have unique gross space allocations that can only reliably be identified once the various user groups clearly understand their own needs. In this study, rather than relying on historical "rule-of-thumb" ratios to generate space budgets, gross-up factors were more precisely identified.

An obvious solution to taking advantage of the benefits of reducing the distinction between programming and design would be to have the architect centrally involved early in the participatory programming process. Unfortunately, this frequently becomes an area of concern from the client's (i.e. the funding body) point of view. The architect's fee is based on a percentage of construction cost. Therefore it is implied that it is advantageous for a designer to have as generous a spatial program as possible. It is for this particular reason that clients often have architectural programs prepared by independent consultants.

The resolution of this quandary is not readily apparent. This case-study resulted in a programme that is a direct graphic representation of user needs, but one that potentially infringes upon the architect's traditional scope of work. In this project, the planning agency assumed a highly progressive stance, one that the project architect was requested to follow. Ideally, a situation where the architect can become more critically involved earlier in the sequence (understanding that a large portion of their initial research and interpretation will be captured as well) is desired and recommended by the investigators. In this case-study the architect did have a representative present at all user groups as an observer and collector of relevant information. It would be advantageous in future studies involving a similar computer-facilitated programming approach the approach to have the architect move from the more passive role of observer to an active and engaged participant, free of agendas other than a fiscally responsible project.

CONCLUSIONS & FUTURE DIRECTIONS

Through the process of producing a dynamic graphically-focused architectural programme the diverse needs of the various participants were met and often exceeded. The planning authority was presented with a document that they were confident met the users' actual needs. The object-oriented database technology was welcomed by the user groups and facility planners, presenting a new way to approach the long-standing problem of effective spatial determination. Most importantly, the future users of the facility had become active participants in the planning and organization of their future work environment. To the benefit of all participants, the predominant goal of maximizing economic efficiency was also met.
While providing a large number of answers, the present project also brought to the forefront a plethora of fundamental questions. This includes issues of user group ownership and professional responsibilities: How can and/or should the user groups be held responsible for their decisions? What about the roles of the programmer? the architect? the planners? management? How each of the various client and user groups as well as consultants involved in the project reconcile their own interests is critical to the overall success of the project.

What has become clear is that the positive application of information technology in the planning and programming of complex projects can only increase. Operational issues and facility development are becoming more intertwined as a central aspect of programming and planning of sophisticated projects (such as healthcare buildings). It is no longer acceptable to clients and funding agencies for environmental design consultants to look at such development without a sound understanding of operational concerns, constraints and realities. To this end the use of technology is paramount to successful management of an increasing wealth of information. Fundamental to this projection are the opportunities for a bottom-up, co-design, participatory and inclusionary approach to facilities programming and needs assessment. Considering its enabling potential remains largely untapped, new technology holds much promise across a range of environment-behaviour-design challenges.

ENDNOTES

1 CADLAB is a research/service umbrella unit of the Faculty of Architecture whose mandate is the development & application of information & computational technologies in the areas of design & planning education and practice.

2 The CAD system was comprised of readily available and affordable technology, including an Apple Macintosh PowerBook 165c (12 MB RAM) for interactive user group sessions and an Apple Quadra 700 (20 MB RAM) for graphics & desktop publishing work back at CADLAB.

3 While certain standards do exist they were inappropriate for this project. Here new organizational paradigms were being introduced that are based on cross-fertilization and sharing amongst departments, thus altering the traditional laboratory “silos” or independent departments (that often have redundant services).
REFERENCES


